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ELECTRONIC DEVICE AND CONTROL MEANS THEREFOR

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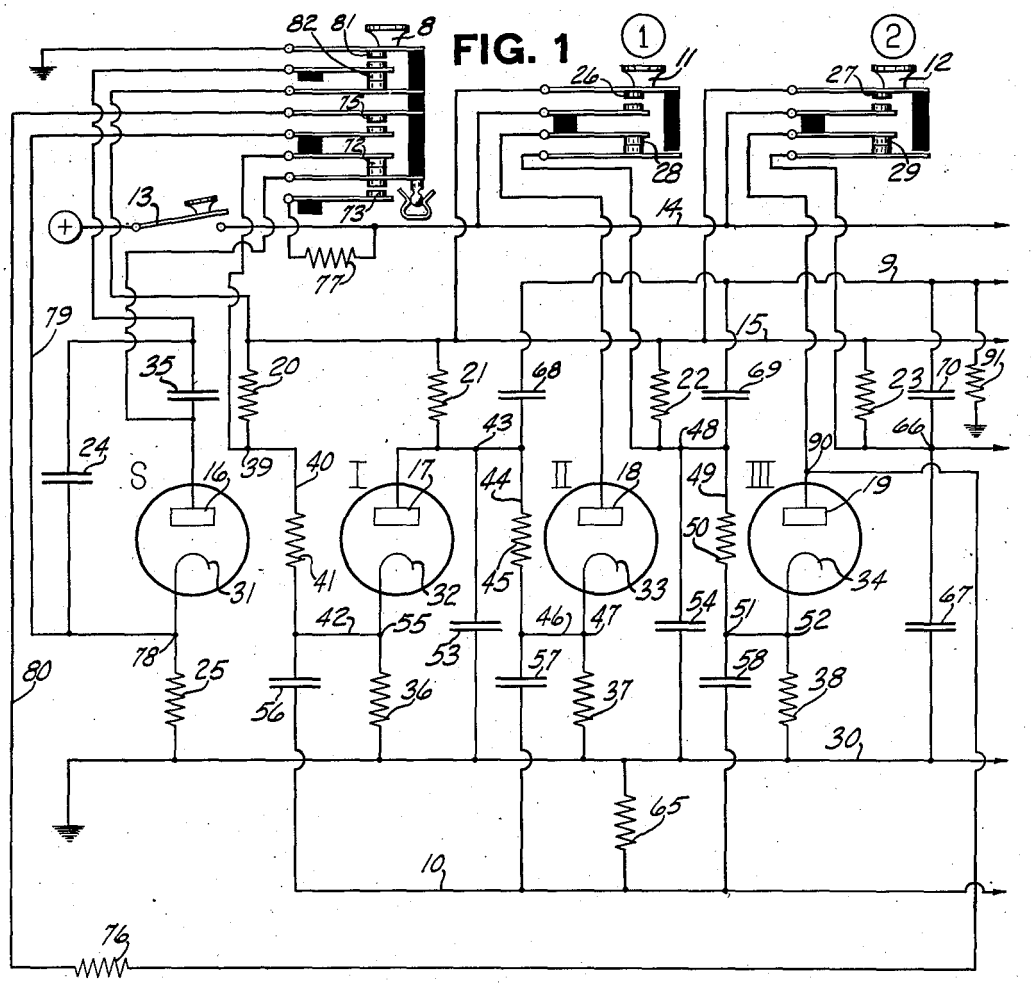
FIG. 1



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ELECTRONIC DEVICE AND CONTROL MEANS THEREFOR

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10 Claims. (Cl. 177—380)

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This invention relates to means for producing a selected number of electrical impulses at high speed by the differential operation of a series of electronic devices.

The invention more particularly pertains to the automatic sequential operation of a selected number of a plurality of interconnected cold cathode electron tubes having a common output conductor, which conductor is given an electric potential impulse on the operation of any of the associated electron tubes.

The use of electric impulses to actuate accounting devices and other devices dealing with digital data or other data represented by impulses has created a need for a simple and rapid method of producing such impulses in any desired number. This invention provides an electrical network and circuits interconnecting a plurality of cold cathode diode electron tubes that are rendered conductive one after another at intervals of a few micro-seconds, the state of conductivity of one tube causing conduction to commence in the next tube of the series until the selected number of electron tubes have been operated. The change from a state of non-conductivity to a state of conductivity of any of the electron tubes in the series causes an electric potential impulse in a common output conductor. Means is also provided to stop the sequential operation of the plurality of electron tubes at any desired point so that a selected number of electric potential impulses is impressed on the output conductor.

Another feature of the invention is that the circuit permits the automatic sequential operation of the series in either direction, depending at which end of the series the operation is initiated.

Therefore it is the principal object of this invention to provide means to connect a plurality of cold cathode diode electron tubes in a series for automatic successive operation in either direction.

Another object of the invention is to provide means to determine what number of the plurality of electron tubes shall be made to operate in succession.

Another object of the invention is to provide means to cause each electron tube, when operated, to produce an electric potential impulse in a common conductor.

With these and incidental objects in view, the invention includes certain novel features of construction and combinations of parts, the essential elements of which are set forth in appended claims and a preferred form or embodiment of

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which is hereinafter described with reference to the drawing which accompanies and forms a part of this specification.

The drawing, the figure shows an electrical network and circuit connecting a plurality of cold cathode and electron tubes for automatic successive operation, an output conductor, and control devices.

