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SWITCHING MATRIX HAVING SEALED SWITCHES OPERATING AS A NORMALLY CLOSED SWITCH MATRIX OR AS A NORMALLY OPEN SWITCH MATRIX

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Fig. 1

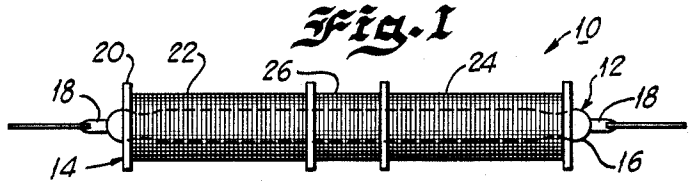


Fig. 2

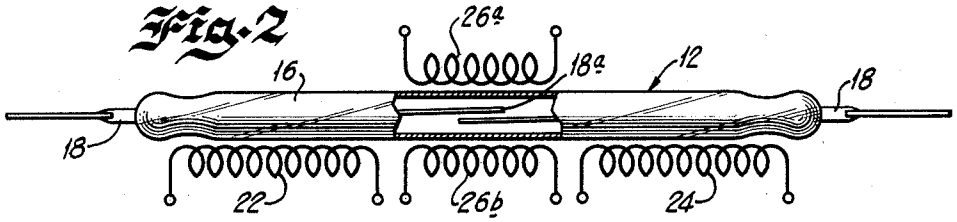


Fig. 3

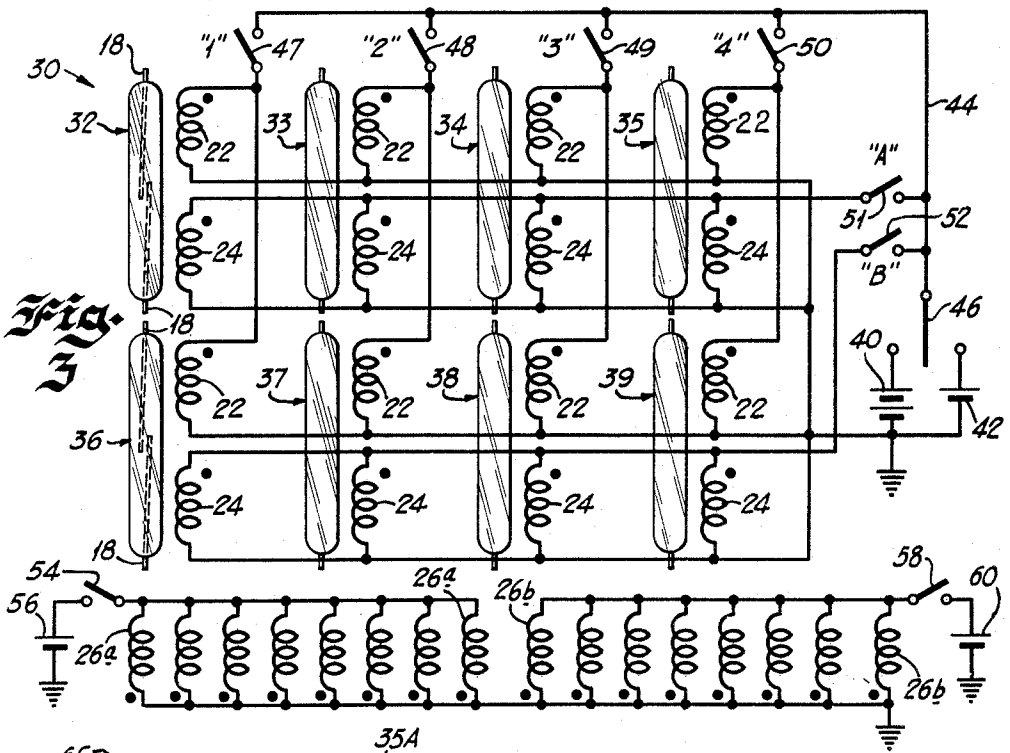
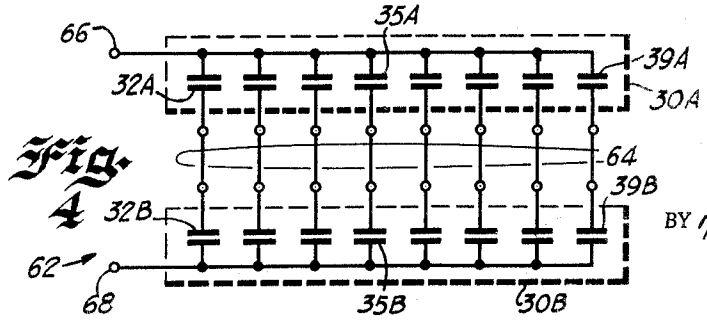


