

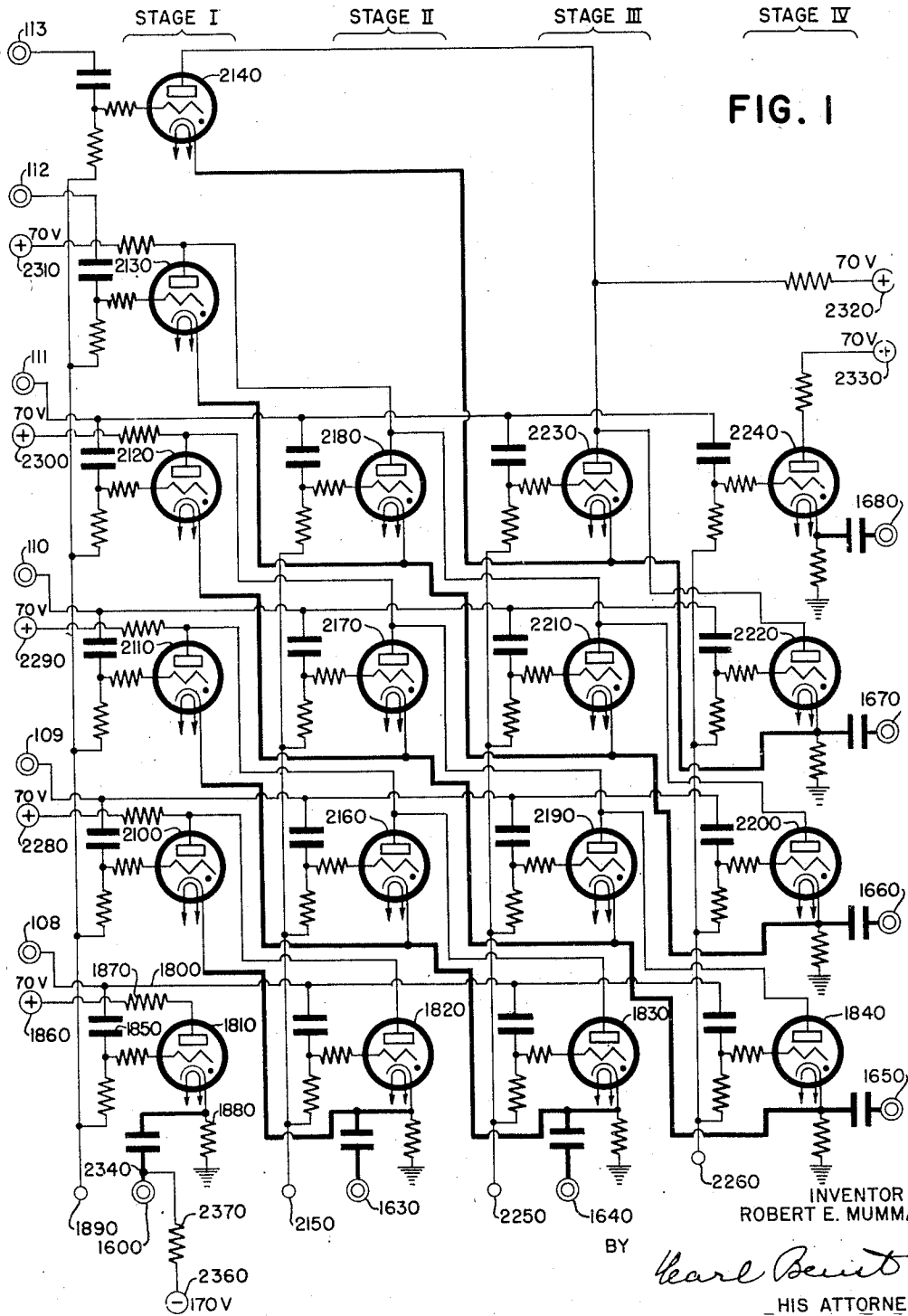
Jan. 17, 1950

R. E. MUMMA
SWITCHING DEVICE

2,495,075

Original Filed Dec. 27, 1943

2 Sheets-Sheet 1



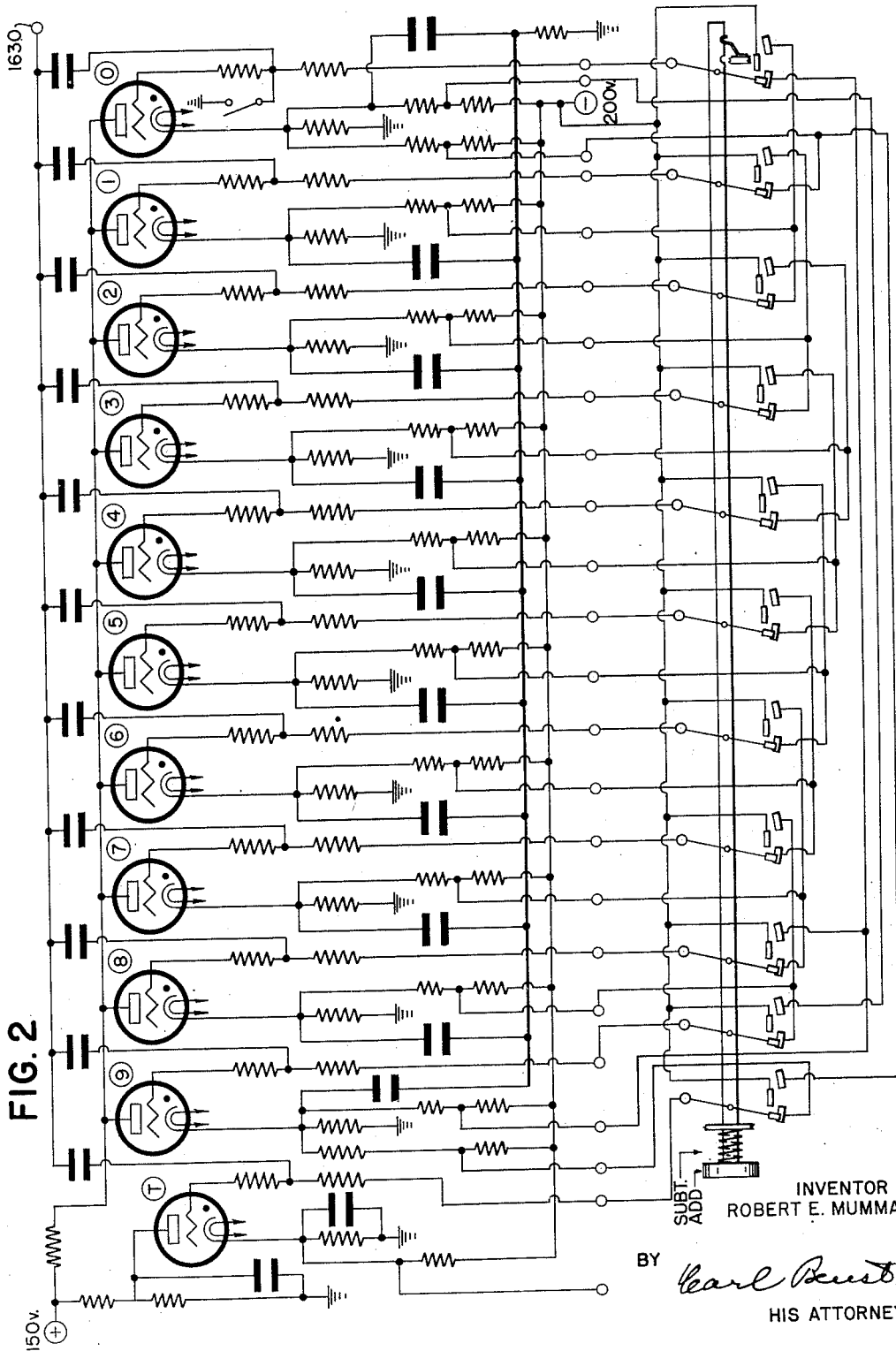
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UNITED STATES PATENT OFFICE

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SWITCHING DEVICE

Robert E. Mumma, Dayton, Ohio, assignor to The National Cash Register Company, Dayton, Ohio, a corporation of Maryland

Original application December 27, 1943, Serial No. 515,718. Divided and this application July 19, 1947, Serial No. 762,040

18 Claims. (Cl. 315—317)

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This invention relates to an electron tube relay switching device for selectively routing electric signals.

