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Kato et al.

[11] **3,928,828**

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[54] **CROSSPOINT ELEMENTS AND ELECTROMAGNETIC COORDINATE SELECTION DEVICES UTILIZING THE SAME**

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[21] Appl. No.: **549,193**

[30] **Foreign Application Priority Data**

Apr. 30, 1974 Japan 49-48555

[52] **U.S. Cl.** **335/112;** 335/151; 335/196

[51] **Int. Cl.**^{2} **H01H 67/30**

[58] **Field of Search** 335/151, 152, 154, 196, 335/153, 265, 112

[56] **References Cited**

UNITED STATES PATENTS

3,377,576 4/1968 Langberg et al. 335/196

3,431,519 3/1969 Giichi Ito et al. 335/112

Primary Examiner—Harold Broome

Attorney, Agent, or Firm—Charles E. Pfund, Esq.

[57] **ABSTRACT**

The crosspoint element comprises a reed switch comprising a pair of reed pieces having cooperating contacts and an exciting winding for operating the contacts. Each reed piece comprises a core conductor of a first magnetic material and a sheath made of a second magnetic metal having different coercive force from that of the first magnetic metal. When a release pulse current is passed through the exciting winding, the crosspoint elements permit a large permissible variation in the peak value of the magnetomotive force required for holding the reed piece at a definite state of mangetization. The crosspoint element is especially suitable to use as a selection element of an electromagnetic coordinate selection device.