Fig. 4



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SWITCHING MATRIX HAVING SEALED SWITCHES OPERATING AS A NORMALLY CLOSED SWITCH MATRIX OR AS A NORMALLY OPEN SWITCH MATRIX

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This invention relates to a switching assembly and, more particularly, to a matrix using a plurality of magnetic sealed switch units.

Matrix circuits are used in many different types of communication and data handling systems for performing such functions as decoding signals or establishing switching paths. Most of these circuits are two coordinate matrices in which the coincidence of signals applied to a given row input and a given column input results in the closure of the desired crosspoint. These matrix circuits can be constructed in many different forms using controlled conduction devices or mechanically actuated contacts as the crosspoint elements. A number of different types of switching matrices have also been made using sealed magnetic reed switches as the crosspoints. In these circuits, each sealed switch is provided with at least a pair of windings, one of which is energized under the control of the row input signal and the other of which is energized under the control of the column input signal. The coincident energization of the two windings on one of the crosspoint switches produces a resultant flux in the switch that is sufficient to operate it and close the crosspoint. In some applications, holding means, such as a permanent magnet, are provided for retaining the crosspoint in a closed condition when the row and column input signals are removed.

In many circuit applications, it would be desirable to have a matrix circuit using sealed magnetic switches that is capable of operating in two different modes. In a first one of these modes, a selected crosspoint or sealed switch is operated from its normally open condition to a closed condition by the row and column input information. In a second or normally closed mode, the matrix crosspoints are all normally held in a closed condition, and the input row and column information opens a selected crosspoint by releasing a selected one of the switches. The known matrices using sealed magnetic switches do not operate in these two modes.

Accordingly, one object of the present invention is to provide a new and improved switching assembly.

Another object is to provide a matrix of sealed magnetic switches operable in two different modes in which the crosspoint switches are either normally open or normally closed.

A further object is to provide a matrix circuit of sealed magnetic switches including new and improved means for operating the matrix in a selected one of two different modes.

A further object is to provide a switching matrix of sealed magnetic switches in which the switch crosspoints are normally held in a closed condition and are selectively opened by coordinately applied control signals.

In accordance with these and many other objects, a switching matrix embodying the invention uses a magnetic sealed switch unit as the crosspoint element. The magnetic sealed switch unit comprises an elongated dielectric housing enclosing a pair of magnetic elements having generally centrally disposed overlapping portions that are moved into engagement with each other to complete a conductive circuit through the switch in response to an applied field of a first strength or value. These elements,

following engagement, are held in engagement by the application of an applied flux field of a second value less than the first value. Each sealed switch crosspoint element is operated by a winding assembly including identical first and second windings each disposed adjacent one of the magnetic elements and a third winding including a pair of coils which are interposed between the first and second windings centered over the overlapping portions of the magnetic elements. The third winding means provides a field of opposite polarity to that provided by the first and second windings.

In the switching matrix, the first and second winding means on the plurality of crosspoint switches are interconnected with suitable row and column input means in the usual manner to provide a two coordinate matrix. When this matrix is to be operated in the first or normally open crosspoint mode, one row input and one column input are energized so that the first and second winding means in the related row and column are energized to provide a flux field of approximately half of the first or operate value. Thus, in only the single sealed switch in which both the first and second winding means are energized, the flux field applied to the magnetic elements is equal to the first value and results in the closure of the switch or crosspoint.

