

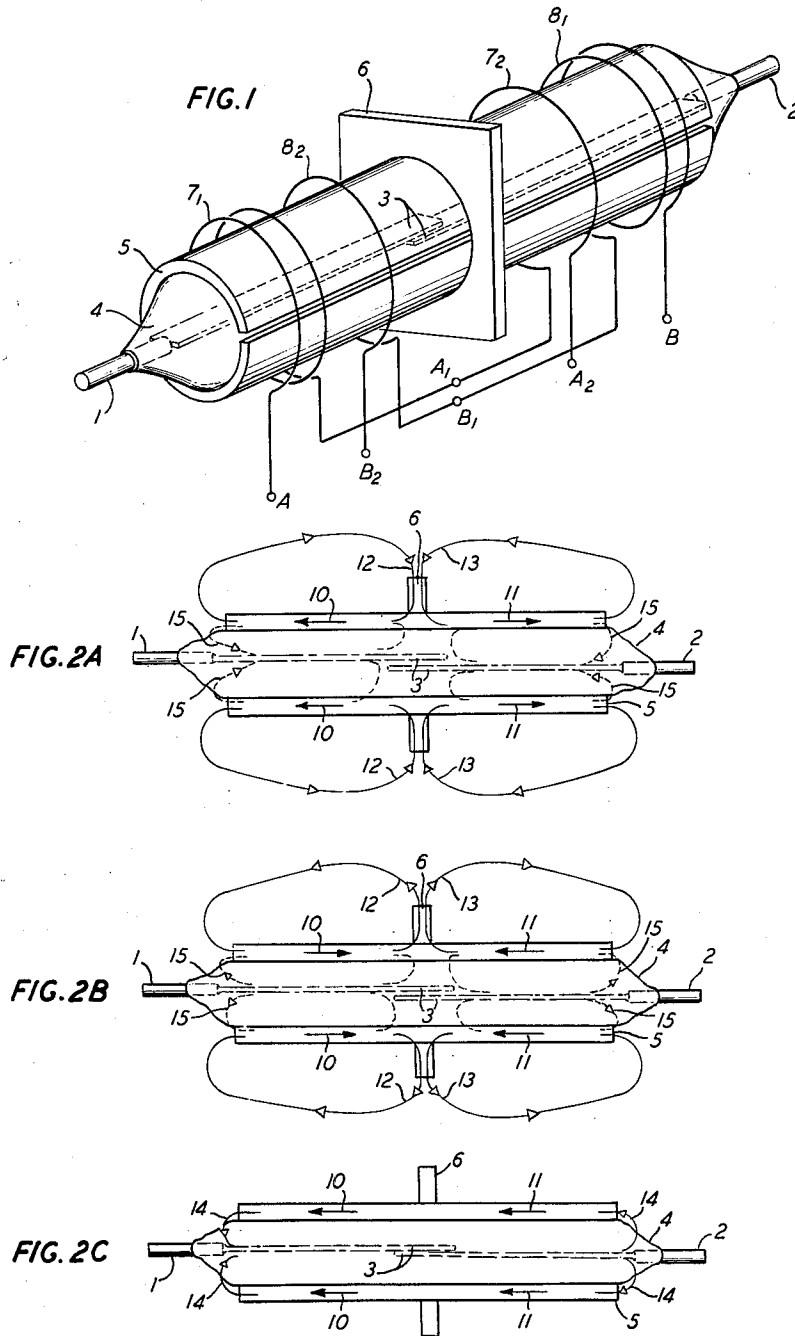
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SWITCHING DEVICE

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SWITCHING DEVICE

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This invention relates generally to switching devices and more particularly to such devices utilizing remanently magnetic members.

Where switching devices are required having the characteristics of electronic duration actuation with metallic contact operation, as, for example, in modern electronic switching systems, devices of the type disclosed in A. Feiner, C. A. Lovell, T. N. Lowry, P. G. Ridinger Patent 2,995,637 of August 8, 1961, may be employed. These devices, which have become known as ferreeds, are also described in the article "The Ferreed—A New Switching Device" by A. Feiner, C. A. Lovell, T. N. Lowry, and P. G. Ridinger at page 1 of the January, 1960, issue of the Bell System Technical Journal. Ferreeds generally comprise a remanently magnetic structure having energizing windings thereon and a sealed reed switch magnetically coupled to particular portions of the structure.

