June 23, 1964 E. J. SMURA 3,138,786

MAGNETIC CORE MATRIX

Filed July 18, 1960 2 Sheets-Sheet 1

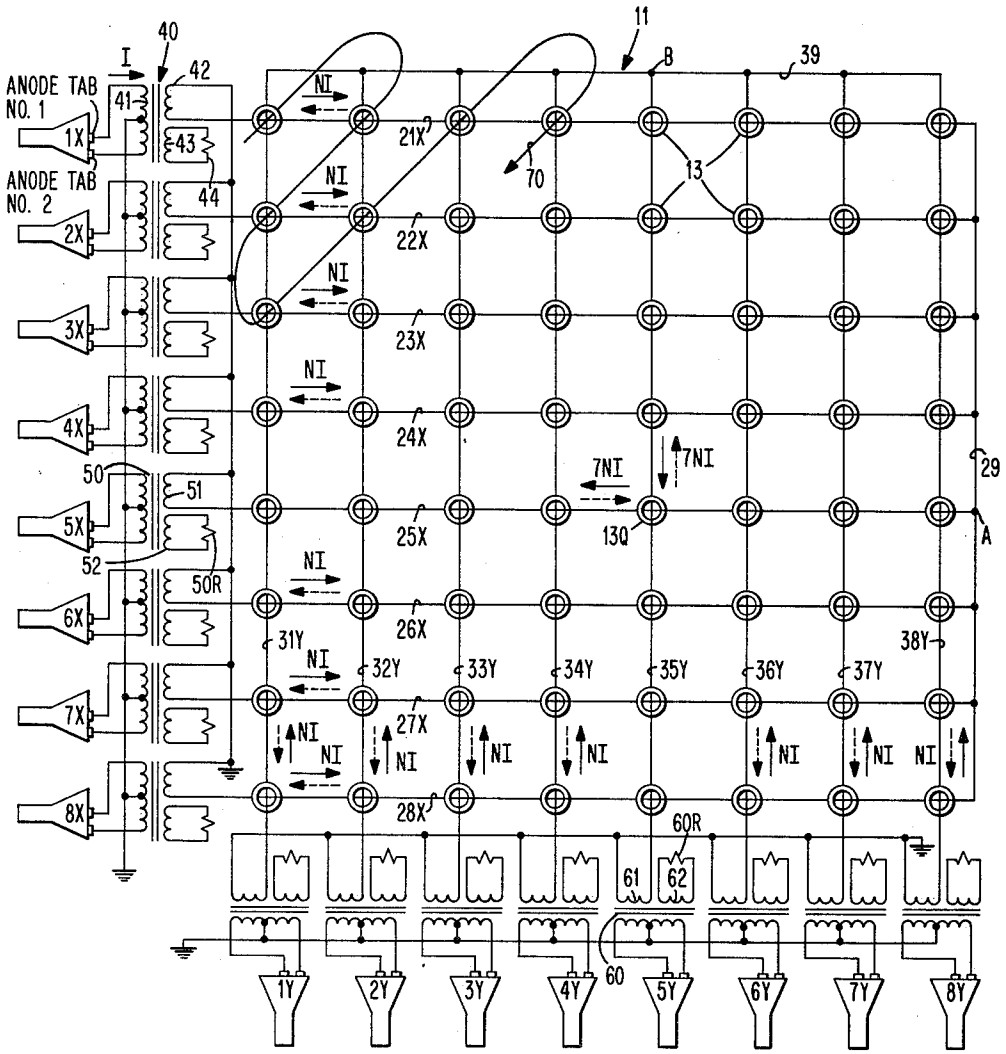


FIG. 1

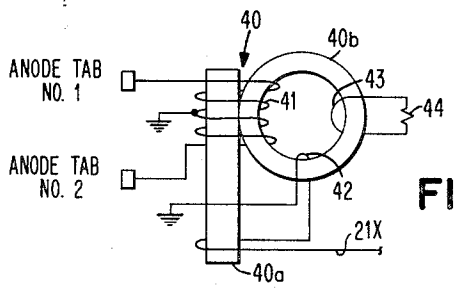


FIG. 2

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MAGNETIC CORE MATRIX

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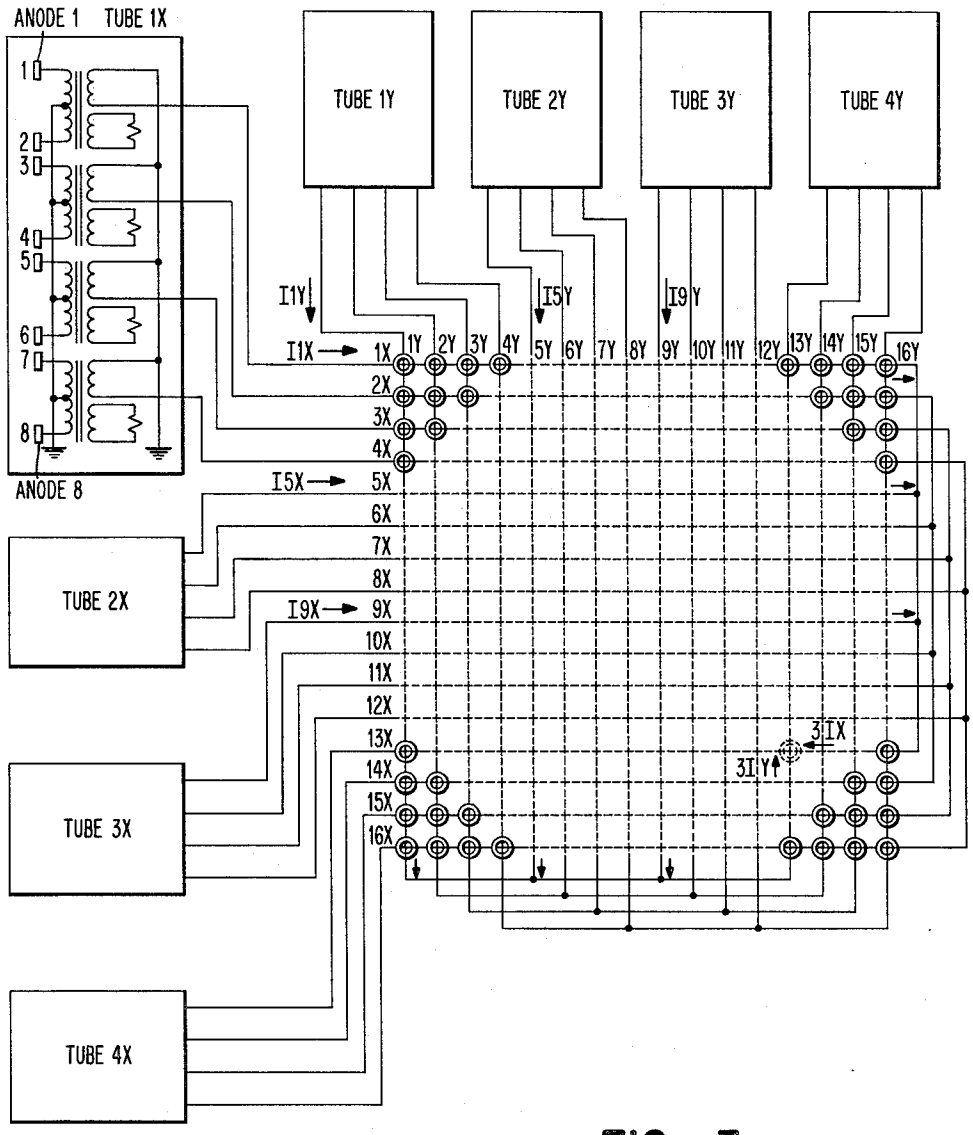


FIG. 3

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3,138,786

MAGNETIC CORE MATRIX

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This invention relates to an information handling matrix comprising binary elements and, more particularly, to a matrix in which the currents flowing in the drive lines of the matrix are combined; the combined current being channeled to energize a particular element.

