

Nov. 7, 1961

C. E. POLLARD, JR

3,008,021

ELECTRICALLY CONTROLLED SWITCHING DEVICE

Filed Dec. 10, 1959

FIG. 1

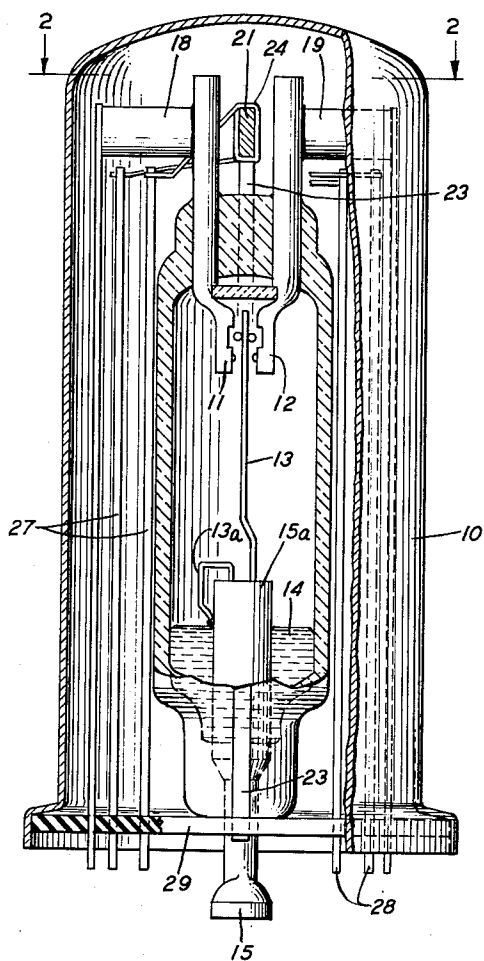


FIG. 2

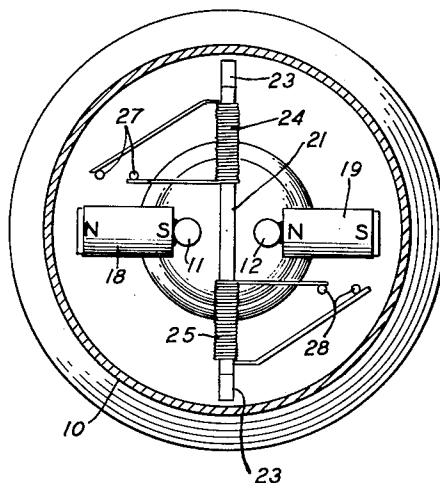
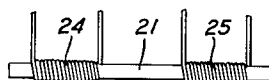


FIG. 3



STATE	MAGNETIC POLES		
I	N	S	N
II	S	N	S
III	S	0	N
IV	N	0	S

INVENTOR
C. E. POLLARD, JR.
BY *Henry M. Bissell*
ATTORNEY

1

3,008,021

ELECTRICALLY CONTROLLED SWITCHING DEVICE

Charles E. Pollard, Jr., Hohokus, N.J., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Filed Dec. 10, 1959, Ser. No. 858,805

14 Claims. (Cl. 200-93)

This invention relates to polarized relay switching devices and more particularly to such devices including a transfer contact.

In certain switching applications such as are encountered, for example, in telephone systems, it may be desirable to provide an electromechanical relay which is simple, reliably free from contact chatter and capable of many operations over a long period of time with a minimum of maintenance. A relay which satisfies these requirements is the mercury contact relay which provides a movable transfer contact between two stationary contacts. A pool of mercury is provided within the switch structure, which mercury wets the contact surfaces to assist in providing the desired characteristics outlined above. The sensitivity of such a device may be improved by adding permanent magnets arranged as is known in the art to establish a predetermined biasing magnetic field in the vicinity of the stationary contacts. Such a relay is disclosed, for example, in J. T. L. Brown-C. E. Pollard, Jr. Patent 2,609,464, granted September 2, 1952.