One problem that has been encountered in prior devices of this type has been the magnetic coupling between the reeds and the magnetic structure. Thus, in such devices, a considerable amount of magnetic material is needed to supply the magnetic flux necessary for the operation of the reeds. As a result, switching of the reeds has required that a heavy current be applied to the windings. The problem is thus to provide a substantial degree of magnetic coupling between the reeds and the magnetic structures without increasing the amount of magnetic material in the magnetic structure.

It is an object of our present invention to increase substantially the magnetic coupling between the contact elements and the magnetic structure of such switching devices.

Other objects of our invention are to reduce the complexity, cost and power requirements of such switching devices and to increase their utility, economy, reliability, and efficiency.

These and other objects of our invention are attained in one specific illustrative embodiment thereof which comprises a sealed reed switch of the type described in W. B. Ellwood Patent 2,289,830, July 14, 1942, surrounded by a split sleeve of remanently magnetic material with a shunt plate of highly permeable magnetic material disposed orthogonal to the axis of the sleeve and situated substantially at its longitudinal midpoint. In this manner the sleeve is closely magnetically coupled to the reeds. Wound on the sleeve are two sets of windings, each set having a winding on each side of the shunt plate.

A remanently magnetic material has the properties of high coercivity and low permeability and exhibits a plurality of stable remanent magnetization states. Accordingly, the remanent magnetization of the sleeve portions separated by and located on both sides of the shunt plate can be established independently of each other either in opposing or aiding relationship. Such independent operation of portions of a remanently magnetic member to control a ferreed is referred to as series ferreed operation and is described in the above mentioned article and in R. W. Ketchledge, C. A. Lovell Patent 3,002,066 of September 26, 1961.

In accordance with the principles of our invention, the

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remanent magnetization of particular portions of the sleeve are selectively altered to steer magnetic flux through the reeds of the switch to cause operation thereof and to selectively steer magnetic flux through the shunt plate so as to circumvent the reeds of the switch to cause release thereof. In one aspect of the invention the switch is also operated in a differential mode, that is, both sets of windings must be concurrently energized to cause operation of the reeds of the switch while energization of but one set of windings causes release of the reeds of the switch; differential operation is more fully discussed in the above mentioned article and in T. N. Lowry Patent 3,037,085 of May 29, 1962.

More specifically in accordance with our present invention, when both sets of windings are coincidentally energized, the windings generate appropriate magnetic fields to establish a longitudinal remanent magnetization in each of the two sleeve portions adjacent to the shunt. The remanent magnetization of one sleeve portion is in aiding relationship with respect to the other. As a result, a substantial amount of magnetic flux is caused to flow from the sleeve through the reeds of the enclosed switch and back to the sleeve. This induces opposite magnetic poles at the contact ends of the reeds causing their mutual attraction and subsequent closure. A small amount of magnetic flux escapes from the sleeve to the air and returns to the sleeve; this flux therefore does not flow through the reeds. This does not, however, affect in any substantial manner the operation of the reeds.

When only one of the two sets of windings is energized, the remanent magnetizations of the two sleeve portions adjacent the shunt are established longitudinally in opposing relationship. As a result, a substantial amount of magnetic flux is caused to flow from the sleeve through the magnetic shunt and back to the sleeve so as to circumvent the reeds of the switch. A small amount of magnetic flux, however, flows from the sleeve through the reeds and back to the sleeve in such a manner as to place similar magnetic poles at the contact ends of the respective reeds. Thus, the mutual repulsion caused by the similar magnetic poles at the contact ends of the reeds and the natural stiffness of the reeds cause release of the reeds.

It is a feature of our invention that a switching device comprise a remanently magnetic sleeve surrounding a pair of magnetizable contact elements with windings inductively coupled to the remanently magnetic sleeve and energizable to alter selectively the remanent magnetization of portions of the sleeve thereby to operate and release the contact elements.