Binary elements such as magnetic cores and ferroelectric capacitors are widely used in information handling matrices since they exhibit two stable states; remnant flux states or polarization states, respectively. In a number of applications, the binary elements are arranged to have at least a pair of current carrying or drive lines coupling current energy thereto. Coincident currents in the drive lines are employed for selection and energization of particular elements of the matrix. However, the problem of driving and switching binary elements, especially magnetic cores, in matrices has remained complex. In general, it is desirable to drive or switch the binary elements with a relatively large current in order that the switching time be decreased. Consequently, when it has heretofore been attempted to employ cathode ray tubes as the driving means for matrices, serious limitations in the amplitude of the current available to drive the matrices have become apparent.

It is a principal object of my invention to provide a matrix of binary elements in which an element is energized to change its stable state by the sum of the currents flowing in the matrix drive lines.

It is another object of my invention to provide a binary element matrix adaptable to be driven by sources of low amplitude current.

It is still another object of my invention to provide a binary element matrix adaptable to be driven by cathode ray tubes.

In one preferred embodiment, the invention provides a matrix comprising a plurality of cores driven by cathode ray tubes. Each cathode ray tube includes a plurality of discrete anode tabs; each of the tabs is transformer coupled to respective drive lines of the matrix. The matrix includes two groups of drive lines; each group of lines is connected to a respective common lead and each core has one line in each group being wound, that is, passing therethrough. To select a core, the cathode ray tubes are energized to provide a current through coupling transformers to all the drive lines except the two lines passing through the desired selected core. In each group of lines, current will flow through the drive lines to the common line whence the currents are combined, and the combined current flows through the drive line passing through the selected core; the combined currents are dissipated in line impedance matching resistors connected across a winding of the respective coupling transformer.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a schematic diagram of a matrix array in accordance with the invention;

FIG. 2 is a schematic diagram of a circuit for coupling current to the drive lines; and,

FIG. 3 is a schematic diagram of a second matrix array in accordance with the invention.

FIG. 1 shows a matrix plane 11 according to the invention. A relatively simplified form of a single plane matrix is shown for purposes of facilitating the explanation of the operation of the invention. Matrix 11 comprises a total of 64 binary elements; in this case, magnetic cores, arranged in a plane formed with eight rows and columns, with eight cores in each row and in each column. Collectively, the cores are designated by the numeral 13; the symbol X designates the rows of the matrix; the symbol Y designates the columns of the matrix. A first group of drive lines designated individually as 21X–28X are wound to pass through the respective rows of cores and are connected to a common line 29. Likewise, a second group of drive lines designated individually as 31Y–38Y are wound to pass through the respective columns of cores and are connected to a common line 39. Thus, in matrix 11, each of the cores 13 has two intersecting drive lines passing therethrough; that is, a core is positioned at the intersection of each two drive lines and each line is wound to have one turn on the core. Drive lines 21X–28X, as well as lines 31Y–38Y, are each connected to the secondary winding of a transformer, the primary of which is connected to an anode of a cathode ray tube.

The cathode ray tubes employed for driving the matrix 11 are preferably of the type shown in Patent Number 3,092,746 of E. J. Smura for Cathode Ray Tube for Processing Digital Data, issued June 4, 1963, and assigned to the same assignee as the present invention. For purposes of this description, it will be appreciated that each of the cathode ray tubes has a plurality of electron beam-receiving anode tabs and the electron beam in each tube is controlled such that it impinges on only one of the anodes of a tube at a given instant. More specifically, in one embodiment, each cathode ray tube has a total of 32 discrete anode tabs; 16 of the tabs being used for writing and 16 of the tabs being used for reading, as will be described hereinbelow. As noted above, for ease in explaining the concept of the invention, only a relatively small matrix plane is shown utilizing only two anodes in each of 16 cathode ray tubes. Obviously, the plane shown can be expanded to include 128 drive lines in the X group and 128 lines in the Y group.

The tubes designated 1X–8X are connected effectively in parallel such that the electron beam is connected to impinge on the same anode of each tube at a given instant. The anode tabs numbered 1 and 2 in tubes 1X–8X are transformer coupled to energize drive lines 21X–28X, respectively. Likewise, cathode ray tubes 1Y–8Y are connected in parallel such that the electron beam is caused to impinge on the same anode on each tube at a given instant. Anode tabs numbered 1 and 2 of tubes 1Y–8Y are transformer coupled to energize drive lines 31Y–38Y, respectively.