Electromechanical switches possess certain advantageous characteristics which make them particularly desirable for use in telephone switching networks. Until recently, however, practical electromechanical switches have been too slow in operation to be generally attractive in modern high speed electronic telephone systems. A switching device which has provided compatibility between the electronic pulses of a few microseconds' duration which are employed for controlling such switching networks and the electromechanical switches which have heretofore provided the bulk of the interconnections in telephone systems is disclosed in A. Feiner et al. application Serial No. 824,222, filed July 1, 1959. This device employs a pair of remanently magnetic members, the remanent magnetization states of which may be established by electronic pulses of a few microseconds' duration. The associated magnetically responsive switch assumes a contact condition corresponding to the magnetization state of the remanently magnetic elements in a time dependent upon the mechanical response characteristics of the switch. High speed, low power control equipment may be employed with such a device since only short control pulses are needed to set the magnetization state thereof; the contact state of the device is thereafter established and maintained by the magnetic field of the remanently magnetic elements.

For specific applications in electronically controlled switching networks there is a need for a metallic contact transfer switch. Such a switch, however, should be controllable by the same type of control pulses and, therefore, provide the same compatibility between electronic switching signals and the mechanical contact structure as is provided by the relay of Feiner et al.

It is, therefore, an object of this invention to provide an improved contact transfer relay. More specifically, it is an object of this invention to provide a contact transfer relay which is controllable by pulses shorter than the mechanical response time of the movable contact member and which is capable of maintaining a predetermined contact position without the requirement of electrical holding power.

It is another object of this invention to provide a mercury contact transfer relay which is controllable by appli-

2

cation of a pair of control signals and which guards against false operation due to an individual control signal.

It is a further object of my invention to provide a mercury contact transfer relay controllable by coincident current control signals in which the magnitude of the control signals need not be limited in order to protect against false operation on occurrence of a single non-coincident control signal.

It is an additional object of my invention to provide a mercury contact transfer relay controllable by plural control signals in which the relative times of application of the control signals are not critical.

One specific embodiment of my invention comprises a mercury contact relay structure similar to that which is disclosed in the above-cited J. T. L. Brown-C. E. Pollard, Jr. patent except that the operating or control winding is not wound around the switch envelope. Two permanent magnets are positioned adjacent corresponding stationary contacts of the relay to provide a biasing magnetic field therefor. To this structure is added, in accordance with my invention, a rod of material exhibiting a plurality of stable remanent magnetization states. This rod is positioned so as to establish a free magnetic pole between the terminals leading to the stationary contacts of the relay so as to control the magnetic flux at these contacts and thus determine the position of the movable contact of the relay. The magnetization state of the remanently magnetic rod may be established by a current-carrying coil wound solely about the member. For coincident current control of the relay, I provide a pair of windings to develop a resultant electromagnetic field adequate to switch the magnetization state of the rod.

In one specific embodiment of my invention, the remanently magnetic rod is arranged with its midpoint between the stationary contact terminals of the relay and with its two control windings at opposite ends of the rod. In this specific embodiment a very considerable margin against false operation of the device by a single control pulse of any magnitude is achieved because of the way in which the magnetization states of the different portions of the rod are established in response to control signals on one of the windings.

The magnetic control member or rod of my invention advantageously comprises a material having a high magnetic remanence. Most such materials also exhibit a relatively high coercive force and a correspondingly low permeability to magnetic flux. It follows, therefore, that when a magnetic field is applied to a particular portion of a rod of such material, the rod having a length which is substantial with respect to its cross-sectional area, the rod is not magnetized throughout its length but is magnetized only in the particular portion to which the field is applied.

Such a situation exists in the specific embodiment of my invention described herein wherein the magnetizing field for the remanently magnetic member is developed by one or both of two control windings at opposite ends of the rod. Each control winding determines the remanent magnetization of a particular portion of the rod which it surrounds. When both of the windings are energized to produce individual magnetic fields in opposite directions, magnetic poles of like polarity are produced at opposite ends of the rod and a magnetic pole of the opposite polarity is developed at the midpoint of the rod. This magnetic pole at the midpoint of the rod affects the magnetic field produced by the permanent magnets so as to control the position of the movable contact with respect to the fixed contacts. If this central magnetic pole is of one polarity, the movable contact will be positioned at one of the stationary contacts, while if it is of the other polarity, the movable contact will be positioned at the other stationary contact. The polarity of this central magnetic pole can

be reversed only by the application of signals to both of the control windings of the remanently magnetic member. This result obtains because the application to only one of the windings of a control signal even many times the amplitude of the normal signal reverses the magnetization of only the portion of the rod included by that winding. Such a reversal serves to establish the same polarity of magnetization throughout the length of the rod, thus developing magnetic poles of opposite polarity at the ends of the rod and eliminating the magnetic pole at the center thereof. The elimination of the central magnetic pole does not affect the contact state of the switch since, in a polarized relay of this type, the movable contact maintains its particular position in the absence of a magnetic field which opposes that contact position. Thus, the upper limit normally imposed upon the magnitude of the individual control signals applied to a coincidentally controlled hysteretic device is advantageously eliminated in the specific embodiments of my invention.