Another feature of our invention is the provision of a highly permeable magnetic shunt in such a switching device and located at substantially the longitudinal midpoint of the remanently magnetic sleeve so as to provide an easy magnetic flux path from the midpoint to other parts of the sleeve.

Still another feature of our invention is such a switching device wherein the remanently magnetic sleeve is interrupted throughout its entire length by a longitudinal slit, at least one winding being inductively coupled to the sleeve on each side of the shunt to alter the longitudinal remanent magnetization of the portions of the sleeve on either side of the shunt independently so as to cause magnetic flux to flow through the contact elements thereby effecting closure of the contact elements and also to cause magnetic flux to flow through the shunt so as to circumvent the contact elements thereby permitting their release.

A complete understanding of these and other advantages and features of our invention may be gained from

a consideration of the following detailed description and the accompanying drawing, in which:

FIG. 1 depicts a pictorial view of one specific illustrative embodiment of our invention; and

FIGS. 2A, 2B, and 2C illustrate the remanent magnetizations of portions of the magnetic sleeve and the corresponding flux flow causing operation and release of the contact elements in the device of FIG. 1.

Referring now to the drawing, in FIG. 1 there is depicted one illustrative embodiment of our invention comprising a pair of magnetizable reeds 1 and 2 enclosed within an appropriate atmosphere by a glass envelope 4 and supported thereby in overlapping relationship to form contact areas 3 at the free ends of the reeds. The reeds are shown to be flat with round terminal ends, although other shapes may be employed, and are of sufficient stiffness to hold the contact areas 3 normally apart.

Surrounding the envelope 4 in accordance with our invention is a split sleeve 5 of a remanently magnetic material. The slit in the sleeve although shown to be parallel to the longitudinal axis of the sleeve, can also be arranged in other ways as, for example, in a helical manner throughout the length of the sleeve. Disposed about the sleeve at substantially its longitudinal midpoint and thus within the vicinity of the contact areas 3 of the reeds 1 and 2 is a shunt plate 6 of a highly permeable magnetic material. This shunt plate provides an easy magnetic flux path from the sleeve midpoint to the ends of the sleeve as explained in greater detail below.

Wound about the sleeve 5 on both sides of the shunt plate 6 are two sets of windings 7₁, 7₂ and 8₁ and 8₂ connected together and terminated at terminals A, A₂ and B, B₂. Each of the windings 7₁ and 8₁ has twice the number of turns of each of the windings 7₂ and 8₂, respectively, in this specific embodiment of our invention so that differential operation of the switch is attained, as discussed above and in the aforementioned Lowry disclosure.

The operation and other details of the specific embodiment depicted in FIG. 1 are best understood with reference to FIGS. 2A, 2B and 2C. These figures depict the pair of reeds 1 and 2, contact areas 3, glass envelope 4, remanently magnetic sleeve 5, and shunt plate 6 of the embodiment of FIG. 1. Superimposed on the schematic depiction of the remanently magnetic sleeve 5 are a plurality of closed arrows 10 and 11 representative of particular remanent magnetization states of corresponding sleeve portions. Similarly, superimposed upon the sleeve 5 and the shunt plate 6 are a plurality of open arrows 12, 13, 14 and 15 representative of the magnetic flux flow in the device in the released and operated states of the switch. FIGS. 2A and 2B depict the released state of the switch and FIG. 2C depicts the operated state of the switch.

To effect a released condition of the switch, either one but not both of the two sets of windings is energized. When only the set of winding 7₁ and 7₂ is energized by an energizing source, not shown, applying an appropriate pulse (such as a positive pulse) to terminal A with terminal A₂ grounded, the windings 7₁ and 7₂ generate appropriate magnetic fields such as to cause the remanent magnetization of the sleeve portions on both sides of the shunt plate 6 to be in opposition as shown in FIG. 2A by closed arrows 10 and 11. As a result, the magnetic flux is split into two flux paths depicted by open arrows 12 and 13, respectively, extending from the shunt plate 6, through the sleeve portions, through the ends of the sleeve, through the air, and back to the shunt plate 6. A small amount of magnetic flux will flow through the pair of reeds 1 and 2, as shown by the dotted lines and open arrows 15, inducing similar magnetic poles at the respective contact areas 3, but the substantial amount of magnetic flux circumvents the pair of reeds. Thus, the natural stiffness of the reeds and the similar magnetic poles induced at the contact areas 3 cause the contact areas to separate and the reeds are released. Similarly,