This is a division of my co-pending application for United States Letters Patent, Serial No. 515,718, filed December 27, 1943, for a Calculating device, which issued on June 1, 1948, as Patent No. 2,442,428.

The novel switching device disclosed herein provides a plurality of gaseous discharge electron tubes arranged in an operative pattern of rows, columns, and resultant diagonals. The terms "columns," "rows" and "resulting diagonals" as used herein are not used to refer to the physical location of the tubes of the switching device but rather are used as a means for setting forth the pattern of the network of connections by which the tubes are connected in various related groups to enable the selective routing of signals to be accomplished. These rows, columns, and diagonals utilize the same tubes, so that the pattern is overlaid, and thereby control potentials may be applied to a selected row of tubes and a selected column of tubes to actuate a selected tube so as to cause it to conduct and to send an electric signal out on a conductor connecting all the tubes on its associated diagonal.

The invention is especially adapted for use in distributing impulse data to a denominational product accumulator of a multiplying device, such as that shown in the aforementioned patent application, of which this is a division, wherein product data is distributed to different denominations of the product accumulator according to that particular digit of multiplier creating the product data which is then controlling. In such use of the device, each horizontal row of the electron tubes represents a particular multiplier and denomination, each column of tubes represents a particular multiplier denomination, and each diagonal output conductor represents a certain correlated denomination of the product accumulator. By an appropriate steady potential applied to the tubes of a selected column and by application of electric impulses applied to the tubes of a selected row, a certain one of the plurality of tubes is selected and caused to become conducting once in response to each impulse and to thereby create a corresponding number of relayed impulses on its associated diagonal output conductor. Each tube is arranged in a circuit so as to become self-extinguished immediately after becoming conducting, so as to be ready to respond to another impulse.

The electron tube relays respond in a matter of

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micro-seconds, and consequently the relaying of impulses may be accomplished very rapidly.

The electron tubes used are of the thyatron type having an anode, a cathode, and a control electrode, all immersed in an ionizable gas.

For the particular purpose of this disclosure, as an example only, the characteristics of the tube disclosed are such that, with an anode-cathode potential of approximately 70 volts, the tube will fire and become conducting when the control electrode becomes more positive than about 12 volts negative with respect to the cathode and wherein the anode-cathode potential drop is about 15 volts during conduction.

From the foregoing, it will be understood that the principal object of the invention is to provide an electronic device for relaying and routing electric impulse data.

With this and incidental objects in view, the invention includes certain novel features of construction, circuits, and combinations of parts, the essential elements of which are set forth in appended claims and a preferred form or embodiment of which is hereinafter described with reference to the drawings which accompany and form a part of this specification.

Of the drawings:

Fig. 1 shows a typical embodiment of the device having seven diagonal output channels.

Fig. 2 shows a denomination of an electron tube denominational accumulator of impulse data, showing the interrelation of such accumulator to the elements of Fig. 1 to provide for self-extinguishing of the tubes of Fig. 1 and to indicate how the relayed impulses may be utilized.

Values of potential, resistance, and capacitance, as given, are relative and are given as one set of values which result in proper operation with the specified tubes, but are not to be considered as limiting the invention, as the principles involved permit of different values and relations of values when other electron tubes are used. Potentials given are with respect to ground potential.

GENERAL DESCRIPTION

The tubes of the switching device are, as has been stated, members in three overlaid groupings. One grouping relates to tubes connected to the same diagonal output conductor. The second grouping relates to tubes having the same signal impulse conductor. The third grouping relates to tubes having the same grid priming conductor. In this showing, a signal impulse conductor joins tubes of a horizontal row, and a priming conductor joins tubes of a vertical row.