When the switching matrix is to be operated in its second or normally closed crosspoint mode, the two coils in all of the third winding means are momentarily energized to apply a flux field of the first value to the magnetic elements in all of the sealed switches, thereby closing all of the crosspoints in the matrix. The energization of one of the coils in each of the third winding means is then deenergized so that the remaining energized coil applies a holding flux less than said first value and greater than said second value to maintain all of the sealed switches in a closed condition. The potential of the row and column input signals is then reduced so that when first and second winding means are supplied with row and column input signals in the manner described above, the first and second windings only provide flux fields on the order of one quarter of the first value. Since these two winding means provide flux fields of an opposite polarity to that provided by the single energized coil in the third winding means, the resultant flux field applied to the magnetic elements in only the selected crosspoint is reduced to less than the second value to cause the release of this switch or the opening of the crosspoint. The remaining crosspoints in the matrix remain in a closed condition because in even those sealed switches in which either the first or the second winding means is energized, the resultant flux is greater than the second value.

The switching matrix can be restored to its normal condition by again momentarily energizing the second coil in each of the third winding means so that all of the crosspoints are closed. Further, the switching matrix can be returned to a condition for operation in the first or normally open crosspoint mode by terminating the energization of the third winding means and by restoring the row and column input potential to the higher value used in the first mode.

Many other objects and advantages of the present invention will become apparent from considering the following detailed description in conjunction with the drawings in which:

FIG. 1 is an elevational view of a sealed switch assembly used as a crosspoint element in a switching matrix embodying the present invention;

FIG. 2 is an enlarged schematic view of the crosspoint element shown in FIG. 1;

FIG. 3 is a schematic diagram of a switching matrix embodying the present invention; and

FIG. 4 is a schematic diagram of a test circuit using two switching matrices of the present invention.

Referring now more specifically to FIGS. 1 and 2 of the drawings, therein is shown a switching assembly, indicated generally as 10, which can be used as a crosspoint element in the switching matrix embodying the present invention. The switching assembly 10 includes a sealed magnetic switch, indicated generally as 12, that is disposed within the axial opening of a winding assembly indicated generally as 14. The sealed switch unit 12 can be of any of the types well known in the art but preferably comprises a magnetic reed switch having an elongated dielectric envelope 16 from the opposite ends of which a pair of magnetic terminals 18 extend. The magnetic terminals 18 are provided with inner overlapping portions 18*a* that are normally maintained in a spaced position from each other so that the sealed switch unit 12 does not provide a conductive circuit between the terminals 18. However, when a flux field of a given value, such as 100 NI, is applied to the magnetic elements 18, the overlapping end portions 18*a* are moved into engagement to complete a conductive circuit through the switch unit 12. Once the magnetic elements 18 have been moved into engagement, they can be retained in this engaged position until the applied flux field is reduced below a second value less than the first value. This second value can be around 30 NI or approximately one-third of the operate or first value.

The winding assembly 14 for each of the sealed switch units 12 comprises a three part bobbin 20 on which three windings 22, 24, and 26 are disposed. The windings 22 and 24 are disposed in a position circling the left-hand and right-hand magnetic elements 18, respectively, and the winding 26 is substantially centered over the gap between the overlapping portions 18*a*. The winding 26 includes two separate windings or coils 26*a* and 26*b* and provides a flux field of opposite polarity to that of the fields produced by the windings 22 and 24.

Referring now more specifically to FIG. 3 of the drawings, therein is illustrated a switching matrix 30 which embodies the present invention and which is capable of operating in two separate modes. The matrix 30 provides eight crosspoints formed by eight switching assemblies 32–39 each of which is identical to the switching assembly 10. The first and second winding means 22 and 24 in the eight switching assemblies 32–39 are connected into a two coordinate matrix circuit having two rows and four columns to provide a 2 x 4 matrix. However, the switching matrix 30 can be made in any size by using a greater number of the switching assemblies 10 in dependence on the desired matrix capacity. In the circuit illustrated in FIG. 3, the first winding means 22 are selectively supplied with signals in accordance with the column input information and the second winding means 24 are provided with row input signals.

To provide means for selectively energizing the first and second winding means 22 and 24 in the plurality of switching assemblies 32–39, the circuit 30 includes two potential sources illustrated as a higher potential battery 40 and a lower potential battery 42 either of which is selectively connected to a common battery conductor 44 by a switch 46. In one embodiment of the invention, the battery 40 provides a twenty-four volt potential and the battery 42 supplies a six volt potential.