when the set of windings 8₁ and 8₂ is energized by an energizing source, not shown, applying an appropriate pulse (such as a positive pulse) to terminal B with terminal B₂ grounded, the windings 8₁ and 8₂ generate appropriate magnetic fields to establish the remanent magnetization of the sleeve portions to be in opposition as shown in FIG. 2B by closed arrows 10 and 11. Similarly, the magnetic flux splits into two paths depicted by open arrows 12 and 13, respectively, extending from the shunt plate 6, through the air, through the ends of the sleeve, through the sleeve portions, and back to the shunt plate 6. A small amount of magnetic flux also flows through the respective reeds, as shown by the dotted lines and open arrows 15, placing similar magnetic poles at the respective contact areas 3. Thus, when only the set of windings 8₁ and 8₂ is energized, the contact areas separate and the reeds are released.

To effect an operated state of the switch, the two sets of windings 7 and 8 are coincidentally energized by an energizing source, not shown, applying appropriate pulses (such as positive pulses) to terminals A and B, with terminals A₂ and B₂ grounded. The respective windings generate magnetic fields such that the magnetizing forces produced by windings 7₁ and 8₂ are substantially canceled by the magnetizing forces produced by windings 7₂ and 8₁, respectively, and such that the resulting magnetizing forces on both sides of the shunt plate are sufficient to alter the remanent magnetization of the sleeve portions to be in aiding relationship as shown in FIG. 2C by closed arrows 10 and 11. As a result, the magnetic flux path is changed to allow a substantial portion of the magnetic flux to flow through the sleeve 5, through the air, through reeds 1 and 2, and back to the sleeve 5 as depicted by open arrows 14. No substantial amount of magnetic flux flows through the shunt plate 6. Opposite magnetic poles are placed on the respective contacting areas 3 causing the reeds to attract so as to overcome their natural stiffness and to thereby close. The switch is thereupon held in the operated state by the opposite remanent magnetic poles at the contact areas of the respective reeds.

Although this illustrative embodiment employs a differential mode of operation it is not necessarily limited thereto. Other modes of operation may be employed; for example, bipolar (i.e., alternate positive and negative polarities) pulsing may be used to cause operation and release of the switch. In this event, a released condition of the switch will, as discussed above, be effected by a pulse of one polarity being applied to terminal A with terminal A₂ grounded so as to cause the remanent magnetization of the sleeve portions to be established in opposing directions as shown by closed arrows 10 and 11 of FIG. 2A. To effect operation of the switch, an appropriate pulse of opposite polarity will be applied to point A₁ with terminals A and A₂ grounded. The remanent magnetization of the left sleeve portion remains the same and the remanent magnetization of the right sleeve portion is altered as shown in FIG. 2C by closed arrows 11. As a result, the magnetic flux path will be changed to permit magnetic flux to flow through the reeds causing opposite magnetic poles to be induced at the respective contact areas 3 thereof. The reeds will attract and thereby close. Similarly, release and operation of the switch may also be effected by using only windings 8₁ and 8₂. It is apparent that a plurality of pairs of magnetizable reeds enclosed within a single or multiple envelopes may be placed within the remanently magnetic sleeve 5 such that a plurality of transmission paths would be simultaneously operated or released.

Although in the preferred embodiment, we have shown a discontinuity or split in the sleeve, devices which do not embody this feature can nevertheless be successfully employed. The split in the sleeve acts to reduce any eddy current that may be caused when the sleeve is being magnetized. As is well known, eddy currents may tend

to delay or hinder the magnetization of the sleeve. Thus, in the preferred embodiment, advantageously, we can reduce both the amount of power required to magnetize the sleeve portions and the amount of time required to switch the remanences thereof.

It is to be understood that the above described embodiment is illustrative of the principles of our invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of our invention.