Furthermore, it can be seen that the magnetization state of the entire remanently magnetic rod can be reversed by successively reversing the magnetization states of the individual portions thereof. Accordingly, this specific embodiment of my invention advantageously responds only to a plurality of control pulses which may be, but need not be, coincident in duration. Thus the margins normally relating to the timing of the plural pulses controlling such a device are also eliminated.

It is a feature of this invention to provide in a polarized transfer relay a remanently magnetic member which is reversible in magnetic polarity for controlling the contact position of the relay. More specifically in accordance with this feature of my invention the remanently magnetic member is positioned so as to develop magnetic poles between the polarizing magnets of the relay to effect transfer operation of the relay.

It is a further feature of this invention to provide a polarized transfer relay having a remanently magnetic member which is reversible in magnetization polarity by coincident signals on a pair of windings thereof.

It is another feature of my invention that a remanently magnetic member having a pair of windings thereon be arranged with respect to a polarized transfer relay so that both windings must be energized to produce a change of contact condition.

It is still another feature of my invention that the remanently magnetic rod or member be positioned between the polarizing magnets of the relay and perpendicular thereto with the control windings wound on opposite ends of the rod so that a magnetic pole for operation of the relay is developed at the middle of the remanently magnetic rod only by application of control signals to the two windings, application of a control signal to a single winding merely serving to magnetize the entire rod in the same direction, thereby eliminating any magnetic pole priorly existing at the center of the rod adjacent the polarizing magnets. Therefore, in accordance with my invention margin limitations on the control signals are removed by arranging that operation of the relay is only effected when the two ends of the remanently magnetic rod are magnetized in opposite directions to establish a magnetic pole adjacent the center of the rod, magnetization of the two ends of the rod in the same direction, as after pulsing of only one of the control windings, merely serving to remove the priorly existing magnetic pole without effecting transfer operation of the relay.

A complete understanding of this invention and of these and various other features thereof may be gained from consideration of the following detailed description and the accompanying drawing, in which:

FIG. 1 is a side view, partially in section, of a mercury contact transfer relay in accordance with one specific illustrative embodiment of my invention;

FIG. 2 is a plan view of the relay of FIG. 1 along the lines 2—2 thereof; and

FIG. 3 is a view of the magnetic control rod of the embodiment of FIG. 1, together with a table indicating the magnetic poles developed therein for the four possible magnetic states.

Turning now to the drawing, in the specific embodiment of my invention depicted in FIG. 1, a mercury contact transfer relay is shown in which a magnetically operated, mercury wetted armature reed 13 is mounted within a glass envelope 10, advantageously hermetically sealed and under pressure, as is known in the art. A pair of stationary contact members 11 and 12 extend through the envelope 10 for contact with the movable armature of contact 13. A quantity of mercury 14 is located at the base of the envelope 10 and is advantageously drawn into a hollow extension 15a of the exhaust tubulation by a looped end 13a of the armature reed 13, as disclosed in my Patent 2,868,926, January 13, 1959. Further, the armature reed 13 is advantageously provided with capillary grooves formed on its front and back surfaces to cause the mercury to rise from the pool 14 to the smaller reservoir within the hollow extension 15a and up to the contacts adjacent the stationary contact members 11 and 12, as disclosed in J. T. L. Brown-C. E. Pollard, Jr. Patent 2,609,464, September 2, 1952.

A magnetic biasing field is provided by permanent magnets 18 and 19 attached to the stationary contact members 11 and 12, respectively.

