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E. C. HELLSTROM ETAL

3,048,677

SWITCHING DEVICE

Filed March 31, 1961

FIG. 1

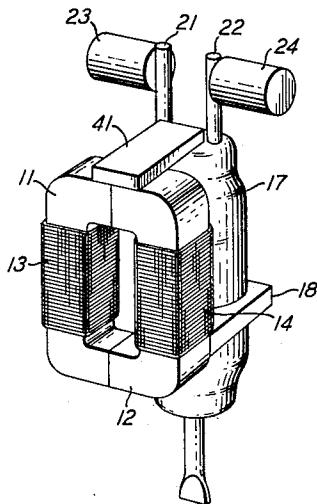


FIG. 2

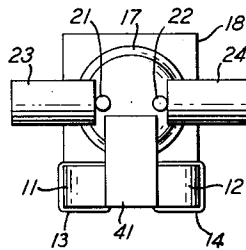


FIG. 3

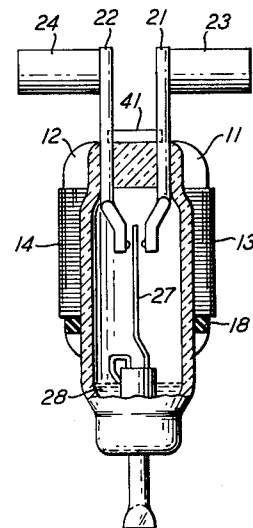


FIG. 4

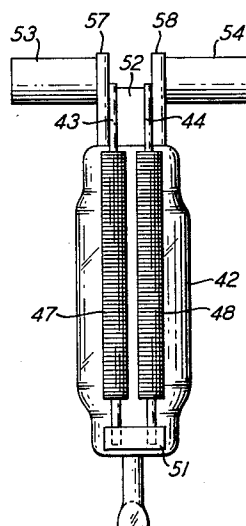
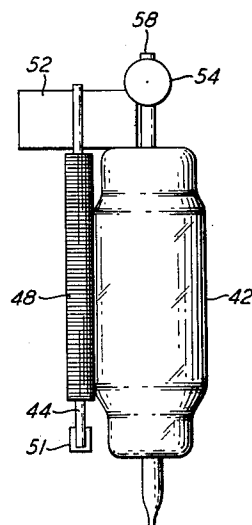


FIG. 5



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SWITCHING DEVICE

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

For many years an important, indeed an essential element of telephone systems and other communication systems has been the electromechanical switch or relay. These devices have proven to be economical and reliable means for interconnecting circuits and, further, have utilized metallic contacts for completing the transmission paths.

There has recently been described, for example in the article, "An Experiment in Switching System Using New Electronic Techniques," by A. E. Joel, Jr., Bell System Technical Journal, vol. 37, September 1958, page 1091, a telephone system utilizing electronic switching and operating at a speed many fold greater than that of present commercial systems. The types of electromechanical relays now in common use do not approach in regard to response time the minimum requirements of the electronic switching systems, even though they do provide the highly desirable economic and reliability factors and, further, utilize metallic contacts for completion of the transmission paths.

There have recently been proposed several designs of switching devices intended to render the relatively slow response mechanical switch compatible with the high speed electronic control signals, one such device being disclosed in United States Patent 2,995,637, issued August 8, 1961, application Serial No. 824,222, filed July 1, 1959, A. Feiner, C. A. Lovell, T. N. Lowry and P. G. Ridinger, and another being disclosed in United States Patent 3,008,021, issued November 7, 1961, on application Serial No. 858,805, filed December 10, 1959, C. E. Pollard, Jr. In general, these devices attain the referred to compatibility by combining a bistable remanently magnetic element with a magnetically responsive mechanical switch.

Our invention also utilizes the above general combination and, accordingly, it is an object of the present invention to improve the performance of an electromechanical relay.

Another object of our invention is to improve the response time characteristic of an electromechanical relay whereby to render feasible its use in high speed switching circuits.

A still further object of the invention is to prevent the operation of an electromechanical relay unless both operating windings have been simultaneously energized.

In accordance with one specific embodiment of our invention a sealed switch unit is utilized which has a mercury coated armature movable between two opposed stationary contacts; the terminal ends of the respective contact members project through the enclosing vessel and comprise opposed pole-pieces. A permanent magnet is attached to each pole-piece whereby to provide opposing magnetic polarities at the respective stationary contacts.