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In Fig. 1, the relay tubes are shown, and their grouping is as follows:

Diagonal grouping

Tubes	Output Terminal
1810.....	1600
2100, 1820.....	1630
2110, 2160, 1830.....	1640
2120, 2170, 2190, 1840.....	1650
2130, 2180, 2210, 2200.....	1660
2140, 2230, 2220.....	1670
2240.....	1680

Signal impulse grouping (horizontal)

Tubes	Input Terminal
2140.....	113
2130.....	112
2120, 2180, 2230, 2240.....	111
2110, 2170, 2210, 2220.....	110
2100, 2160, 2190, 2200.....	109
1810, 1820, 1830, 1840.....	108

Priming grouping (vertical)

Tubes	Priming Terminal
1810, 2100, 2110, 2120, 2130, 2140.....	1890
1820, 2160, 2170, 2180.....	2150
1830, 2190, 2210, 2230.....	2250
1840, 2200, 2220, 2240.....	2260

It is to be understood that the operational relation of the tubes is not dependent on the location of the tubes in space, as their coordinate relation is not dependent on the juxtaposition of the tubes themselves as long as they are connected by conductors in the pattern shown in Fig. 1.

Seventy volts anode potential is supplied to each tube. There is a separate potential source for the anodes of each diagonal row of tubes, and there is a 1,500-ohm resistor in series between each source and the anodes of its associated tubes. For instance, the source 1860 is connected through resistor 1870 to supply tube 1810 with anode potential. The following table gives the other anode potential sources and the diagonal group of tubes supplied by each.

Potential Source	Tubes
2230.....	2100, 1820
2290.....	2110, 2160, 1830
2300.....	2120, 2170, 2190, 1840
2310.....	2130, 2180, 2210, 2200
2320.....	2140, 2230, 2220
2330.....	2240

The grid of a tube is connected conductively to a source of biasing potential and is also coupled electrostatically to the signal impulse conductor of its associated row. Thus, for instance, the grid of tube 1810 is connected to terminal 1890, from which it receives its bias potential, and is also coupled electrostatically to signal impulse input terminal 108 by way of conductor 1895 and capacitor 1850 of .001 microfarad. All tubes in a column have the same bias potential source, and all the tubes in a row are coupled electrostatically to the same signal impulse conductor.

The cathodes of the tubes which are associated in a diagonal group are connected to a common diagonal output conductor which is grounded

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through a resistor of 50,000 ohms, like resistor 1890 furnishing cathode potential to tube 1810.

It will now be apparent that, to prevent the tubes of a column from conducting, a controlling bias potential may be placed on the common bias supply terminal for that column. When a column is to be primed, this bias potential is reduced to near the critical value, and then a positive potential impulse of small magnitude on a signal impulse conductor will cause the tube thereby selected to fire. When a tube fires, its cathode rises in potential due to the resistance in its cathode circuit. The output terminal for a diagonal row is coupled to the cathodes of the tubes of the row through a capacitor, and, as any tube of the row fires, a positive impulse is impressed through said capacitor. Thus the capacitor between terminal 1650 and the cathode of the tube 1840 serves to couple all of the tubes of the associated diagonal—namely, tubes 1840, 2190, 2170, and 2120—to said output terminal 1650.

As this switching device is embodied in the multiplying device of my co-pending application to which reference has been made and of which this is a division, priming terminals 1890, 2150, and 2250 are given a normally controlling bias of 63 volts with reference to the cathode potential, which is relieved to about 18 volts in the primed condition. Any one or all of the columns may be placed in primed condition by application of the proper potentials to the selected priming terminals.

It will be apparent that the magnitude of the signal impulses should be such as to discriminate between a primed tube and an unprimed tube. For the values of potential given, positive signal impulses of from 20 to 40 volts and of fairly steep wave front will give reliable operation.

As has been said, each time a tube fires, it is extinguished immediately due to circuit elements permitting a high initial surge of current through a fired tube followed by a sudden lowering of the current. This results in an oscillatory rise in potential of the cathode by reason of the distributed inductance of the wiring, causing a temporary cessation of anode-cathode potential and deionization of the tube, allowing the control element to resume its control.