9 Claims, 10 Drawing Figures

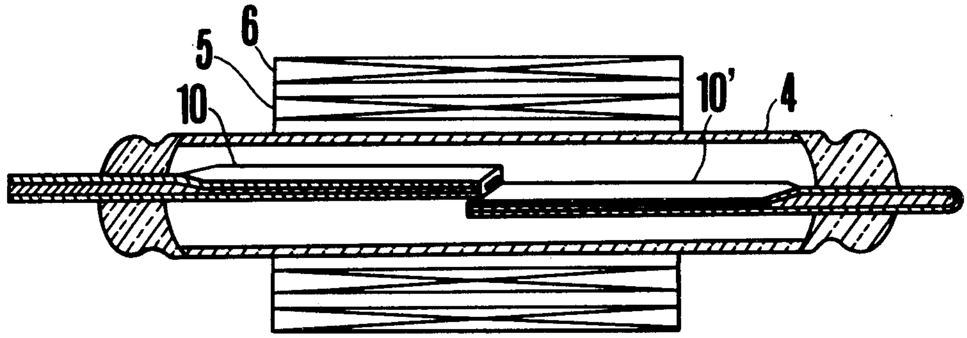


FIG.1

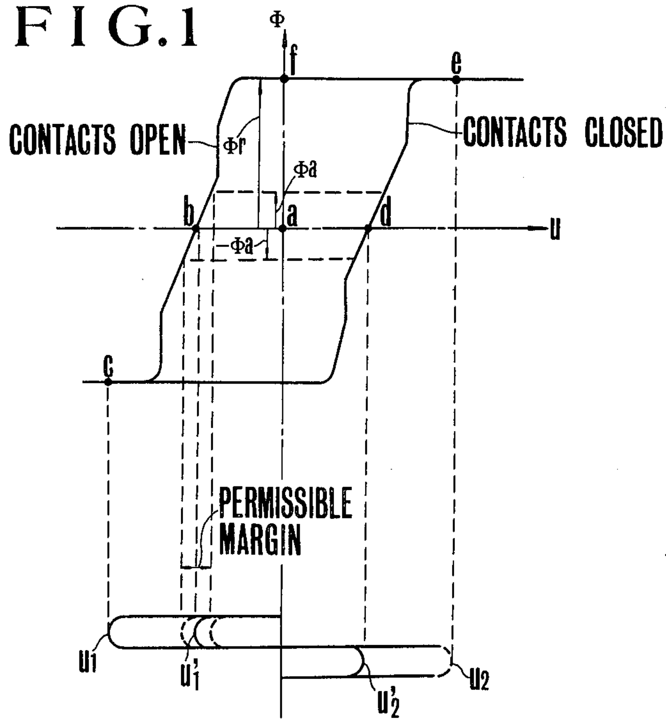


FIG.2A

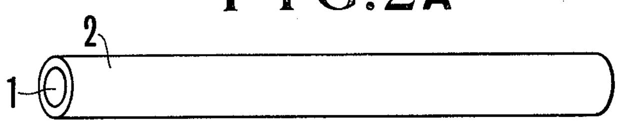


FIG.2B

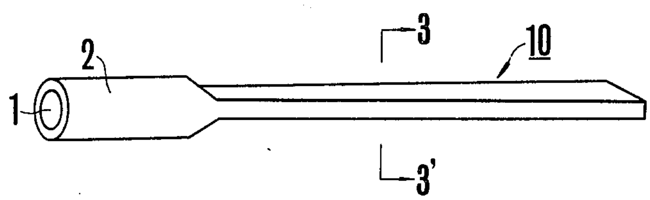


FIG.3

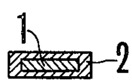


FIG.4

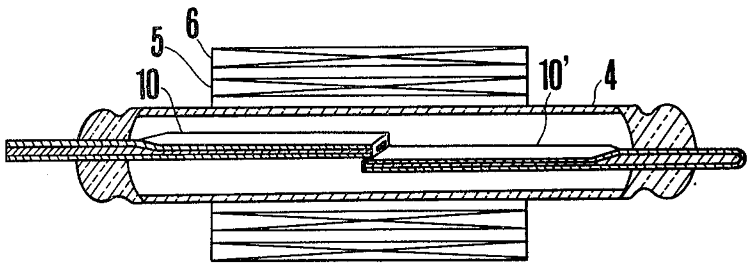
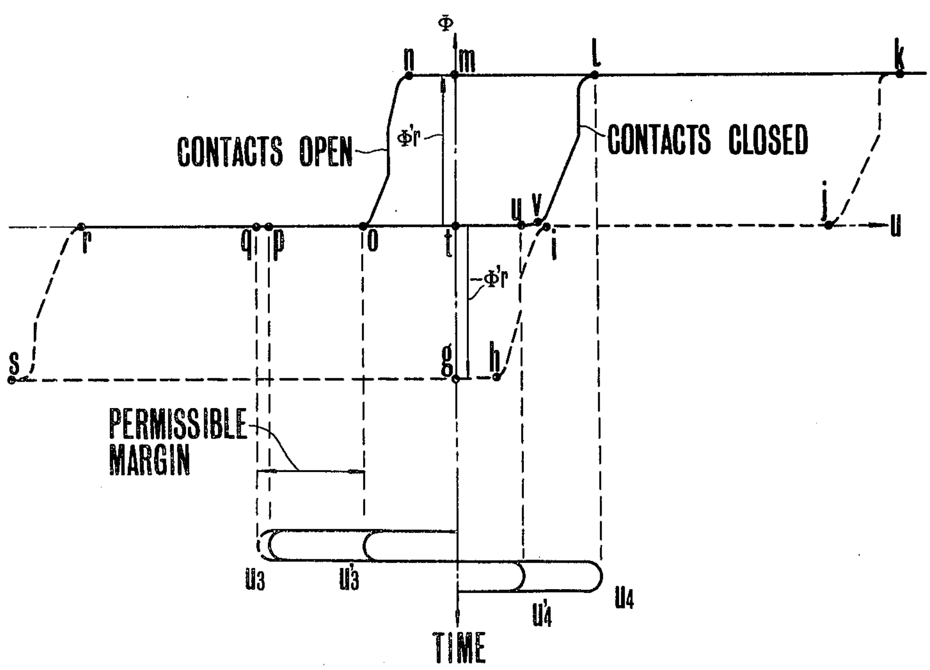