The associated magnetic circuit comprises two U-shaped cores, butted together and cemented at their junction, an energizing winding for each core, and a rectangular plate of remanent magnetic material mounted over the core junction and extending into the space in front of, and between, the terminal ends of the switch pole-pieces. Simultaneous energization of both coils in the same direction

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causes flux to pass through the remanent magnetic plate whereby to establish a bias and move the armature from the contact with which it is in engagement to the opposed contact.

In accordance with this embodiment the core sections are of a nonretentive material, for example, manganese-zinc ferrite, while the extending plate is of a hard ferrite, for example cobalt ferrite, a remanent magnetic material. This arrangement, wherein the retentive member is magnetically coupled to the two-branch nonremanent core and extends into the area of the opposed contact members, permits operation on short pulses in the microsecond range and assures against false operation by energization of one core section alone.

In accordance with a second specific embodiment of our invention the general arrangement of the switching device is similar to that of the first embodiment except for the omission of the plate of magnetically remanent material and the utilization, instead, of an element having low magnetic reluctance. The device of the second embodiment is intended for operation on substantially longer current pulses than those with which the device of the first embodiment is used.

A feature of the present invention is the utilization, as the control elements for a switch unit, of a two-branch core section on each of which a winding is placed together with a further magnetic member joined to the two branches at one end and extending to the switch unit, the member offering a higher reluctance to magnetic flux than either core section when only one of the windings is energized. Thus in accordance with this feature of our invention flux for operating the switch unit is only directed along the magnetic member when both core sections are energized in parallel.

It is a further feature of this invention that the switch unit be a sealed switch having an armature movable between two opposed stationary contacts, the contacts being connected to external pole-pieces and the magnetic member extending between these pole-pieces.

Another feature of our invention is the two-branch core section of a material of relatively low reluctance compared to the magnetic member, a material with which low reluctance butt joints are readily obtained, which has a high permeability, and which has a relatively high resistivity.

It is further a feature of one embodiment of our invention that the magnetic member extending from the two-branch core section to between the pole-pieces be of a remanently magnetic material.

A full understanding of the arrangements contemplated by the present invention as well as an appreciation of the various advantageous features thereof may be gained from consideration of the following detailed description in connection with the accompanying drawing, in which:

FIG. 1 is a perspective view of one specific illustrative embodiment of the invention;

FIG. 2 is a plan view of the specific illustrative embodiment of FIG. 1;

FIG. 3 is a rear elevation in partial section of the device of FIG. 1;

FIG. 4 is a front elevation view of another specific illustrative embodiment of the invention; and

FIG. 5 is a side elevation view of the device of FIG. 4.

Referring now to the drawings, and first to FIGS. 1, 2 and 3, an electromagnet assembly is shown comprising two U-shaped magnetic cores 11 and 12 with respective coils 13 and 14, the two cores being butted together and cemented at their junction. Cores 11 and 12 are preferably of manganese-zinc ferrite since this material provides a high permeability, has a relatively high resistivity, and since with its use low reluctance butt joints are easily

obtained. The electromagnet assembly is supported in proximity to switch assembly 17 by a suitable block 18, preferably of insulating material.

Mercury contact switch assembly 17 may be of the general type disclosed in United States Patent 3,008,021, issued November 7, 1961, on application Serial No. 858,805, filed December 10, 1959, C. E. Pollard, Jr., and its arrangement and operation will not be described herein in detail.

Pole-pieces 21 and 22 are sealed through the upper end wall of the glass enclosing vessel of switch assembly 17 and, as shown particularly in FIG. 3, extend within the vessel to form opposed stationary contacts. Permanent magnets 23 and 24 are attached, for example by welding, to the respective pole-pieces 21 and 22 and provide a suitable magnetic biasing field. The permanent magnets are so adjusted that pole-pieces 21 and 22 are magnetized to respectively opposite polarities. Armature 27 (FIG. 3), which moves between the opposed stationary contacts, is advantageously provided with capillary grooves as described in the copending application mentioned in the preceding paragraph and, during movement of the armature mercury is drawn from the supply pool 28 and transmitted to the area of the stationary contacts. This method of operation is described in greater detail in J. T. L. Brown-C. E. Pollard, Jr., United States Patent 2,609,464, issued September 2, 1952.