In accordance with an aspect of my invention, there is positioned in this specific embodiment a remanently magnetic member or rod 21 between the two permanent magnets 18 and 19 and perpendicular thereto, as best seen in FIG. 2. It is also readily apparent that the remanently magnetic rod 21 is also positioned between the stationary contact members 11 and 12. As can be seen in FIG. 2, the stationary member 11 develops a south magnetic pole at its contact and the stationary member 12 develops a north magnetic pole at its contact in response to the biasing magnetic field of the permanent magnets 18 and 19. As is known in the art relating to polarized relay structures, I provide a balanced polar adjustment of the magnets 18 and 19 so that the movable contact member 13 operates symmetrically with respect to the stationary contact members 11 and 12 when a small variation in the relative strengths of the induced magnetic poles is produced. This variation in pole strength is developed, in accordance with my invention, by the remanently magnetic member 21 which is positioned between the magnetic poles induced by magnets 18 and 19 and supported by side elements 23. Side elements 23 are advantageously of a magnetically permeable material and also serve to complete a somewhat horseshoe shaped magnetic circuit including the member or rod 21.

Windings 24 and 25 are situated at opposite ends of the rod 21 and are connected to suitable terminals 27 and 28 which are extended through the base 29 of the relay housing to permit connection to external circuitry.

Advantageously, the member or rod 21 comprises a material, such as one of the ferrite class, which exhibits a plurality of stable remanent magnetization states and has a substantially rectangular hysteresis loop. Control pulses are applied to the windings 24 and 25 to reverse the magnetization state or polarity of that portion of the rod directly under the winding thereby to establish a particular magnetic pole at the midpoint of the rod 21. Whenever the magnetization of the rod or member 21 is changed so that the magnetic pole present at the portion of the rod between the magnets 18 and 19 is reversed, the biasing field from the permanent magnets is modified thereby so that the movable armature 13 becomes attracted by the opposite stationary contact member 11 or 12, as the case may be.

The material selected for the rod 21 and the dimensions of the rod are such that the remanent magnetization of one half of the rod is not affected by the electro-

5

magnetic field of the winding about the other half thereof.

In the operation of this embodiment of my invention, the control signals may be applied either individually or concurrently to the control windings 24 and 25. However, in accordance with an aspect of my invention, improved signal margins accrue from the fact that the device is not subject to false operation from an extra large amplitude signal on a single control winding, for reasons which will now be explained, specifically with reference to FIG. 3. When the member 21 is magnetized by opposing fields from the windings 24 and 25, which may be developed concurrently or successively, free magnetic poles are produced at its opposite ends. These magnetic poles will be of the same polarity, either north poles, as shown in state I, or south poles, as shown in state II, while a magnetic pole of the opposite polarity will be developed at the middle of the rod 21. The contact position of the movable armature 13 is controlled by the polarity of these magnetic poles developed at the center of the rod 21, i.e., the contact position is controlled only by a magnetic pole so positioned as to affect the magnetic field between the stationary contact members 11 and 12 as provided by the permanent magnets 18 and 19. Reversal of the particular contact condition of the relay is effected by signals of opposite polarity upon the windings 24 and 25.

However, if a single signal or repeated signals of the opposite polarity are applied to only one of the windings 24 and 25, the only effect is to reverse the magnetization of the section of the member 21 upon which it is wound. This serves only to align the magnetization of that section of the member 21 with the magnetization at the opposite end, thus producing the same magnetization throughout its length and developing magnetic poles of opposite polarity at the opposite ends of the member 21, as seen in states III and IV of FIG. 3. This situation is, in effect, a neutral condition which does not affect the biasing field of the permanent magnets 18 and 19 and so does not act to change the existing position of the movable contact member 13. Accordingly, it is clear that, in accordance with this aspect of my invention, the margins which constitute the upper bound normally placed upon the amplitude of the control signals of a switching device responsive to coincident signals as well as the margins respecting the coincidence of such signals advantageously are eliminated in this specific embodiment of my invention.

It is to be understood that the windings 24 and 25 may either or both be replaced by pairs of windings to which are applied coincident signals individually of insufficient magnitude to effect the magnetization state of the material. Further, the member 21 may be of other forms or shapes in order to provide a remanent magnetic pole in the space between the two permanent magnetic poles to alter the magnetic field and effect the transfer operation of the relay.

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. An electrical switching device comprising a pair of fixed contacts, a third contact movable between said fixed contacts, permanently magnetized means for establishing a biasing magnetic field to develop opposite magnetic poles at said fixed contacts, and means for selectively varying said magnetic field to control the position of said third contact relative to said fixed contacts, said varying means comprising a magnetic member of a material exhibiting a plurality of stable remanent magnetization states and having a portion at which a remanent magnetic pole may be developed positioned adjacent said permanently magnetized means and in said biasing field.