6
5
10
10'
4

FIG.5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TIME

FIG.6

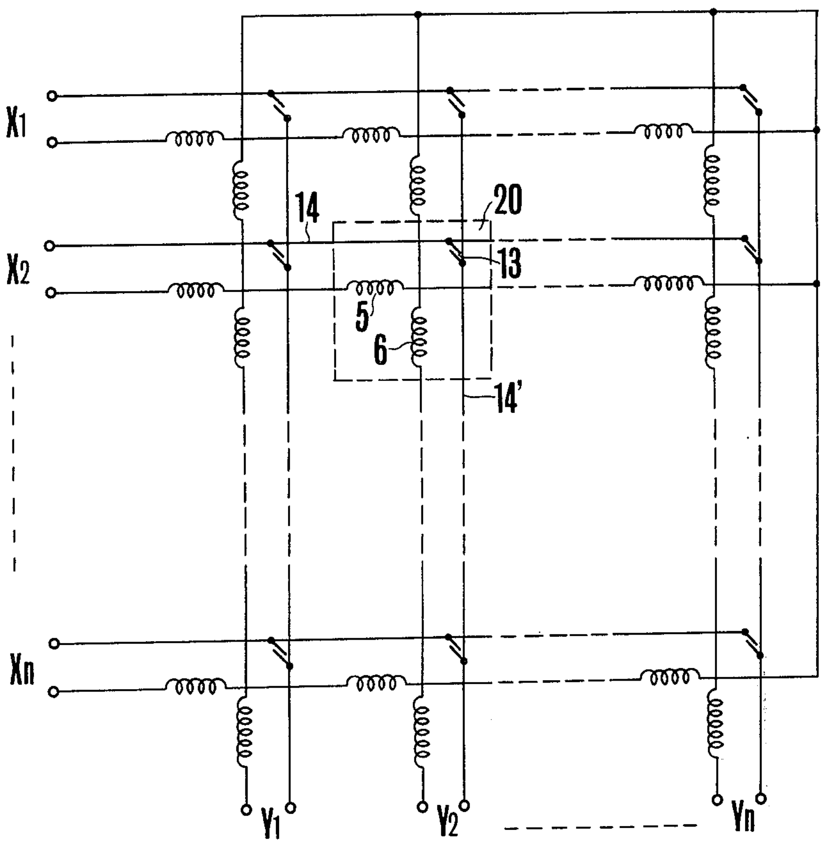


FIG.7

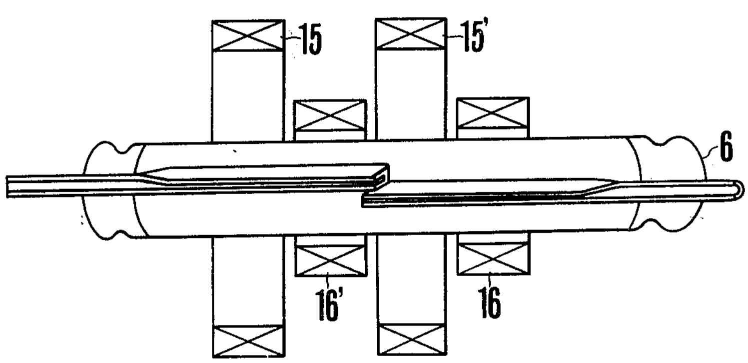


FIG.8A

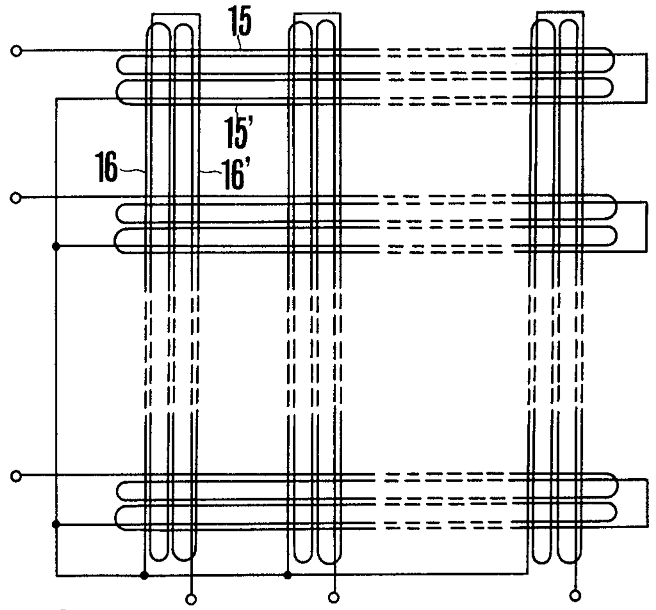
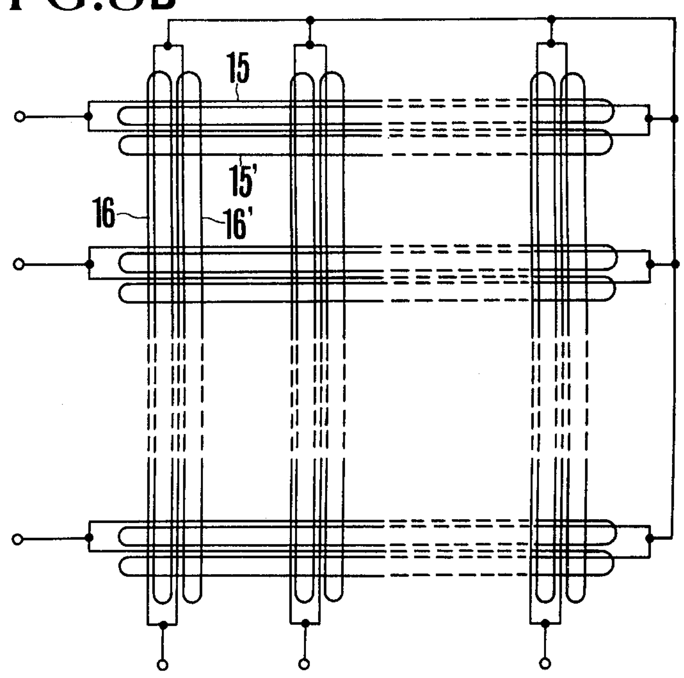


FIG.8B



CROSSPOINT ELEMENTS AND ELECTROMAGNETIC COORDINATE SELECTION DEVICES UTILIZING THE SAME

BACKGROUND OF THE INVENTION

This invention relates to novel crosspoint elements and an electromagnetic coordinate selection device utilizing such elements.

As is well known in the art, in a space division type telephone exchange, crosspoint elements are located at respective crosspoints between signal conductors arranged in the direction of rows and columns in the form of a matrix and the signal conductors are selected by rendering ON and OFF these crosspoint elements.

The crosspoint element utilized in the electromagnetic coordinate selection device of the type referred to above comprises a so-called magnetic reed switch provided with an exciting coil. A conventional self-hold type reed switch comprises two reed pieces of semi-permanent magnetic metal which are sealed in a glass envelope in which is sealed inert gas with their confronting ends spaced apart a short distance to act as contact. A row winding and a column winding having a turn ratio of 1:1 are wound about the envelope of the reed switch, thereby completing a crosspoint element.