Since cathode ray tubes 1X–8X and 1Y–8Y are all similar and operate in a similar manner, and since the transformers associated with each tube are similar and operate in a similar manner, an explanation of one tube and the associated transformer is thus deemed sufficient to the understanding of the operation of my invention. Particular reference will thus be made to cathode ray tube 1X and associated transformer 40 coupled to drive line 21X.

The structure of transformer 40 is shown in more detail in FIG. 2. Transformer 40 comprises a primary winding 41, a secondary winding 42 and a tertiary winding 43. Magnetic material 40*a* having no sharply defined remanant flux state inductively couples the primary winding 41 to the secondary winding 42; and magnetic switching material having two stable remanant flux states, such as a magnetic or ferrite core 40*b*, couples the secondary

winding 42 to the tertiary winding 43. Primary winding 41 has one terminal connected to anode tab number 1 in tube 1X, and its other terminal connected to anode tab number 2 of tube 1X; the midpoint of winding 41 is grounded. The upper half of winding 41; that is, the portion extending from anode tab number 1 to ground, is wound in a first direction, say, counterclockwise, around transformer material 40*a*; the lower half of winding 41 which extends from ground to anode tab number 2 is wound in the opposite or clockwise direction around transformer material 40*a*. Secondary winding 42 has one terminal connected to ground and the other terminal connected to drive line 21X. Tertiary winding 43 has a resistor 44 connected thereacross. Resistor 44 is selected to match the characteristic impedance of line 21X and thus prevents any energy received through 21X from being reflected back down the line for purposes which will be evident hereinbelow. For current less than a given amplitude, as will be explained hereinbelow, the magnetic core 40*b* provides zero coupling between the secondary winding 42 and tertiary winding 43 such that the tertiary winding does not affect the operation of the circuit. For currents above a given amplitude, the core 40*b* will switch or change stable states and thereby couple energy to the tertiary winding, which energy is dissipated by resistor 44.

The upper half of winding 41 is utilized as the write line and the lower half of winding 41 is utilized as the read line. The odd-numbered anode tabs in the cathode ray tubes are used to write and the even-numbered anode tabs are used to read. In one embodiment, each tube has 32 anode tabs, with 16 tabs used in reading and 16 tabs used in writing. As is known, the write and read operations in the matrix are essentially similar with the binary element being driven to one stable state during the writing operation and being driven to the other stable state during the reading operation.

As noted above, tubes 1X–8X comprising the X drive group have their deflection plates electrically connected in parallel, thus the electron beam is directed to impinge on the same respective anode in each tube at a given instant; that is, during each selection period. Likewise, tubes 1Y–8Y have their deflection plates electrically connected in parallel such that the electron beam is directed to impinge on the same respective anode in each tube during each selection period.

The tubes 1X–8X and 1Y–8Y are controlled to be turned on or off; that is, the tubes are controlled to have an electron beam being emitted from the respective cathode of a tube and impinging on one of the anode tabs, or the electron beam is not being emitted; that is, the beam is cut off.

The writing operation of the matrix is as follows. Assume that it is desired to energize the core designated as 13Q in matrix 11. Assume initially that core 13Q is in an initially neutral state. Tubes 1X–4X and 6X–8X, that is, all the tubes in the X group except tube 5X, will be on, or conducting. Likewise, tubes 1Y–4Y and 6Y–8Y, that is, all the tubes in the Y group except tube 5Y, will be on. All the tubes which are turned on will be addressed such that the electron beam is directed to impinge on anode number 1. Thus, in tube 1X, for example, a current I will be caused to flow in transformer 40 from anode number 1 through the upper part of primary winding 41 to ground reference. A current NI, indicated by the solid arrow, will flow in the secondary winding 42 due to transformer action; N being the current transfer ratio of the transformer. The current path is traceable from ground through secondary winding 42, drive line 21X to the common line 29 and to point A. Likewise, in each of the tubes which are turned on in the X and Y drive groups, the current impinging on anode number 1 will cause a current I to flow in the respective primary winding inducing a current NI in the secondary winding which flows in the direction shown by the solid arrows in the respective drive line. Note, in this case, that all