A plate 41 of remanent magnetic material is attached to the upper surface of joined cores 11 and 12 with its free end, as shown most clearly in FIG. 2, projecting into the space in front of and between pole-pieces 21 and 22. Member 41 should be of the so-called "hard" ferrite material, for example cobalt ferrite, and capable of assuming a plurality of stable remanent magnetization states.

Coming now to the operation of the illustrated device, armature 27 is normally held in engagement with whichever contact it last engaged (since in a polarized relay of this general type the movable contact maintains its particular position in the absence of a magnetic field which opposes the contact position), but will move into engagement with the opposite contact whenever a small variation in the relative strengths of the induced magnetic poles (in pole-pieces 21 and 22) is produced. Assuming first that windings 13 and 14 are energized in parallel, opposing magnetic flux patterns will be established in cores 11 and 12; for example the flux lines in core 11 may be in a generally clockwise direction while the flux lines in core 12 are in a generally counterclockwise direction. These opposing flux patterns, meeting at the upper junction of cores 11 and 12, cause flux to pass through ferrite plate 41 to the area near pole-pieces 21 and 22 whereby to establish a bias effective to cause armature 27 to move from the stationary contact with which it is then engaged to the opposite contact.

It will be understood, of course, that the energization of coils 13 and 14 may be only for a very short interval and that, because of the remanent magnetic characteristics of member 41, the actual operation of armature 27 may be delayed consistent with the normal response time characteristic of the device.

Assuming now that in the above instance only one winding, for example winding 13, had been energized, then practically none of the flux established in core 11 would have flowed into hard ferrite plate 41 since a path of much lower reluctance is "open" through core 12. The magnetic state of plate 41 is unchanged therefore and armature 27 is not moved from whichever contact it is then engaging.

It will be apparent, therefore, that in view of the novel arrangement described, operation of the switch cannot take place when only one coil is energized; this is true regardless of polarity or magnitude of the energizing pulse. The switch is particularly well adapted for cross-point applications, therefore, where operation is desired when two circuits are energized but where false opera-

tion by energization of one circuit alone must be guarded against.

After the first operation of the device as described above, the armature may be again moved to the opposed contact by energization of both windings 13 and 14 as before but in the opposite direction. This will reverse the magnetization of ferrite member 41 and establish a bias to move armature 27 from the contact with which it is then engaged to the opposed contact.

Referring now to FIGS. 4 and 5 a second specific embodiment of the invention is illustrated, this embodiment being adapted for operation on substantially longer pulses than is the case with the embodiment first described. The switch assembly 42 of the present embodiment is assumed to be the same as switch assembly 17 of the previously described embodiment. The electromagnetic assembly comprises cores 43 and 44, of highly permeable material such as "78.5 permalloy," with respective windings 47 and 48. The cores are coupled at their lower ends by clamp 51 and at their upper ends by attachment, for example by welding, to rectangular block 52. Elements 51 and 52 are preferably of highly permeable material such as "45 permalloy." The electromagnetic assembly is attached to the enclosing vessel of switch 42 by suitable adhesive or other means. Permanent magnets 53 and 54 are attached to respective pole-pieces 57 and 58 and serve a purpose similar to that described above in connection with the first embodiment. As shown most clearly in FIG. 5, top end piece 52 is extended to introduce flux into the area between pole-pieces 57 and 58.

The operation of the device of FIGS. 4 and 5 is similar in general to that of the device first described. However, since the response time characteristic is compatible in this case with the length of control pulses contemplated for use, it is not necessary to provide a magnetically remanent end piece. When both coils 47 and 48 are energized in parallel opposing flux paths are established in cores 43 and 44 and sufficient flux is induced in low reluctance end piece 52, and introduced thereby into the area between pole-pieces 57 and 58, to cause movement of the armature from the contact with which it is engaged to the opposed contact. However, when only one of the windings is energized, insufficient flux is induced in end piece 52 to operate the switch due both to the extended area of member 52 and to the low reluctance return path opened through the other core, the material utilized for core members 43 and 44 being of a lower magnetic reluctance than that of end member 52. The device therefore, like the first embodiment described, is especially adaptable for crosspoint application since operation can be attained only by energization of both coils, and false operation through energization of one coil alone is prevented.

While certain specific embodiments of the invention have been selected for detailed disclosure, the invention is not, of course, limited in its application to the embodiments disclosed. The embodiments which have been described should be taken as illustrative rather than restrictive thereof.