The column input to the matrix 30 is supplied by four manually actuated switches 47–50 representing the column digits "1–4," respectively. These switches are connected between the battery conductor 44 and one terminal of the two first winding means 22 in each of the columns. Two manually actuated switches 51 and 52 representing rows "A" and "B," respectively, are individually connected between the battery conductor 44 and the second windings 24 in the four switches 32–35 in row "A" and the second windings 24 in the four switches 36–39 in row "B." Although the inputs to the matrix 30 are illustrated in simplified form as comprising manually actuated switches and batteries, these input signals can be provided by other suitable input means, such as diodes or semiconductor devices.

When the switching matrix 30 is to be operated in its first or normally open mode, the magnetic elements 18 in all of the switching assemblies 32–39 are in their normally open position, and the switch 46 is operated to connect the higher potential battery 40 to the conductor 44. Assuming that the crosspoint "B1" is to be closed, the switches 47 and 52 are closed. The closure of the switch 47 energizes the first windings 22 in the two switching assemblies 32 and 36 so that a flux of around 120 NI is developed by each of these windings. The closure of the switch 52 energizes the second winding means 24 in the four switching assemblies 36–39 in the "B" column so that each of these windings also develops a flux field of around 120 NI.

As set forth above, the sealed switches 12 or 32–39 are operated by the application of an effective flux field of around 100 NI to the elements 18. Since each of the windings 22 and 24 energized by the closed switches 47 and 52 develops a flux field having a strength of around 120 NI, it would appear as if all the switches 32 and 36–39 which have at least one energized winding 22 or 24 would be operated to a closed condition. However, with the two magnetic reeds 18 spaced from each other to provide a gap between the overlapping portions 18*a* and with the windings 22 and 24 spaced axially from the gap, the coupling between the windings 22 and 24 and the magnetic elements 18 is so poor that it is necessary for either of the coils 22 or 24 to develop a flux field having a strength on the order of 500 NI in order to apply an effective field of at least 100 NI to these magnetic elements. Since the windings 22 and 24 individually generate flux fields of around 120 NI and since the switches 12 or 32–39 require a field on the order of 500 NI with only one winding 22 or 24 energized and the switch open, a wide operating margin is provided to prevent the operation of any switch 32–39 having only one winding 22 or 24 in an energized condition.

However, when both of the windings 22 and 24 on a sealed switch 12 are concurrently energized, the development of a field of a strength approximating 100 NI (120 NI) in each of the two windings 22 and 24 is effective to apply a resultant or effective field of 100 NI to the magnetic elements 18 to close the switch or crosspoint. In the illustrative example, a resultant or effective flux field of 100 NI is developed in the magnetic elements 18 of only the desired or selected sealed switch 36 representing the desired crosspoint "B1". Since the sealed switches 12 or 32–39 are retained in an operated condition by the application of a flux of 30 NI and since either of the energized windings 22 or 24 provides an effective field in the elements 18 of a closed switch that is on the order of 50 NI, either the switch 47 or the switch 52 can be opened to terminate the energization of the first windings 22 or the second windings 24 without releasing the closed crosspoint provided by the actuated switch 36. When both of the switches 47 and 52 are opened, the switching assembly 36 is released, and the switching matrix 30 is restored to its normal condition.

When the switching matrix 30 is to be operated in its second or normally closed crosspoint mode, the third winding means 26 are used. The first coil 26*a* in each of the third windings 26 is connected through a normally open memory switch 54 to a battery 56 of the same potential as the battery 42, and the second coil 26*b* in each of the third windings is connected through a pick-up switch 58 to a battery 60 of the same potential as the battery 42. The matrix 30 is also conditioned for operation in the second mode and disabled from operation in the first mode by actuating the selector switch 46 to disconnect the battery 40 from the conductor 44 and to connect the lower potential battery 42 to this conductor.

Since the battery 42 is of the same potential as the batteries 56 and 60, the batteries 56 and 60 can be replaced by connecting the switches 54 and 58 to the battery 42.

To prepare the matrix 30 in which all of the crosspoints are open for operation in the second mode, the switch 54 is closed to energize all of the first coils 26*a* in the third windings 26 of the switching assemblies 32–39. The coils 26*a* are so wound that, when energized by the lower potential provided by the battery 56, a half unit of flux 50 NI is applied to the magnetic elements 18 in all of the switching assemblies 32–39. Thereafter, the pick-up switch 58 is momentarily closed to momentarily energize the coils 26*b* in the third windings 26 of all of the switches 32–39. The coils or windings 26*b* also apply a half unit 50 NI of flux of the same polarity as that produced by the coils 26*a* to the magnetic elements 18 in all of the switches 32–39.