In the disclosed embodiment of the invention, the elements contributing to cause the high initial current in a tube of Fig. 1 as it fires are the capacitor joining any one of the diagonal output conductors to its output terminal and the coupling of such output terminal to the corresponding input terminal of a denominational bank of an electronic accumulator, as is shown in Fig. 2. For instance, terminal 1630 (Fig. 1) is shown coupled to terminal 1630 (Fig. 2) and the input conductor of the counting ring shown therein. This input conductor is connected capacitatively to the grid bias negative potential source of each of the digit-representing tubes of Fig. 2 numbered 0 to 9 inclusive. Thus, the diagonal output conductor joining the tubes 2100 and 1820 (Fig. 1) is coupled to ground and to one side of a capacitor whose other side is connected to terminal 1630, which in turn is coupled capacitatively to a source of bias potential. Thus, as either tube 1820 or 2100 fires, the capacitor coupling its cathode to terminal 1630 discharges through the tube, causing a high momentary current, which is suddenly reduced sharply by the presence of the cathode resistor as the capacitor is discharged. The distributed inductance in the wiring causes the cathodes of tubes

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1820 and 2100 to rise in a positive direction, momentarily, to a point more positive than the anode supply potential, thus extinguishing the tube that was conducting.

It will be understood that the particular embodiment of the invention shown herein was taken from my co-pending application Serial No. 515,718, wherein the coupling of a diagonal output conductor through a capacitor to an input conductor of a counting ring, which input conductor itself is coupled to a source of potential, was merely the use of a convenient electrostatic power source to cause the temporary high current in the firing tube. The same effect could be secured by coupling an output terminal, like terminal 1630, directly to a source of potential.

As each output group of tubes is supplied separately with potential, adjustment may be made in the circuit constants of a particular group to adjust the output impulse strength. A means also is provided, as shown in Fig. 1, wherein point 2340 is connected through a resistor 2370 to a source of potential, for loading an output terminal for additional adjustment of the output impulses. By the foregoing two means, the output signals from any diagonal output conductor may be adjusted to the demands of the particular devices into which they are fed.

While the invention is shown in the specification and drawings in a preferred embodiment, the principle thereof is not confined to it but is susceptible of embodiment in various forms coming within the scope of the claims.

What is claimed is:

1. In a selective switching device, the combination of a plurality of electron tubes, each tube having at least an anode, a cathode, and means to control conduction therein; a plurality of input conductors on which input signals may be impressed; means coupling the input conductors to the control means of the tubes to form a plurality of input row groups of said tubes, each row group containing one or more tubes; a plurality of switching control circuits connecting the tubes of the row groups into control column groups of one or more tubes, any column group having no more than one tube of any row group, said control circuits being connected to the control means of the tubes of their related column groups and supplying the control means normally with a bias potential which will prevent the input signals from causing conduction in the tubes, which potential can be modified selectively in any of the control circuits to relieve the bias and prime the tubes of the selected column group to respond to input signals; and further means connecting the tubes of the input row groups and control column groups into parallel groups diagonal to the input row groups and to the control column groups, said further means including a separate anode-cathode potential supply circuit for the tubes of each diagonal group, an output conductor for each diagonal group and couplings between the tubes of a diagonal group and the output conductor to cause an output signal on the output conductor whenever a tube in its related diagonal group conducts; said input conductors and their coupling to the tubes and said switching control circuits cooperating to control the conduction in the tubes to enable input signals on any predetermined set of input conductors to cause output signals to occur selectively on different sets of diagonal group output conductors.

2. In a selective switching device, the combi-

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nation of a plurality of gaseous discharge electron tubes, each tube having at least an anode, a cathode, and means to control conduction therein; a plurality of input conductors on which input signals may be impressed; means coupling the input conductors to the control means of the tubes to form a plurality of input row groups of said tubes, each row group containing one or more tubes; a plurality of switching control circuits connecting the tubes of the row groups into control column groups of one or more tubes, any column group having no more than one tube of any row group, said control circuits being connected to the control means of the tubes of their related column groups and supplying the control means normally with a bias potential which will prevent the input signals from causing conduction in the tubes, which potential can be modified selectively in any of the control circuits to relieve the bias and prime the tubes of the selected column group to respond to input signals; and further means connecting the tubes of the input row groups and control column groups into parallel groups diagonal to the input row groups and to the control column groups, said further means including a separate anode-cathode potential supply circuit for the tubes of each diagonal group, said anode-cathode potential supply circuits having values of resistance, capacitance and inductance which cause the tubes to be self-extinguished after having been rendered conducting, an output conductor for each diagonal group and couplings between the tubes of a diagonal group and the output conductor to cause an output signal on the output conductor whenever a tube in its related diagonal group conducts; said input conductors and their coupling to the tubes and said switching control circuits cooperating to control the conduction in the tubes to enable input signals on any predetermined set of input conductors to cause output signals to occur selectively on different sets of diagonal group output conductors.