FIG. 1 shows the magnetization characteristics of the reed piece for explaining the operation of a prior art crosspoint element, which show the relationships between the magnetomotive force U produced by passing current through the windings of the crosspoint element and the magnetic flux Φ across the opposing ends of the reed pieces that comprise contacts, and between the magnetomotive forces created by positive and negative current pulses impressed across the windings and time. The magnetomotive force created by consecutively passing a negative release current pulse and a positive operating current pulse through the row winding and the column winding of a crosspoint element constructed as above described in such a manner that the magnetomotive forces created by both windings add each other has a negative peak value U_1 and a positive peak value U_2. Due to the magnetomotive force created by both windings the magnetization of the reed pieces varies along a path $a \rightarrow b \rightarrow c \rightarrow d \rightarrow e \rightarrow f$ or a path $f \rightarrow b \rightarrow c \rightarrow d \rightarrow e \rightarrow f$, and the contacts of the reed switch are closed and maintained in the closed state by the magnetic attractive force due to the residual magnetic flux at point f. On the other hand, the magnetomotive force created by consecutively passing a negative release current and a positive operating current pulse through only one row winding or column winding has a negative peak value U'_1 and a positive peak value U'_2. Peak values U'_1 and U'_2 have values of about one half of said peak values U_1 and U_2, respectively so that the magnetization of the reed pieces will vary along a path $f \rightarrow b \rightarrow a \rightarrow d \rightarrow a$ or a path $a \rightarrow b \rightarrow a \rightarrow d \rightarrow a$, thus reducing the residual magnetic flux to substantially zero. As a result, the contacts of the reed switch are opened by the resilient restoring force of the reed pieces. In this manner, a signal conductor is selected by the ON and OFF operations of the contacts.

In the actual operation of the prior art cross-point element described above, the absolute value of the peak value U'_1 of the magnetomotive force may be a value that can assure a residual magnetic flux less than a maximum allowable flux Φa for opening the contacts but as can be noted from FIG. 1 the amount of allowable variation in the peak value of the magnetomotive force caused by the application of the release current pulse across the winding is small. Consequently, it is necessary to use a source voltage, winding resistance and a wiring resistance, each having a small variation for an electromagnetic coordinate selection device of the magnetically self-holding type which utilizes such crosspoint elements, whereby limits are imposed upon the design and manufacture of the source and the electromagnetic coordinate selection device.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide an improved crosspoint element which has a large permissible margin of the absolute value of the magneto-motive force required for maintaining the state of magnetization when a release current pulse is passed through the exciting winding and which can be readily incorporated in the electromagnetic coordinate selection device.

Another object of this invention is to provide an improved electromagnetic coordinate selection device of simple construction but can provide an accurate selection irrespective of a certain variation in the source voltage and the resistance of the winding.

Further objects will become apparent as the description of the preferred embodiment proceeds.

According to this invention, the crosspoint element comprises a reed switch including a pair of reed pieces having cooperating contacts and sealed in a glass envelope and a row winding and a column winding surrounding the glass envelope for operating the contacts. Each reed piece comprises a core conductor made of a first semipermanent magnetic metal and a sheath surrounding the core conductor and made of a second semipermanent magnetic metal having different coercive force from that of the first magnetic metal.

According to another aspect of this invention there is provided a crosspoint element comprising a reed switch including a glass envelope, a pair of reed pieces having cooperating contacts and sealed to the glass envelope, a row and column windings surrounding the glass envelope, the row and column windings being respectively divided into a plurality of sections which are interleaved each other along the axis of the envelope.

There is also provided an electromagnetic coordinate selection device of the type comprising a plurality of row signal conductors and a plurality of column signal conductors which are arranged in a matrix, and a plurality of reed switches respectively disposed at the crosspoints between the row and column signal conductors for interconnecting corresponding signal conductors, each switch comprising a pair of reed pieces having cooperating contacts, a row winding and a column winding which operate cumulatively for operating the contacts, characterized in that each reed piece comprises a core conductor of a first magnetic metal and a sheath surrounding the core conductor and made of a second magnetic metal, and that the first and second magnetic metals have different coercive force.