the X drive lines except drive line 25X will be energized by the respective transformer to have current flowing therein. The current in drive lines 21X–24X and 26X–28X will flow toward and be summed in common line 29; in this particular case, at junction point A. A total current of 7 NI will thus be flowing into junction A. From Kirchhoff's Law, it will be appreciated that the sum of all the current flowing into junction A must equal the sum of the current flowing away from junction A. Therefore, all the currents flowing into junction A will be summed and a total current 7 NI will flow away from junction A, through drive line 25X and the secondary winding 51 of the transformer 50 associated with tube 5X to ground. The total current 7 NI in the secondary winding 51 will cause the core material of transformer 50 to switch magnetic states and cause tertiary winding 52 to couple a current to load resistor 50R. Since resistor 50R is matched to the characteristic impedance of line 25X, it will dissipate all the energy flowing in line 25X and no current will be reflected back.

The operation is similar for the Y group of drive lines. All the Y drive lines except drive line 25Y will be energized by the respective transformer to have current flowing therein. A current NI, shown by the solid arrows, will flow in each of lines 31Y–34Y and 36Y–38Y toward a common line 39 and junction B. At junction B, the currents will be summed and a total current 7 NI, shown by the solid arrow, will flow down drive line 35Y through the secondary winding 61 of the transformer 60 associated with tube 5Y. The total current 7 NI in the secondary winding 61 will cause the core material of transformer 60 to switch magnetic states and cause tertiary winding 62 to couple current 7 NI to resistor 60R, where the current is dissipated.

The current flow through the X and Y groups of drive lines is arranged to be concurrent; therefore, it will be obvious that a total current of 14 NI will be passing through the desired core 13Q. The The total current flowing through core 13Q is sufficient to energize core 13Q and cause it to shift from one to the other of its stable states.

As will be appreciated, the reading operation is similar to the writing operation. In this case, the desired tubes are addressed, such that the electron beam is caused to impinge on anode number 2 in each tube. As above, all the tubes except tubes 5X and 5Y are turned on. Current will thus flow in the primary windings of all the transformers except transformers 50 and 60 associated with tubes 5X and 5Y. Since the electron beams are impinging on the anode number 2 in each tube, the current flowing through the lower half of winding 41 will induce a current in the secondary winding which will flow in a relatively opposite direction from that shown above for the write operation; that is, the current will be flowing through the drive lines in the direction shown by the dotted arrows. The theory of operation is as stated above, with the direction of the current flow being reversed. It can be considered that the total current 7 NI, shown by the dotted arrow, showing in the X group of drive lines, will flow from ground reference, through the secondary winding 51 of the transformer 50 and drive line 25X to point A, and will divide into seven approximately equal currents which flow through each of the other drive lines in the X group and through the secondary windings of the respective transformers to ground.

The Y group of drive lines functions in a similar manner. The electron beam is addressed to impinge on the second anode of each of the tubes in the Y group. All the tubes in the Y group, except tube 5Y, are turned on or conducting. A current will be caused to flow in the direction shown by the dotted arrows through each of the Y drive lines. It can be considered that the total current 7 NI, shown by the dotted arrow, flowing in the Ygroup of drive lines, will flow from ground through the secondary winding 61 of transformer 60 and drive line 25Y to point B and will then divide into seven ap-

proximately equal currents which will flow through each of the other drive lines in the Y group and through the secondary windings of the respective transformers to ground. Common lines **29** and **39** thus provide a means of combining the currents in the respective X and Y groups of drive lines, and the matrix arrangement channels or directs the combined current to flow through the drive lines associated with the core to be selected.

The current flow through the X and Y groups of drive lines is arranged to be concurrent; therefore, the total current **14** NI will be sufficient to energize or switch core **13Q** from the stable state to which it was energized by the writing operation to its other stable state and thus provide a reading operation.

A suitable sensing line **70** of any well-known type is wound through each of the cores in series such that a writing or reading operation is sensed when a selected core shifts from one to the other of its stable states.

As noted above, the matrix plane shown is relatively small and may be only a part of a larger plane. With the type and number of tubes shown, the matrix plane may be expanded to include 128 drive lines in each of the X and Y groups since each cathode ray utbe comprises 16 anode pairs; also, various combinations of drive lines in the two groups of lines that may be energized for selecting a particular element. Any number of tubes may also be used and the number of drive lines is essentially unlimited.