What is claimed is:

1. A switching device comprising a plurality of magnetizable contact elements arranged in operable relationship to each other, a remanently magnetic sleeve disposed substantially about and magnetically coupled to said plurality of contact elements, magnetic shunt means coupled to a part of said sleeve for providing a magnetic flux path extending from said sleeve part to another part of said sleeve, and means comprising a plurality of energizable windings wound about particular portions of said sleeve for selectively altering the remanent magnetization of said sleeve portions to steer magnetic flux through said contact elements thereby causing operation thereof and to steer said magnetic flux through said magnetic shunt means bypassing said contact elements thereby causing release thereof.

2. The invention described in claim 1 wherein said magnetic sleeve is electrically interrupted throughout its entire length.

3. A switching device comprising at least two magnetizable contact elements arranged in overlapping relationship, a cylindrical sleeve of remanently magnetic material enclosing and magnetically coupling said contact elements, magnetic shunt means magnetically coupled to a particular part of said cylinder for providing an easy magnetic flux path extending from said particular part of said cylinder to other parts of said cylinder, means including a pair of energizable windings wound about respective portions of said cylinder for altering the remanent magnetization of said cylinder portions to induce opposite magnetic poles at said other cylinder parts thereby enabling magnetic flux to flow through said contact elements and causing closure thereof and to induce similar magnetic poles at said other cylinder parts thereby enabling magnetic flux to flow through said shunt means circumventing said contact elements and causing release thereof.

4. The invention described in claim 3 wherein said sleeve defines a slit extending throughout its axial length and wherein respective said contact elements are magnetically coupled to said respective parts of said cylinder.

5. A switching device comprising a pair of magnetizable contact elements arranged in overlapping relationship, a remanently magnetic sleeve surrounding said pair of contact elements and magnetically coupling said pair of contact elements, said magnetic sleeve being electrically interrupted throughout its entire length, magnetic plate means disposed about a part of said sleeve and within substantial vicinity of the overlapping ends of said contact elements for providing a magnetic flux path extending from said sleeve part to the ends of said sleeve, and energizable means disposed on both sides of said plate

means and inductively coupled to portions of said sleeve for selectively establishing particular remanent magnetizations at said portions to cause magnetic flux to flow through said contact elements thereby enabling operation thereof and to cause magnetic flux to flow through said plate means away from said contact elements thereby enabling release thereof.

6. A switching device comprising a pair of magnetizable reeds having cooperating contact areas and sealed in a vessel, a cylindrical split sleeve of remanently magnetic material substantially covering the length of said reeds, said pair of reeds magnetically coupled to particular respective parts of said sleeve, a magnetic shunt disposed about a part of said sleeve orthogonal to the axis of said sleeve and situated substantially at said contact area of said reeds, said magnetic shunt magnetically coupled to said sleeve to provide a magnetic flux path extending from said sleeve part to other parts of said sleeve substantially near the ends of said vessel, and at least two windings inductively coupled to portions of said sleeve on opposite sides of said plate energizable to selectively alter the remanent magnetization of said sleeve portions directly under said windings to effect closure and release of said reeds.

7. The invention described in claim 6 wherein said magnetizable reeds are flat reeds situated parallel to each other and forming overlapping contact areas at the free ends thereof and wherein said vessel comprises a vitrified material and is of a circular cylindrical shape with its axis coextensive with the said pair of reeds and wherein said cylindrical sleeve is a circular cylinder substantially covering said vessel and said pair of reeds and defining a split parallel to the axis of said cylinder and throughout the entire length of the said circular cylindrical sleeve, and further comprising two sets of windings, each set of windings having one winding on each side of the said shunt connected to each other with one winding of each set of windings having twice the number of turns as the winding of the other set on the same side of the said shunt whereby concurrent energization of both sets of windings causes magnetic field cancellations such as to alter the axial remanent magnetization of the sleeve portions on both sides of the said shunt to be in aiding relationship thereby causing magnetic flux to flow through the said pair of reeds to effect their closure and whereby energization of one of said sets of windings generates magnetic fields such as to alter the axial remanent magnetization of both said sleeve portions to be in opposing relationship thereby causing magnetic flux to flow through the said magnetic shunt circumventing the said pair of reeds to effect their release.

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