In a modification of the electromagnetic coordinate selection device just described, the column winding is divided into two sections for each row which are wound in common for the reed switches in respective rows, and the column winding is also divided into two sections for each column which are wound in common for the reed switches in respective columns, the two sections of the row and column windings being interleaved each other.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a graph useful to explain the operation of a prior art crosspoint element;

FIGS. 2A and 2B are perspective views to show different steps of manufacturing a reed piece to be employed in the novel crosspoint element of this invention;

FIG. 3 shows a cross-sectional view of the reed piece shown in FIG. 2B taken along a line 3—3;

FIG. 4 is a longitudinal sectional view of one embodiment of the crosspoint element embodying the invention;

FIG. 5 shows magnetic characteristics of a reed piece for explaining the operation of the crosspoint element embodying the invention;

FIG. 6 shows one example of the connection diagram of an electromagnetic coordinate selection device utilizing the novel crosspoint elements of this invention;

FIG. 7 is a longitudinal sectional view showing a modified crosspoint element of this invention; and

FIGS. 8A and 8B are connection diagrams of the windings of two types of electromagnetic coordinate selection devices utilizing the crosspoint elements shown in FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 2A, 2B and 3, there are shown a reed piece to be used in the crosspoint element of this invention and steps of manufacturing the reed piece. To prepare a reed piece utilized in this invention, as shown in FIG. 2A, about a core conductor 1 having a definite coercive force and made of semipermanent magnetic metal for example, is formed a sheath 2 having substantially the same saturation flux as said magnetic metal, for example semipermanent magnetic material. The magnetic metal comprising the conductor 1 may be an alloy consisting of 48% of iron, 49% of cobalt, and 3% of vanadium or a magnetic alloy consisting of 81.7% of iron, 14.5% of nickel, 2.4% of aluminum, 1.0% of titamium and 0.4% of manganese. The magnetic metal comprising the outer sheath 2 may be a magnetic alloy consisting of 42% of iron, 49% of cobalt, and 9% of vanadium or a magnetic alloy consisting of 74.8% of iron, 20% of nickel, 3.8% of aluminum, 1.0% of titanium and 0.4% of manganese. The magnetic metal for the core conductor 1 has a coercive force of about 30 oersted whereas the magnetic metal for the outer sheath 2 has a coercive force of higher than 100 oersted. Furthermore, for the purpose of substantially equalizing the saturation fluxes of these two types of magnetic metals, the cross-sectional areas of the conductor 1 and of the outer sheath 2 are made to be substantially equal.

The composite magnetic material shown in FIG. 2A is then flattened as shown in FIG. 2B to form a reed piece 10 to be utilized in this invention. Two reed pieces 10 and 10′ prepared in this manner are sealed in a glass envelope 4 containing inert gas and the flattened ends of the reed pieces are disposed to oppose with each other with a definite gap therebetween thus forming contacts. In the same manner as in the conventional reed switch, the contacts are plated with a suitable contact metal. The portions of the reed pieces 10 and 10′ that extend through the glass envelope are not flattened for the purpose of improving the air tight seal between them. As shown in FIG. 4, cumulative windings consisting of a row winding 5 and a column winding 6 are wound about the glass envelope, said windings having a turn ratio of 1:1.