It should also be understood that a number of separate matrix planes can be employed; the drive lines in a plane can be connected to the drive lines in other planes, and the common line in which the currents are summed can be in any one of the planes.

FIG. 3 shows an example of a larger matrix array according to the invention. The principle of operation of the circuit of FIG. 3 is the same as that described for FIGS. 1 and 2; therefore, a detail description of FIG. 3 is not considered necessary since the operation of the circuit of FIG. 3 can be understood by reference to Table I which follows this paragraph and which is essentially self-explanatory. In the circuit of FIG. 3, four tubes are used in each of the X and Y groups and eight anodes in each tube are coupled to the matrix. During each selection period, three of the four tubes in each of the X and Y groups are turned on, causing current to flow in three of the four drive lines of each of the X and Y groups respectively. As before, the tubes in each group are connected in parallel such that the electron beam is caused to impinge on the same respective anode tab in each of the tubes in a group during a given selection period. However, since two groups of tubes with a plurality of anode tabs in each tube are utilized, various combinations of lines can be energized. For example, as seen from the table, the electron beams can be addressed to impinge on anode number **1** in the X group of tubes and the electron beams can be addressed to impinge on the anode number **1** in the Y group of tubes; or, as indicated on the lower half of the graph, the electron beam can be caused to impinge on anode tab number **3** of the X group and anode tab number **1** in the Y group. Any number of such combinations can obviously be obtained. As in FIG. 1, current will be caused to flow in those drive lines connected to the anodes on which the electron beam is impinging. For example, if tubes **1**, **2** and **3** in the X group are turned on and the electron beam impinges on anode tabs number **1**, currents I_{1X}, I_{5X} and I_{9X} will flow in lines **1X**, **5X** and **9X**, respectively; likewise, when tubes **1**, **2** and **3** in the Y group are turned on and the electron beam impinges on anode tabs number **1**, currents I_{1Y}, I_{5Y} and I_{9Y} will flow in lines **1Y**, **5Y** and **9Y**, respectively. By turning on various combinations of tubes and addressing the electron beam to impinge on various anode tabs, different cores in the matrix may be energized, as indicated in the table.

Table 1

X GROUP TUBES, BEAM TO ANODE #1—Y GROUP TUBES, BEAM TO ANODE #1

	Combinations of Current Flow through X Drive Lines	Combinations of Current Flow through Y Drive Lines	Core Switched at Intersection
Case (*a*)	$I_{1X}+I_{5X}+I_{9X}$ (I_{1X}=current flow through drive line 1X due to tube 1X being on, and I_{5X}=current flow through drive line 5X due to tube 5X being on, etc.)	$I_{1Y}+I_{5Y}+I_{9Y}$	13X, 13Y
		$I_{5Y}+I_{9Y}+I_{13Y}$	13X, 1Y
		$I_{1Y}+I_{9Y}+I_{13Y}$	13X, 5Y
		$I_{1Y}+I_{5Y}+I_{13Y}$	13X, 9Y
Case (*b*)	$I_{5X}+I_{9X}+I_{13X}$	$I_{1Y}+I_{5Y}+I_{9Y}$	1X, 13Y
		$I_{5Y}+I_{9Y}+I_{13Y}$	1X, 1Y
		$I_{1Y}+I_{9Y}+I_{13Y}$	1X, 5Y
		$I_{1Y}+I_{5Y}+I_{13Y}$	1X, 9Y
Case (*c*)	$I_{1X}+I_{9X}+I_{13X}$	$I_{1Y}+I_{5Y}+I_{9Y}$	5X, 13Y
		$I_{5Y}+I_{9Y}+I_{13Y}$	5X, 1Y
		$I_{1Y}+I_{9Y}+I_{13Y}$	5X, 5Y
		$I_{1Y}+I_{5Y}+I_{13Y}$	5X, 9Y
Case (*d*)	$I_{1X}+I_{5X}+I_{13X}$	$I_{1Y}+I_{5Y}+I_{9Y}$	9X, 13Y
		$I_{5Y}+I_{9Y}+I_{13Y}$	9X, 1Y
		$I_{1Y}+I_{9Y}+I_{13Y}$	9X, 5Y
		$I_{1Y}+I_{5Y}+I_{13Y}$	9X, 9Y