In the interval in which both of the coils 26*a* and 26*b* in all of the third windings 26 are energized, these coils develop a total flux field of around 100 NI. The most effective winding for a sealed magnetic reed switch theoretically comprises a single turn directly centered over the gap, and the efficiency of the coil decreases as its axial length is increased. The windings 26 are directly centered over the gaps between the overlapping portions 18*a* of the magnetic elements 18, and the 100 NI fields developed by the concurrent energization of both of the coils 26*a* and 26*b* in all of the third windings 26 close all of the switches. Further, when the energization of the coils 26*b* is terminated so that only coils 26*a* remain energized to develop fields of around 50 NI, the closed condition of all of the magnetic elements 18 provides a condition in which these magnetic elements "see" an effective flux field on the order of 70 to 75 NI, a value in excess of the 50 NI field developed by the energized coils 26*a*. This value is well in excess of the holding value of 30 NI for the sealed switches 12, and all of the sealed switches 32–39 in the matrix circuit 30 remain operated.

The switches 47–52 are then selectively actuated to provide two coordinate or row and column input information in the same manner as in the first mode except that the conductor 44 is provided with the lower potential of the battery 42 which is about one-quarter of that provided by the battery 40. Assuming that the crosspoint "A1" is to be opened, the switches 47 and 51 are closed. The closure of the switch 47 energizes the first windings 22 for the switches 32 and 36 so that a flux is developed that is of an opposite polarity to that provided by the energized coils 26*a*. These generated fields have a magnitude of 30 NI which is around one-quarter of that generated by these windings when the matrix 30 operates in its first mode. The closure of the switch 51 energizes the second windings 24 in the four switches 32–35 so that they also generate flux fields of around 30 NI which is one-quarter of the fields generated in the first mode. Since all of the magnetic elements 18 are now engaged substantially the full 30 NI field developed by the windings 22 and 24 is effective in the reeds 18. In the switch 32, the 50 NI field of the coil 26*a* provides an effect on its elements 18 of 75 NI, and the concurrent energization of its two windings 22 and 24 provides an effective opposing field of 60 NI. Thus, the resultant field in the elements 18 in the switch 32 is only 15 NI. This is below the holding value of 30 NI so that the switch unit 32 is opened.

In the switches 33–36 in which only one of the windings 22 or 24 is energized, the 30 NI flux fields generated by these windings are effective to reduce the oppositely directed effective flux fields of 75 NI in the magnetic elements 18 to a value of around 45 NI. This resultant field is greater than the holding value of 30 NI, and the switches 33–36 remain actuated to provide closed crosspoints. Since the switches 37–39 do not include energized windings, these switches also remain held in a closed condition by the energized coils 26*a*. Accordingly, the closure of the switches 47 and 51 results in the release of only the "A1" switch 32.

When the switches 47 and 51 are opened, the unopposed effective flux field in the open switch 32 provided by the energized coil 26*a* is less than the operate value of 100 NI, and the switch 32 is not reclosed. Thus, with the removal of the input signals, the matrix 30 remains in its previous condition with the selected crosspoint open. The matrix 30 can be restored to its normal second mode condition by again momentarily closing the pick-up switch 58 to apply flux wheels equal to or in excess of 100 NI to all of the switching assemblies in the matrix 30.

Although the switching assembly 10 and the matrix circuit 30 have been described with reference to specific operating characteristics for the sealed switches 12, for instance, and specific values of operating potential, the two mode matrix can be constructed with a number of similar means. As an example, the sealed switches 12 can operate in substantially the same manner as that described with different values of operate and hold flux, and the various windings can be energized by different potentials so long as the flux ratios required by the switches are maintained, as by varying the number of turns in the coils. The use of a number of different value potentials is, however, not desirable in most systems.

A test circuit 62 using matrix circuits embodying the present invention is illustrated in FIG. 4 of the drawings. The test circuit 62 includes two matrices 30A and 30B which are identical to the matrix 30 and which each includes eight crosspoints shown schematically as normally open contacts identified as 32A–39A and 32B–39B, respectively. The circuit 62 is used to check an eight conductor cable 64 that is connected between the two sets of contacts 32A–39A and 32B–39B.