FIG. 5 shows the magnitization characteristics of a crosspoint element utilizing reed pieces comprising coaxial and integrated semipermanent magnetic metals having different coercive forces. The curves shown in FIG. 5 show the relationship between the magnetomotive force U created by passing current through the windings and the flux Φ across the gap or contacts between reed pieces 10 and 10′ and the relationship between the magnetomotive forces created by passing positive and negative current pulses through the windings and the time. The operation of the crosspoint element shown in FIG. 4 will now be described with reference to FIG. 5. It should be understood that FIG. 5 shows the magnetization characteristics where the magnetic metal comprising the core conductor 1 has lower coercive force than the magnetic metal comprising the outer sheath 2. Suppose now that, under a state of magnetization at point of where negative residual flux $-\Phi'r$ presents, a positive current pulse is passed through at least one of the row winding 5 and the column winding 6 thus increasing the residual flux, the reversal of the magnetization of the magnetic metal having smaller coercive force occurs at point h and the state of magnetization proceeds to a point *i*. As the current is increased further, the reversal of the magnetization of the magnetic metal having higher coercive force occurs at point *j* and the state of magnetization proceeds to point *k*. When the current is then decreased the state of magnetization moves to a point m of the residual flux $\Phi'r$ through a point *l*. In the same manner, as a negative current is passed, the state of magnetization moves along a path $m \to n \to o \to p \to q \to r \to s$. When the negative current is removed at any state of magnetization between point *o* at which the magnetic reversal of the magnetic metal comprising the conductor 1 terminates and point *r* at which the magnetic reversal of the magnetic metal comprising the outer sheath 2 commences, the state of magnetization will move to point *t* at which the residual flux is substantially zero. When the negative current is reapplied the state of magnetization moves along a path $t \to o \to p \to q \to r \to s$. If positive current is applied at pont t, the magnetization will move along a path $t \to u \to v \to l \to k$.

More particularly, the magnetomotive force created by consecutively passing a negative release current pulse and a positive operating current pulse through both row winding 5 and column winding 6 such that they produce cumulative magnetomotive forces has a negative peak value U_3 and a positive peak value U_4. Due to these peak values U_3 and U_4, the state of magnetization moves along a path $m \to n \to o \to p \to o \to t \to u \to v \to l \to m$ or a path $t \to o \to p \to o \to t \to u \to v \to l \to m$ so that the contacts of the crosspoint element are held open by the magnetic attraction caused by the residual flux $\Phi'r$ at point *m*. On the other hand, when a negative release current pulse and a positive operating current pulse are consecutively passed through only the row winding 5 or the column winding 6, the resulting magnetomotive force will have a negative peak value U'_3 and a positive peak value U'_4 which are about one half of said peak values

U_3 and U_4, respectively. Where the contacts are closed by these peak values U'_3 and U'_4, the state of magnetization moves along a path $m \rightarrow n \rightarrow o \rightarrow t \rightarrow u \rightarrow t$, whereas when the contacts are opened the state of magnetization moves along a path $t \rightarrow o \rightarrow t \rightarrow u \rightarrow t$, so that the residual flux is reduced to substantially zero with the result that the contact is opened by the spring force of the reed pieces **10** and **10'**.

While in the foregoing description it was assumed that the magnetic metals comprising the core conductor **1** and the outer sheath **2**, respectively have substantially the same saturation fluxes, any magnetic metals could be used provided that the difference of the saturation fluxes is less than the permissible maximum flux for opening the contacts. Furthermore, the negative peak value U_3 of the magnetomotive force produced by consecutively passing the negative release current pulse and the positive operating current pulse such that the magnetomotive forces produced by the row and column windings will be cumulative should be smaller than the coercive force at point r. Accordingly, the permissible variation in the negative peak value produced by the negative release current pulse applied to one winding lies between points o and q having a value approximately one half of the coercive force at point r. As can be clearly noted from FIG. **5** it is possible to make large the permissible variation of the magnetomotive force produced by applying the release current pulse upon the winding as the difference in the coercive forces of the two magnetic metals is increased.

FIG. **6** shows the connection diagram of one example of a novel electromagnetic coordination selection device utilizing the crosspoint elements shown in FIG. **4.** As shown, the selection device comprises a plurality of crosspoint elements **20** each disposed at one of the crosspoints between a plurality of row conductors $x_1, x_2 \ldots x_n$ and a plurality of column conductors $y_1, y_2 \ldots y_n$, and comprises a row winding **5** and column winding **6** which are wound about a glass envelope as shown in FIG. **3,** and contacts **13** connected between a row signal conductor **14** and a column signal conductor **14'** respectively. In the arrangement shown in FIG. **6,** when a release current pulse and an operating current pulse are consecutively passed through the windings of any row and columns, for example row x_2 and column y_2, among all crosspoints between row x_2 and column y_2, only the crosspoint element at the coordinate (x_2, y_2) is selected for closing its contacts. Accordingly, the signal path established at this time extends between an input terminal, for example x_2, and an output terminal, for example y_2, through row and column conductors and the closed contacts of a crosspoint element.