+ GROUP TUBES, BEAM TO ANODE #3—Y GROUP TUBES BEAM TO ANODE #1

Case (*e*)	$I_{2X}+I_{6X}+I_{10X}$	$I_{1Y}+I_{5Y}+I_{9Y}$	14X, 13Y
		$I_{5Y}+I_{9Y}+I_{13Y}$	14X, 1Y
		$I_{1Y}+I_{9Y}+I_{13Y}$	14X, 5Y
		$I_{1Y}+I_{5Y}+I_{13Y}$	14X, 9Y
Case (*f*)	$I_{6X}+I_{10X}+I_{14X}$	$I_{1Y}+I_{5Y}+I_{9Y}$	2X, 13Y
		$I_{5Y}+I_{9Y}+I_{13Y}$	2X, 1Y
		$I_{1Y}+I_{9Y}+I_{13Y}$	2X, 5Y
		$I_{1Y}+I_{5Y}+I_{13Y}$	2X, 9Y
Case (*g*)	$I_{2X}+I_{10X}+I_{14X}$	$I_{1Y}+I_{5Y}+I_{9Y}$	6X, 13Y
		$I_{5Y}+I_{9Y}+I_{13Y}$	6X, 1Y
		$I_{1Y}+I_{9Y}+I_{13Y}$	6X, 5Y
		$I_{1Y}+I_{5Y}+I_{13Y}$	6X, 9Y
Case (*h*)	$I_{2X}+I_{6X}+I_{14X}$	$I_{1Y}+I_{5Y}+I_{9Y}$	10X, 13Y
		$I_{5Y}+I_{9Y}+I_{13Y}$	10X, 1Y
		$I_{1Y}+I_{9Y}+I_{13Y}$	10X, 5Y
		$I_{1Y}+I_{5Y}+I_{13Y}$	10X, 9Y

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A matrix comprising a plurality of binary elements, row and column drive lines connected to a plurality of current sources for coupling current energy from said plurality of current sources to said elements, means including a common connection between said drive lines for combining the current flowing in said drive lines, and means including a common connection between said sources for channeling the combined current to flow through selected ones of said row and column drive lines to energize a selected element.

2. A matrix comprising a plurality of binary elements, at least first and second groups of drive lines having a separate current sources connected to each line for coupling current energy from the plurality of current sources to said elements, means associated with each group of lines for combining the current flowing in said drive lines, and means including a common connection between the sources of each group for channeling the combined current in each group of lines to flow through a selected one of the lines in each group to energize a selected element.

3. An information handling matrix comprising a plurality of binary elements arranged in rows and columns, at least first and second groups of current carrying drive lines associated with the rows and columns of elements re-

spectively, each element being energizable by at least one of the drive lines in each group, a first common junction for said first group of lines, and a second common junction for said second group of lines, means for connecting the lines of each group to separate sources, including a common connection between the sources of each group, whereby, to select an element, all the lines in the matrix except those lines associated with the selected element receive current energy with their respective sources, the received current being combined at said junctions and flowing through the lines which are associated with the selected element, and the total of the combined currents flowing through the lines associated with the selected element energizes the element.

4. An information handling matrix comprising a plurality of binary elements arranged in rows and columns, at least first and second groups of current carrying drive lines one group being associated with the elements of the rows and the other with the elements of the columns, each element being energizable by or associated with at least one of the drive lines in each group, a first common junction for said first group of lines, and a second common junction for said second group of lines, transformer source means individual to each line, and circuit means connecting the source means of each group, whereby, in selecting an element, all the lines in the matrix except those lines associated with the selected element receive current energy with their respective source means, the received current combining at said junctions and flowing through the lines which are associated with the selected element, and the total of said combined currents flowing back through the lines in said first and second groups associated with the selected element, causing said selected element to be energized.