When the continuity of each of the conductors in the cable 64 is to be determined, a test potential source is connected to a terminal 66, and an indicating meter is connected to a terminal 68. The two matrices 30A and 30B are operated in their first mode so that the designations of the end terminals of one of the conductors in the cable 64 can be concurrently supplied to the two matrices 30A and 30B to connect the conductor to be tested between the terminals 66 and 68. As an example, if the right-hand conductor in the cable 64 is to be checked for continuity, the designation "B4" is supplied to both of the matrices 30A ad 30B to close the contacts 39A and 39B. The right-hand conductor in the cable 64 is now connected between the test potential supplied to the terminal 66 and the indicating meter connected to the terminal 68. In a similar manner, the designations of the end terminals of each of the other conductors in the cable 64 can be sequentially supplied to the two matrices 30A and 30B so that the continuity of each of these conductors can be checked in sequence.

The cable 64 can be checked for the presence of shorts between its conductors by operating the matrix 30A in its first mode and the matrix 30B in its second mode. A source of breakdown test voltage is connected to the terminal 66 and an indicating means is again connected to the terminal 68. The second matrix 30B is operated to its second mode in the manner described above by operating the switch 46 to connect the lower potential source to the conductor 44, by closing the switch 54, and by momentarily closing the pick-up switch 58 so that all of the switches 32B–39B are closed. If the breakdown characteristic of the left-hand conductor in the cable 64 is to be checked, the designation "A1" is supplied to the matrix 30B so that the contacts 32B are opened. Thus, all of the remaining conductors in the cable 64 are connected together and to the indicating meter through the closed contacts 33B–39B. The designation of the input terminal for the left-hand conductor in the cable 64, i.e. "A1", is then supplied to the matrix 30A which operates in its first mode. This closes the contacts 32A so that the breakdown potential at the terminal 66 is applied to the

left-hand conductor. In this manner, the presence of a short circuit or a voltage breakdown between the left-hand conductor and the remaining conductors in the cable 64 can be determined.

If it is desired to individually check the breakdown characteristic between the lefth-and conductor in the cable 64 and each single conductor or group of conductors in the cable, the matrix 30B can be supplied with a sequence of different designations so that any one or combination of the remaining conductors in the cable 64 are connected to the indicating meter at the terminal 68. At the termination of the breakdown testing, the second matrix 30B can be restored to its first mode of operation in the manner described above by operating the switch 46 to connect the higher potential battery 40 to the conductor 44 and by opening the switches 54 and 58.

Although the present invention has been described with reference to a single illustrative embodiment thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this invention.

What is claimed as new and desired to be secured by Letters Patent of the United States of America is:

1. A switching matrix comprising a plurality of sealed switches, each of said switches including a pair of magnetic elements movable into engagement by an applied flux field of a given strength; first and second winding means for applying a flux field to each of said sealed switches; circuit means for connecting the first and second winding means in a two coordinate matrix; and control means for operating said matrix as a normally closed switch matrix and as a normally open switch matrix, said control means including first means for selectively applying signals to said circuit means to energize the first and second winding means to apply a flux field of said given strength to only the coordinately selected switch, said control means also including second means for operating all of the switches and for selectively applying signals to said circuit means to energize the first and second winding means to apply a flux field of less than said given strength to the coordinately selected switch to release this selected switch.

2. A switching matrix comprising a plurality of sealed switches, each of said switches including a pair of magnetic elements movable into engagement by an applied flux field of a given strength; first and second winding means for applying a flux field to each of said sealed switches; circuit means for connecting the first and second winding means in a two coordinate matrix; and control means for operating said matrix as a normally closed switch matrix and as a normally open switch matrix, said control means including first means for selectively applying signals to said circuit means in two coordinate directions to energize the first and second winding means of the desired switch, and second means for changing the potential of the signals applied by said first means between a given potential level when said matrix operates as an open switch matrix and a potential level lower than said given level when said matrix operates as a closed switch matrix.