FIG. **7** shows a longitudinal section of a modified crosspoint element of this invention which is similar to that shown in FIG. **4** except the construction of exciting windings. Thus, windings **15** and **15'** are wound in common about all crosspoint elements in the direction of rows thus constituting row windings, whereas windings **16** and **16'** are wound in common about all crosspoint elements in the direction of columns thus constituting column windings. Coils **15, 15'** and **16** and **16'** are interleaved along the longitudinal direction of the crosspoint elements and are disposed symmetrically with respect to the axes of the crosspoint elements. Although the crosspoint elements shown in FIG. **7** operate in the same manner as that shown in FIG. **4** they make easier the fabrication of the electromagnetic coordinate selection device and improve the space factor thereof.

FIGS. **8A** and **8B** shown connection diagrams of the row windings and the column windings, respectively of a novel electromagnetic coordinate selection device utilizing a plurality of crosspoint elements shown in FIG. **7.** In FIG. **8A,** the row windings **15** and **15'** and the column windings of the crosspoint elements are connected in series respectively, whereas in FIG. **8B,** these windings are connected in parallel respectively.

Although in the illustrated examples of the electromagnetic coordinate selection devices, one reed switch has been provided for each crosspoint, it will be clear that a plurality of crosspoint elements may be provided for each crosspoint and that row signal conductors and column signal conductors corresponding to each crosspoint element may be used, thereby enabling to select a plurality of signal circuits.

It should be understood that the invention is not limited to the specific embodiments illustrated and that many changes and modifications may be made without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In a crosspoint element of the class comprising a glass envelope, a pair of reed pieces sealed in said envelope and having cooperating contacts, and an exciting winding surrounding said envelope for operating said contacts, the improvement wherein each one of said reed pieces comprises a core conductor of a first magnetic metal and a sheath made of a second magnetic metal and coaxially surrounding said core conductor, said first and second magnetic metals having different coercive force.

2. The crosspoint element according to claim **1** wherein the difference in the saturation fluxes of said first and second magnetic metals is smaller than the maximum permissible flux for opening the contacts of the reed pieces.

3. The crosspoint element according to claim **1** wherein the portion of each reed piece contained in said glass envelope is flattened.

4. The crosspoint element according to claim **1** wherein the cross-sectional areas of said core conductor and said sheath are substantially equal.

5. The crosspoint element according to claim **1** wherein said exciting winding comprises a row winding and a column winding which are adapted to be connected in row and column conductors, respectively, of a matrix circuit.

6. The crosspoint element according to claim **5** wherein said row and column windings are wound concentrically about said glass envelope.

7. The crosspoint element according to claim **5** wherein each of said row and column windings are divided into two sections, and the sections of the row and column windings are interleaved each other along the axis of said glass envelope.

8. An electromagnetic coordinate selection device comprising a plurality of row signal conductors and a plurality of column signal conductors which are arranged in a matrix, and a plurality of reed switches respectively disposed at the crosspoints between said row and column signal conductors for interconnecting corresponding signal conductors, each reed switch comprising a pair of reed pieces having cooperating contacts, a row winding and a column winding which operate cumulatively for operating said contacts, each reed piece comprising a core conductor of a first magnetic metal and a sheath surrounding said core conductor and made of a second magnetic metal, said first and second magnetic metals having different coercive force.

9. The electromagnetic coordinate selection device according to claim **8** wherein said column winding is divided into two sections for each row which are wound

in common for the reed switches in respective rows, and wherein said column winding is divided into two sections for each column which are wound in common for the reed switches in respective columns, the two sections of said row and column windings being interleaved each other.

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