2. An electrical switching device as set forth in claim 1 wherein said permanently magnetized means comprises

6

a pair of permanent magnets individually attached to corresponding ones of said fixed contacts and wherein said varying means further comprises winding means energizable to determine the presence and nature of said remanent magnetic pole.

3. An electrical switching device in accordance with claim 2 wherein said magnetic member comprises an elongated rod and wherein said winding means comprises a pair of windings wound on said rod adjacent said portion.

4. An electrical switching device in accordance with claim 3 wherein said windings are wound about opposite ends of said rod with said portion situated at the midpoint of said rod and wherein said rod is positioned with its said midpoint portion substantially midway between said permanent magnets.

5. A polarized transfer relay comprising a pair of stationary contacts, a movable contact positioned therebetween for making contact with either of said stationary contacts, means connected to said stationary contacts for developing particular magnetic poles thereat, and means for selectively modifying said magnetic poles to control the position of said movable contact, said modifying means comprising a remanently magnetic member of a material exhibiting a plurality of stable remanent magnetization states.

6. A polarized transfer relay in accordance with claim 5 wherein said remanently magnetic member is positioned equidistant from said stationary contacts and wherein said modifying means further comprises winding means energizable to establish a remanent magnetic pole at a portion of said member.

7. A polarized transfer relay in accordance with claim 6 wherein said remanently magnetic member comprises a rod and wherein said winding means comprises a pair of control windings inductively coupled to said rod adjacent said portion.

8. A polarized transfer relay in accordance with claim 7 wherein said rod portion is situated at the midpoint of said rod, wherein said rod is positioned with its said midpoint portion in line with said magnetic pole developing means, and wherein said control windings are arranged at opposite ends of said rod.

9. An electrical switching device comprising first and second stationary contacts, permanent magnet means of one polarity attached to said first contact, permanent magnet means of the opposite polarity attached to said second contact, a third contact movable between said first and second contacts, and means for determining the effects of said magnetic polarities on said third contact, said determining means comprising a remanently magnetic member of a material exhibiting a plurality of stable remanent magnetization states.

10. An electrical switching device in accordance with claim 9 wherein said determining means further comprises electromagnetic field producing means for controlling the remanent magnetization states of said remanently magnetic member to selectively establish a remanent magnetic pole at a portion of said member.

11. An electrical switching device in accordance with claim 10 wherein said electromagnetic field producing means comprises two windings at opposite ends of said remanently magnetic member with said portion situated at the midpoint of said rod and wherein said remanently magnetic member is positioned with its said midpoint portion substantially midway between said permanent magnet means attached to said first and said second contacts.

12. An electrical switching device in accordance with claim 11 wherein said remanently magnetic member comprises an elongated rod having a ratio of length to cross-sectional area such that the remanent magnetization states of particular sections of said rod may be individually controlled to selectively establish said remanent magnetic pole at said portion.

13. A mercury contact transfer relay comprising a pair of stationary contacts, means for establishing opposite

7

magnetic poles at said stationary contacts comprising a pair of permanent magnets for establishing a biasing magnetic field, a transfer armature, and means for varying said biasing field to effect closure of said armature to said contacts, said varying means including a member of a magnetic material having a plurality of stable remanent magnetization states and winding means thereon for altering the magnetization states of said material to provide remanent magnetic poles in said biasing magnetic field.

14. A mercury contact transfer relay in accordance with claim 13 wherein said member is a rod extending between said magnets and perpendicular thereto, and wherein said winding means includes a winding at each end of said rod whereby energization of both windings is re-

8

quired to change the remanent magnetization state of the rod portion directly thereunder to provide an appropriate remanent magnetic pole at the center of said rod in said biasing field, energization of but a single winding merely serving to magnetize said rod in the same direction during its entire length thereby removing any existent remanent magnetic pole at the center of said rod in said biasing field without providing an appropriate remanent magnetic pole at the center of said rod.

10

References Cited in the file of this patent

UNITED STATES PATENTS

2,609,464	Brown et al. _____	Sept. 2, 1952
2,872,546	Babcock _____	Feb. 3, 1959

15