What is claimed is:

1. An electrical switching device comprising an enclosing vessel, a pair of elongated contact members sealed in one end wall of said vessel having portions extending within said vessel to form opposed stationary contacts and portions extending outside said vessel to form spaced pole-pieces, an armature mounted within said vessel movable between said stationary contacts, means outside of said vessel attached to each of said spaced pole-pieces for establishing at each of said stationary contacts respectively opposite magnetic poles, and additional means mounted outside of said vessel for controlling movement of said armature from one of said contacts to the other, said additional means comprising a pair of magnetic cores magnetically joined to each other at their ends, a control coil on each core and an elongated magnetic member at-

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tached to said cores at one of the joined ends thereof and extending into the area adjacent to and between said spaced pole-pieces whereby to extend the magnetizing effect in said cores to said area.

2. An electrical switching device comprising an enclosing vessel, a pair of elongated conductive members sealed in one end wall of said vessel having respective portions extending within said vessel to form opposed stationary contacts and portions extending outside said vessel to form spaced pole-pieces, an armature mounted within said vessel movable between said opposed stationary contacts, a pair of permanent magnets, one of said permanent magnets being attached to one of said pole-pieces and the other permanent magnet being attached to the other of said pole-pieces whereby to establish at each of said stationary contacts respectively opposite magnetic poles, and additional means mounted outside of said vessel for controlling movement of said armature from one of said contacts to the other, said additional means including a pair of magnetic cores conductively joined to each other at their ends, a control coil on each core and means effective only when both of said coils are energized in parallel for transferring flux established in said cores into the area adjacent to and between said spaced pole-pieces.

3. An electrical switching device comprising an enclosing vessel, a pair of elongated conductive members sealed in one end wall of said vessel having respective portions extending within said vessel to form opposed stationary contacts and portions extending outside said vessel to form spaced pole-pieces, an armature mounted within said vessel movable between said opposed stationary contacts, a pair of permanent magnets, one of said permanent magnets being attached to one of said pole-pieces and the other permanent magnet being attached to the other of said pole-pieces whereby to establish at each of said stationary contacts respectively opposite magnetic poles, and additional means mounted outside of said vessel for controlling movement of said armature from one of said contacts to the other, said additional means including a pair of magnetic cores conductively joined to each other at their ends, a control coil on each core and means effective only when opposing flux paths are established in the respective cores for transferring a portion of the flux into the area adjacent to and between said spaced pole-pieces.

4. An electrical switching device comprising an enclosing vessel, a pair of elongated conductive members sealed in one end wall of said vessel having respective portions extending within said vessel to form opposed stationary contacts and portions extending outside said vessels to form spaced pole-pieces, an armature mounted within said vessel movable between said opposed stationary contacts, a pair of permanent magnets, one of said permanent magnets being attached to one of said pole-pieces and the other permanent magnet being attached to the other of said pole-pieces whereby to establish at each of said stationary contacts respectively opposite magnetic poles, and additional means mounted outside of said vessel for controlling movement of said armature from one of said contacts to the other, said additional means including a pair of magnetic cores conductively joined to each other at their ends, an elongated magnetic member attached to said cores at one of the joined ends thereof and extending into the area adjacent to and between said spaced pole-pieces, and means for establishing opposing flux paths in said cores whereby to cause a flow of flux through said elongated magnetic member to said area.

5. An electrical switching device responsive to short control pulses in the microsecond range comprising a pair of opposed stationary contact members, a third contact member movable between said stationary contact members, a two-branch core of nonremnant magnetic material, means responsive to short control pulses in the microsecond range for establishing parallel flux paths in

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said core, and means for extending a portion of said flux paths into the area of said contact members, said last-mentioned means comprising a member of remanent magnetic material joined to said core.

6. An electrical switching device comprising a pair of opposed contact members and an armature movable therebetween sealed within an enclosing vessel, and means mounted outside said vessel for controlling the movement of said armature, said controlling means being responsive to short pulses in the microsecond range and comprising a two-branch core section of nonremnant magnetic material, an energizing winding for each core section, and a plate of remanent magnetic material joined at one end to said core sections and extending into the area of said contact members whereby to extend the pulse magnetizing effect in said core sections to said contact members.

7. An electrical switching device comprising a pair of opposed contact members and an armature movable therebetween positioned within an enclosing vessel, and means positioned outside of said vessel for controlling the movement of said armature between said contacts, said controlling means being responsive to short pulses in the microsecond range and comprising two U-shaped core sections magnetically joined to each other at their ends, means for applying control pulses to each of said core sections individually, and means effective when said core sections are magnetized in parallel for transferring the resultant flux to the area of said contact members.