3. A switching matrix comprising a plurality of sealed switches, each of said switches including a pair of magnetic elements movable into engagement by an applied flux field of a given strength; first and second winding means for applying a flux field to each of said sealed switches; circuit means for connecting the first and second winding means in a two coordinate matrix; and control means for operating said matrix as a normally closed switch matrix and as a normally open switch matrix, said control means including an open switch matrix control having means for selectively applying signals in two coordinate directions to said circuit means to energize both the first and second winding means of only the desired switch to apply an effective flux field of the given strength to the magnetic elements of the desired switch, said control means also including a closed switch matrix control for operating all of the switches and for selectively applying signals in two coordinate directions to said circuit means to energize the first and second winding means of only the desired switch to release this desired switch.

4. A switching matrix comprising a plurality of sealed switches each operable from an open condition to a closed condition by an applied flux field of a first strength and held in closed condition by an applied flux field of a second strength less than said first strength; winding means for each of said sealed switches; circuit means interconnecting the winding means in a two coordinate matrix with first and second coordinate inputs to said winding means; first control means for selectively applying input signals to said first and second coordinate inputs to energize the winding means to apply a resultant flux field of said first strength to the selected switch in the matrix and a resultant flux field of less than said first strength to any other switch in the matrix; and second control means including means for operating all of the switches to a closed condition and for holding all of the switches in a closed condition by the application of a resultant flux of at least said second strength to all of said switches, said second control means also including means for selectively applying input signals to said first and second coordinate inputs to energize the winding means to apply a resultant flux field of less than said second strength to only the selected switch and more than said second strength and less than said first strength to the remaining switches.

5. A switching matrix comprising a plurality of sealed switches, each of said sealed switches including a pair of magnetic elements movable into engagement by an applied flux field of a first value and movable out of engagement when the applied flux field fails to a second value less than the first value; first, second and third winding means for applying flux fields to the magnetic elements in each of the sealed switches; first control means for momentarily energizing all of said third winding means to apply a flux field of said first value or greater to all of the switches to operate all of the switches and for then applying a flux field of said second value or greater to all of the switches to hold the switches operated; circuit means connecting the first and second winding means into a two coordinate matrix having first and second coordinate inputs; and second control means for selectively applying signals to the first and second coordinate inputs to energize said first and second winding means to reduce the resultant flux field applied to a selected one of the switches to a value less than said second value.

6. A switching matrix comprising a plurality of sealed switch units, each of said switch units including a pair of magnetic elements movable into engagement in response to an applied effective flux field of a given strength NI and being retained in engagement by an applied effective flux field having a strength less than NI; a plurality of first and second winding means for applying flux fields to the magnetic elements in the plurality of sealed switch units; circuit means connecting the plurality of first and second winding means in a two coordinate matrix; first control means applying signals to said circuit means to selectively energize said first and second winding means to apply flux fields of a strength greater than

$$\frac{NI}{2}$$

to said sealed switch units so that the sealed switch whose first and second winding means are concurrently energized is operated by the resultant effective applied field of a strength at least as great as NI; and second control means including means for operating all of the switch units and holding them operated with applied fields of a strength less than NI, and means for selectively applying signals to said circuit means to selectively energize said first and

second winding means to apply flux fields of a strength less than

$$\frac{NI}{2}$$

to said sealed switch units to release the sealed switch whose first and second winding means are concurrently energized.

7. A switching matrix comprising a plurality of sealed switch units, each of said switch units including a pair of magnetic elements movable into engagement in response to an applied effective flux field of a strength NI and being retained in engagement by an applied effective flux field having a strength on the order of

$$\frac{NI}{3}$$

a plurality of first and second winding means for applying flux fields to the magnetic elements in the plurality of sealed switch units; circuits means connecting the plurality of first and second winding means in a two coordinate matrix; first control means applying signals to said circuit means to selectively energize said first and second winding means to apply flux fields of a strength greater than

$$\frac{NI}{2}$$

to said sealed switch units so that the sealed switch whose first and second winding means are concurrently energized is operated; and second control means including means for operating all of said sealed switch units and for selectively applying signals to said circuit means to selectively energize said first and second winding means to apply flux fields of a strength less than

$$\frac{NI}{2}$$

to said sealed switch units to release the sealed switch whose first and second winding means are concurrently energized.