5. A matrix comprising a plurality of binary elements having two stable states, first and second groups of drive lines for energizing said elements, said first and second groups of lines being connected to first and second common junctions respectively, each element being energizable by an associated drive line of each group, a plurality of sources selectively controllable to develop or not develop current energy, and means including a saturable transformer for coupling each of said sources to a respective drive line for selecting a particular element in the matrix, said transformer of each group having a common connection and said sources being controllable to provide energy in one direction to all of said drive lines except the two drive lines associated with the particular element, the current flowing in said first and second group of drive lines being combined at said first and second junctions respectively, said combined current in each group flowing in the opposite direction through the drive lines associated with the element to be selected, whereby the total of said summed currents causes said selected element to be energized to one of its stable states.

6. A matrix comprising a plurality of binary elements having two stable states, first and second groups of drive lines for energizing said elements, said first and second groups of lines being connected to first and second common junctions respectively, each element being energizable by an associated drive line in said first group and an associated drive line in said second group, a plurality of current sources selectively controllable to provide or not provide current energy, and means including a saturable core transformer having a plurality of windings including primary and secondary windings for coupling each of said sources to a respective drive line, for selecting a particular element all of said sources except the sources coupled to the two drive lines associated with the selected element being controlled to provide current energy to their respective lines, the current flowing in said first group of drive lines being combined at said first junction and said combined current flowing through the drive line in said first group associated with said selected element, the current flowing in said second group of drive lines being combined at said second junction and said combined current flowing through the drive line in said second group associated with said selected element, whereby the total of said combined currents causes said selected element to be energized to one of its stable states, and means including another one of said winding connected to a load matching impedance for coupling said impedance to the other windings so long as the core is not saturated.

7. A matrix comprising a plurality of binary elements each having two stable states, a plurality of drive lines; at least two drive lines being arranged to energize each of said elements; current coupling means comprising a transformer having a first core with no defined stable states, a second core having two stable states, a primary winding and a secondary winding wound on both of said cores, and a tertiary winding wound on said second core; a line matching resistor connected across said tertiary winding; a plurality of sources of current energy; the primary winding of each of said transformers being connected to a respective source; the secondary winding of each transformer being connected to one end of a respective drive line, the other end of each of said drive lines being connected to a common junction; each of said sources of current being controllable for energizing the respective transformer for developing current flow in the respective drive line; a binary element being selected by developing current flow in all said drive lines except the drive lines associated with the selected element, said current in said drive lines being combined at a common junction and said combined current flowing in the drive lines associated with the selected element to energize said element to one of its stable states, and said combined current energizing the second core of the transformer coupled to the line associated with the selected element to change from one to the other of its stable states, thereby to energize said tertiary winding and cause the combined current to be dissipated in said line matching resistor.

8. A matrix comprising a plurality of binary elements each having two stable states; first and second groups of current carrying drive lines, each element being energizable by one of the drive lines in each group; each drive line in said first groups having one terminal connected to a first common junction, each line in said second group having one terminal connected to a second common junction; a plurality of current coupling means each comprising a transformer having a first core with no defined stable state, a second core having two stable states, a primary winding, a secondary winding, a tertiary winding, said primary and secondary windings being wound on both of said cores, said tertiary winding being wound only on said second core, and a line matching impedance being connected across said tertiary winding; one terminal of each said secondary winding being connected to ground and the other terminal being connected to the other terminal of a respective drive line; first and second groups of sources of current each individually controllable to provide or not provide current; each source connected for providing current to the primary winding of a respective transformer; current flow in a primary winding source causing a current to be induced in the associated secondary winding and consequent current flow in the associated drive line; the magnitude of the current provided by each source to the respective primary winding being insufficient to shift the state of the respective second core; whereby no current energy is coupled to the respective tertiary winding; for selecting a particular element in said matrix all said sources except those sources coupling current energy to the selected element being activated to provide current energy to the respective drive lines; the currents flowing in each line of said first group of drive lines being combined at said first junction and flowing through the drive line in said first group which energizes said selected element; the currents flowing in each line of said second

group of drive lines being combined at said second junction and flowing through the drive line in said second group which energizes said selected element; the total of said combined currents energizing said element to shift its stable state; and each of said combined currents being of sufficient magnitude to shift the stable state of the second core in the respective transformer whereby current energy is coupled to the tertiary winding to flow through and be dissipated in the associated line matching impedance.

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