8. The structure of claim 7 further characterized in that said last-mentioned means comprises a rectangular plate of remanent magnetic material joined at one end to one of the junctions of said core section with the other end extending close to said contact members.

9. An electrical switching device comprising an enclosing vessel, a pair of elongated conductive members sealed in one end wall of said vessel having respective portions extending within said vessel to form opposed stationary contacts and portions extending outside said vessel to form spaced pole-pieces, an armature mounted within said vessel movable between said opposed stationary contacts, a pair of permanent magnets, one of said permanent magnets being attached to one of said pole-pieces and the other permanent magnet being attached to the other of said pole-pieces whereby to establish at each of said stationary contacts respectively opposite magnetic poles, and additional means mounted outside of said vessel for controlling movement of said armature from one of said contacts to the other, said additional means including a pair of U-shaped magnetic cores butted together and conductively joined at their ends, a control coil on each of said cores and a rectangular plate of magnetically remanent material connected at one end to said cores at one of the joined ends thereof and with the free end extending into the area adjacent to and between said spaced pole-pieces.

10. An electrical switching device comprising an enclosing vessel, a pair of elongated conductive members sealed in one end wall of said vessel having respective portions extending within said vessel to form opposed stationary contacts and portions extending outside said vessel to form spaced pole-pieces, an armature mounted within said vessel movable between said opposed stationary contacts, a pair of permanent magnets, one of said permanent magnets being attached to one of said pole-pieces and the other permanent magnet being attached to the other of said pole-pieces whereby to establish at each of said stationary contacts respectively opposite magnetic poles, and additional means mounted outside of said vessel for controlling movement of said armature from one of said contacts to the other, said additional means including a pair of U-shaped cores of nonretentive magnetic material butted together and conductively joined at their ends, an elongated member of a material exhibiting a plurality of stable remanent mag-

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netization states connected at one end to said cores at one of the joined ends thereof and with the other end extending into the area adjacent to and between said spaced pole-pieces, and means for establishing opposed flux paths in said cores whereby to change the magnetization of said elongated member from one of said stable states to another.

11. An electrical switching device comprising an enclosing vessel, a pair of elongated conductive members sealed in one end wall of said vessel having respective portions extending within said vessel to form opposed stationary contacts and portions extending outside said vessel to form spaced pole-pieces, an armature mounted within said vessel movable between said opposed stationary contacts, a pair of permanent magnets, one of said permanent magnets being attached to one of said pole-pieces and the other permanent magnet being attached to the other of said pole-pieces whereby to establish at each of said stationary contacts respectively opposite magnetic poles, and additional means mounted outside of said vessel for controlling movement of said armature from one of said contacts to the other, said additional means including a pair of U-shaped cores of non-retentive magnetic material butted together and joined at their ends to provide a low reluctance coupling between the two cores, a control coil on each core, a rectangular plate of magnetically remanent material connected to said cores at one of the junctions thereof and extending laterally into the area adjacent to and between said spaced pole-pieces, and means to energize said control coils in parallel whereby to establish opposing flux paths in said cores and a resulting flow of flux into said rectangular plate of magnetically remanent material.

12. An electrical switching device comprising an enclosing vessel, a pair of elongated conductive members sealed in one end wall of said vessel having respective

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portions extending within said vessel to form opposed stationary contacts and portions extending outside said vessel to form spaced pole-pieces, an armature mounted within said vessel movable between said opposed stationary contacts, a pair of permanent magnets, one of said permanent magnets being attached to one of said pole-pieces and the other permanent magnet being attached to the other of said pole-pieces whereby to establish at each of said stationary contacts respectively opposite magnetic poles, and additional means mounted outside of said vessel for controlling movement of said armature from one of said contacts to the other, said additional means including a pair of U-shaped cores of non-retentive magnetic material butted together and joined at their ends to provide a low reluctance coupling of the two cores, a control coil on each of said cores, and an elongated plate member of a material exhibiting a plurality of stable remanent magnetization states connected at one of its ends to said cores at one of the joined ends thereof and with the free end extending into the area adjacent to and between said spaced pole-pieces, said additional means being effected by energization of both of said control coils in parallel but not effected by energization of one of said coils alone for changing an existing magnetization state of said plate member to a second magnetization state.

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