8. A switching matrix comprising a plurality of sealed switch units, each of said switch units including a pair of magnetic elements movable into engagement in response to an applied flux field of a strength NI and being retained in engagement by an applied flux field having a strength on the order of

$$\frac{NI}{3}$$

a plurality of first, second, and third winding means for applying flux fields to the magnetic elements in the plurality of sealed switch units; circuit means connecting the plurality of first and second winding means in a matrix arrangement; first control means applying signals to said circuit means to selectively energize said first and second winding means to apply flux fields of a strength greater than

$$\frac{NI}{2}$$

to said sealed switch units so that the sealed switch whose first and second winding means are concurrently energized is operated; and second control means including means for energizing said third winding means to operate all of said sealed switch units and for selectively applying signals to said circuit means to selectively energize said first and second winding means to apply flux fields of a strength less than

$$\frac{NI}{2}$$

to said sealed switch units to release the sealed switch whose first and second winding means are concurrently energized.

9. A switching matrix comprising a plurality of sealed switch units, each of said switch units including a pair of

magnetic elements movable into engagement in response to an applied flux field of a strength NI and being retained in engagement by an applied flux field having a strength on the order of

$$\frac{NI}{3}$$

a plurality of first, second, and third winding means for applying flux fields to the magnetic elements in the plurality of sealed switch units; first circuit means connecting the plurality of first and second winding means in a two coordinate matrix arrangement; first control means applying signals to said circuit means to selectively energize said first and second winding means to apply flux fields of a strength greater than

$$\frac{NI}{2}$$

to said sealed switch units so that the sealed switch whose first and second winding means are concurrently energized is operated; and second control means including second circuit means for energizing all of said third winding means to provide flux fields of the strength NI to operate all of said sealed switch units and for then providing flux fields of strengths less than NI but more than

$$\frac{NI}{3}$$

to hold all of the switch units operated, said second control means also including means for selectively applying signals to said first circuit means to selectively energize said first and second winding means to apply flux fields of a strength less than

$$\frac{NI}{2}$$

to said sealed switch units to release the sealed switch whose first and second winding means are concurrently energized.

10. A switching matrix comprising a plurality of sealed switch units, each of said switch units including a pair of magnetic elements having overlapping portions movable into engagement in response to an applied flux field of a strength NI and being retained in engagement by an applied flux field having a strength on the order of

$$\frac{NI}{3}$$

a set of first, second, and third winding means for applying flux fields to the magnetic elements in each of the sealed switch units, the third winding means encircling the overlapping portions of the magnetic elements interposed between the first and second winding means, the third winding means including first and second coils; circuit means connecting the plurality of first and second winding means in a two coordinate matrix, first control means applying signals to said circuit means to selectively energize said first and second winding means to apply flux fields of a strength greater than

$$\frac{NI}{2}$$

to said sealed switch units so that the sealed switch whose first and second winding means are concurrently energized is operated; and second control means including means for momentarily energizing the first and second coils in all of the third winding means to operate all of said sealed switch units and for then energizing the first coils only to hold all of the switch units operated with applied fields of strengths on the order of

$$\frac{NI}{2}$$

and means for selectively applying signals to said circuit

means to selectively energize said first and second winding means to apply flux fields of a strength less than

$$\frac{NI}{2}$$

to said sealed switch units to release the sealed switch whose first and second winding means are concurrently energized.

11. A switching matrix comprising a plurality of sealed switch units, each of said switch units including a pair of magnetic elements movable into engagement in response to an effective flux field of a strength NI and being retained in engagement by an applied flux field having a strength less than NI; a plurality of first and second winding means for applying flux fields to the magnetic elements in the plurality of sealed switch units; circuit means connecting the plurality of first and second winding means in a matrix arrangement; first control means applying signals to said circuit means to selectively energize said first and second winding means to develop flux fields of a strength on the order of NI, said first and second windings being coupled to the magnetic elements in the switch units so that the flux field NI developed by one of each pair of first and second windings

is not sufficient to operate the switches and so that the concurrently energized first and second winding means on the selected switch supply fields on the order of NI to produce an effective field of at least NI in the magnetic elements of the selected switch; and second control means including means for operating all of said sealed switch units and for selectively applying signals to said circuit means to selectively energize said first and second winding means to apply flux fields of a strength on the order of

$$\frac{NI}{4}$$

to said sealed switch units to release the sealed switch whose first and second winding means are concurrently energized.

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