3. A plurality of electron tubes; and means connecting the tubes in a square operative pattern of rows and columns having resultant parallels diagonal to the rows and columns, said means including a common operating energy supply for all the tubes on the same diagonal, a common input circuit for all the tubes in a row, and a common control circuit for all the tubes in a column; said input circuits and control circuits cooperating to select the diagonals in which tubes will operate.

4. A plurality of gaseous electron tubes arranged in a square operative pattern of rows and columns having resultant parallels diagonal to the rows and columns; a common operating energy supply for all the tubes on the same diagonal; an output circuit related to each diagonal of the pattern; means coupling the output circuit to the tubes of the related diagonal to be energized each time one of the tubes of the related diagonal operates; a common input impulse circuit for all the tubes in a row; and a common control circuit for all the tubes in a column; said input circuits cooperating to control the operation of the tubes to select which output circuits will be energized by input impulses on the input circuits.

5. A plurality of electron tubes, each of said tubes having at least an anode, a cathode, and a control element; and means connecting the tubes in an operative switching network pattern of input rows, control columns and resultant out-

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put parallels diagonal to the rows and columns, said network including an anode-cathode electric supply circuit common to the tubes of each output diagonal, an output conductor related to the tubes of each output diagonal, means coupling the output conductors to the tubes of their related diagonals to enable an output signal to be impressed on an output conductor each time a tube in its related diagonal operates, a control element electric supply circuit common to the tubes of each control column, and an input signal circuit common to the control elements of the tubes of each input row, the input signal circuits and control element electric supply circuits cooperating to control the operation of the tubes to determine on which output circuits output signals will be produced by input signals on the input signal circuits, whereby input signals on a related group of input circuits can cause output signals to appear on a selected one or another related group of output conductors as controlled by the control element electric supply circuits.

6. A plurality of gaseous electron tubes each tube having at least an anode, a cathode and a control element; and means connecting the tubes in a switching network having an operative pattern of a plurality of input rows, a plurality of control columns, and a plurality of output parallels diagonal to the rows and columns, the network including an anode-cathode electric supply circuit common to the tubes of each diagonal, an output circuit for each output diagonal, means coupling the output circuits to the cathodes of the tubes of their related diagonal to receive an output impulse when any tube of the diagonal conducts, a control element electric supply circuit common to the tubes of each control column, and a signal input impulse circuit coupled to the control elements of the tubes of each input row, the signal input circuits and the control element electric supply circuits cooperating to control conduction in the tubes to determine on which output circuits output impulses will be produced as a consequence of input impulses on input circuits, the controls enabling input impulses on a related group of input circuits to cause output impulses to appear selectively on one or other related groups of output circuits as determined by the control exerted by the control element electric supply circuits.

7. A plurality of electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including a separate common control element electric supply circuit common to all the tubes in a column group for supplying normal disabling bias to the tubes of the group, which bias if reduced in a circuit primes the tubes of the column group for operation; means connecting the tubes of the column groups in row groups squared to the column groups so that a row group will have but one tube from a given column group, said means including a separate input signal circuit common to all the tubes in a row group, signals on said signal input circuits being effective to cause the operation only of primed tubes; and means connecting the tubes of row groups and column groups in parallel groups diagonal to the row and column groups, said means including a separate anode-cathode electric supply circuit common to all the tubes in a diagonal group.

8. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the

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tubes in column groups, said means including an electric potential bias circuit common to all the control elements of the tubes of a column group, said circuits each being normally furnished with sufficient potential to prevent conduction in any associated tube which bias may be relieved selectively to prime tubes of any column group; means connecting the tubes of the column groups in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means including a separate input conductor electrostatically connected to each of the control elements of the tubes of a row group; and means further connecting the tubes of the row groups and the column groups in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said further connecting means including an anode-cathode electric supply circuit common to the tubes of a diagonal group.

9. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including an electric potential bias circuit for each column group and connected to all the control elements of the tubes of the related column group, said circuits each being normally furnished with sufficient potential bias to prevent conduction in any associated tube in response to input signals which bias is relieved selectively to prime the tube of any column group to enable them to respond to input signals; means connecting the tubes of the column groups in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means including a separate input conductor coupled to the control elements of the tubes of a row for impressing input signals on the tubes; and means further connecting the tubes of the row groups and the column groups in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said further connecting means including an anode-cathode electric supply circuit common to the tubes of a diagonal group.

10. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including an electric potential bias circuit common to all the control elements of the tubes of a column group, said circuits each being normally furnished with sufficient potential to prevent conduction in any associated tube in response to input signals, which potential can be modified selectively on the bias circuits to reduce the bias and prime the tubes of the selected column group to enable them to respond to input signals; means connecting the tubes of the column groups in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means including a separate input conductor electrostatically connected to each of the control elements of the tubes of a row group for applying input signals thereon; and means connecting the tubes of the row groups and column groups in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said connecting means including an anode-cathode electric supply circuit common to the

tubes of a diagonal group, said supply circuits having values of resistance, capacitance, and inductance which cause a tube in the circuit to be self-extinguished when rendered conducting.

11. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including an electric potential bias circuit common to the control elements of all the tubes of a column, each of said circuits being connected to the control elements of the tubes of a related column group and normally furnishing the control elements of the column group with sufficient potential to prevent conduction in any associated tube in response to input signals, which potential if modified on the circuits selectively will relieve the bias and allow the tubes of a selected column group to respond to input signals; means connecting the tubes of said column groups in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means including a common input conductor electrostatically connected to the control elements of the tubes of a row group to impress input signals thereon; means connecting the tubes of the row and column groups in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said connecting means including an anode-cathode electric supply circuit common to the tubes of each diagonal group; and means to prepare the tubes of a column to fire by relieving the controlling bias potential to near the critical point.

12. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including an electric potential bias circuit related to each column group and connected to all the control elements of the tubes of its related column group, said circuits each being normally furnished with sufficient potential to prevent conduction in any associated tube which potential can be modified selectively on the bias circuits to reduce the bias and prime the tubes of the selected column; means connecting the tubes in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means including a common input conductor electrostatically connected to the control elements of the tubes of a row group and upon which signals are impressed which are ineffective on unprimed tubes; means connecting the tubes in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said connecting means including an anode-cathode electric supply circuit common to the tubes of a diagonal group; said input conductors and bias circuits co-operating to control the selective operation of the tubes to govern in which diagonal group a tube will operate when a signal is impressed on the input conductors; a plurality of output means; and means coupling an output means to the tubes of a diagonal group to enable an output signal to be impressed on the output means each time a tube of its related diagonal group operates.

13. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including an electric potential bias circuit connected to all the

control elements of the tubes of a column group, said circuits each being normally furnished with sufficient potential to prevent conduction in any associated tube, said potential when modified on any selected circuit enabling the tubes of that column group to conduct in response to input signals; means connecting the tubes of the column groups in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means impressing input signals on the tubes of the row groups and including a common input conductor electrostatically connected to the control elements of the tubes of a row group; means further connecting said tubes in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said further connecting means including an anode-cathode electric supply circuit common to the tubes of a diagonal group; and means to cause a selected tube to conduct by relieving the bias on the column group in which the tube is located and simultaneously impressing a positive impulse on the input conductor for the row group in which the tube is located.

14. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including an electric potential bias source circuit common to all the control elements of the tubes of a column group, said circuits each being normally furnished with sufficient potential to prevent conduction in any associated tube which potential can be selectively modified to allow tubes of any selected column group to respond to input signals; means connecting the tubes of the column groups in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means impressing input signals on related row groups and including a separate input conductor electrostatically connected to the control elements of the tubes of a row group; and means connecting said tubes in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said connecting means including an anode-cathode circuit common to the tubes of a diagonal group, said circuit including a common cathode potential supply source and a resistance in parallel with a capacitor connecting said source with said cathodes.

15. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including an electric potential bias source circuit for each column group and connected to all the control elements of the tubes of a related column group, said circuits each being normally furnished with sufficient potential to prevent conduction in any associated tube in response to input signals, which bias may be relieved selectively on any circuit to enable the tubes of the related column group to respond to input signals; means connecting the tubes in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means enabling input signals to be impressed on the row groups and including a separate input conductor for each row group which is electrostatically connected to the control elements of the

tubes in a related row group; and means connecting the tubes in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said connecting means including an anode-cathode circuit common to the tubes of a diagonal group, said circuit including a common cathode potential supply source and a resistance in parallel with a capacitor connecting said source with said cathodes, the values of resistance and capacitance in combination with normal distributed wiring inductance causing any conducting tube to become extinguished by cessation momentarily anode-cathode potential.

16. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including an electric potential bias source circuit for each column group and connected to the control elements of all the tubes of its related column group, said circuits each being normally furnished with sufficient potential to prevent conduction in any associated tube in response to input signals, which bias may be relieved selectively on any circuit to enable the tubes of the related column group to respond to input signals; means connecting the tubes in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means including a separate input conductor electrostatically connected to the control elements of the tubes of a row group to impress input signals thereon; means connecting the tubes in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said connecting means including an anode-cathode circuit common to the tubes of a diagonal group, the cathode portion of said circuit including a common cathode potential supply source and a resistance in parallel with a capacitor connecting said source with said cathodes, the values of resistance and capacitance in combination with normal distributed wiring inductance causing any conducting tube to become extinguished; and an output circuit connected to the cathodes of the tubes of a diagonal group, which output circuit is given a potential impulse as any associated tube commences to conduct.

17. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including an electric potential bias source circuit common to all the tubes of a column group, said circuits each being normally furnished with sufficient potential to prevent conduction in any associated tube; means connecting the tubes in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means including a separate input conductor electrostatically connected to the control elements of the tubes of a row group; means connecting the tubes in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said connecting means including an anode-cathode circuit common to the tubes of a diagonal

group, the cathode portion of said circuit including a common cathode supply source and a resistance in parallel with a capacitor connecting said source with said cathodes, the values of resistance and capacitance in combination with normal distributed wiring inductance causing any conducting tube to become extinguished; an output circuit connected to the cathodes of the tubes of a diagonal group, which output circuit is given a potential impulse as any associated tube commences to conduct; and means to relieve the normal bias potential on the tubes of any column group to near the critical point where a tube in the column group may be fired to the exclusion of any other tube by impressing a potential impulse on its input conductor sufficient to overcome the relieved bias but insufficient to fire other normally biased tubes of the row group.

18. A plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element; means connecting the tubes in column groups, said means including an electric potential bias source circuit common to all the tubes of a column group, said circuits each being normally furnished with sufficient potential to prevent conduction in any associated tube; means connecting the tubes in row groups squared to the column groups so that a row group will have but one tube from a given column group, said connecting means including a separate input conductor electrostatically connected to the control elements of the tubes of a row group; means connecting the tubes in parallel groups diagonal to the row and column groups, no diagonal group having more than one tube in any row or column group, said connecting means including an anode-cathode circuit common to the tubes of a diagonal group, the cathode portion of said circuit including a common cathode supply source and a resistance in parallel with a capacitor connecting said source with said cathodes, the values of resistance and capacitance in combination with normal distributed wiring inductance causing any conducting tube to become extinguished; an output circuit connected to the cathodes of the tubes of a diagonal group, which output circuit is given a potential impulse as any associated tube commences to conduct; means to relieve the normal bias potential on the tubes of any selected column group toward the critical firing point; and means to impress a positive potential impulse on any input conductor sufficient to fire a tube in the row group having its bias potential relieved, whereby any selected tube of the plurality may be rendered momentarily conducting to furnish an electric impulse to its associated output circuit.

ROBERT E. MUMMA.

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