General description

Referring to the drawing, three cold cathode diode gas discharge electron tubes, designated "I," "II," and "III," are shown as the beginning portion of a plurality of electron tubes of any desired number connected together in a group for successive operation. The cold cathode diode electron tube S is provided for starting the automatic successive operation of the tubes of the group in either direction. It will be obvious that hot cathode diodes may be used in place of cold cathode diodes without departing from the principles of the invention. Tubes I, II, and III represent those connected to output conductors 9 and 10 and may represent data, numerical or otherwise. The operation of any one of said electron tubes I, II, III, etc., produces a negative electric potential impulse on output conductor 9 and a positive electric potential impulse on output conductor 10. The data-representing tubes I, II, and III are normally connected to operate under control of keys 11 and 12 serially from I to III or, if reversing key 8 be used in conjunction with the said keys, from III to I.

The two keys 11 and 12 represent tubes I and II, respectively. Operation of key 11, followed by operation of starting key 13, will cause the tubes S and I to become conductive successively. Operation of key 12 in conjunction with the starting key 13 will cause the tubes S and I and II to become conductive successively. Thus, by the use of key 11 in conjunction with the starting key 13, a single electric potential impulse is produced in the output conductors 9 and 10, and, by the use of key 12 in conjunction with key 13, two electric potential impulses are produced in conductors 9 and 10.

Operation of reversing key 8, key 11, and key 13 in conjunction, in the order named, will cause tubes S and III to become conductive. Operation of key 8 in conjunction with key 13 will cause tubes S, III, II, and I to become conductive in that order. Only two keys, like keys 11 and 12, are shown, but the principle which will be exemplified in the explanation which follows is applicable to any number of tubes like tubes I, II, and III and associated keys, like keys 11 and 12.

The cold cathode gas discharge diode electron tubes S, I, II, and III, which have been selected for a typical embodiment of the invention, have a breakdown requirement of 225 volts for starting a cathode-anode discharge and a potential drop in a discharging tube of approximately 70 volts. Values of operating potentials, resistors, and capacitors are given as an example only as desirable to be used with a tube of the characteristics mentioned and should not be deemed to limit the invention.

Common to tubes S, I, II, and III is a conductor 14 carrying a source of anode potential of 500 volts positive with respect to ground when starting key 13 is closed. A common conductor 15 is provided, to which the anodes 16, 17, 18, and 19 are normally connected, each through a linear resistor of 150,000 ohms, respectively numbered 20, 21, 22, and 23. Operation of the "1" key 11 closes contacts 26 connecting the conductor 14 to conductor 15 and opens contacts 28, disconnecting anode 18 of the "II" tube from conductor 15. Operation of the "2" key 12 closes contacts 27 connecting the conductor 14 to conductor 15 and opens contacts 29, disconnecting anode 19 of tube III from conductor 15. Thus, operation of the "1" key connects the anodes of all except the "II" tube to the anode supply conductor 14, and operation of the "2" key connects the anodes of all except the "III" tube to the anode supply conductor 14.

Each of the cathodes 31, 32, 33, and 34 is connected to a grounded conductor 30 through 150,000-ohm linear resistors, numbered 25, 36, 37, and 38, respectively.

The anode of each tube is connected to the cathode of the tube following in the series of tubes S, I, II, and III through a linear resistor of 200,000 ohms. Thus, anode 16 of the "S" tube is normally connected to cathode 32 of the "I" tube through contacts 72, point 39, conductor 40, resistor 41 of 200,000 ohms, and conductor 42 to point 55. Anode 17 of tube I is connected to cathode 33 of the tube II through point 43, through a conductor 44, a resistor 45 of 200,000 ohms, and conductor 46 to point 47. Anode 18 of tube II is connected to cathode 34 of tube III through contacts 28, point 48, conductor 49, resistor 50 of 200,000 ohms, conductor 51, and point 52. Points 43, 48, and 66 are respectively grounded through condensers 53, 54, and 67, each of .01 microfarad capacity.

The electron tubes are therefore symmetrically connected to a gridlike system of resistances connecting potential supply conductors.

If the "1" key 11 is depressed, closing contacts 26 and opening contacts 28, and the starting key 13 is thereafter closed, anode voltage is applied to the "S," "I," and "III" tubes, and the "II" tube is disconnected. Capacitors 53, 54, 67, 68, 69, and 70 charge.

Anode 17 of the "I" tube tends to become 350 volts positive with respect to ground, being connected through resistor 21 of 150,000 ohms to the 500-volt positive conductor 15 and being connected to ground through resistor 45 of 200,000 ohms and resistor 37 of 150,000 ohms. Anode 18 of the "II" tube receives no potential. Cathode 32 of the "I" tube tends to become 150 volts positive with respect to ground, being connected at point 55 through resistor 36 of 150,000 ohms to ground and to the 500-volt conductor 15 through resistor 41 of 200,000 ohms, point 39, and resistor 20 of 150,000 ohms. Anode 16 of the "S" tube would tend immediately to assume the 350-volt potential of point 39, as determined by resistors

20, 41, and 36, and cathode 31 would remain at ground potential, being connected through resistor 25 of 150,000 ohms to conductor 30, were it not for capacitor 35 of .01 microfarad normally connecting anode 16 through contacts 82 to the 500-volt supply conductor 15 and capacitor 24 of .01 microfarad connecting the cathode 31 to the same 500-volt supply conductor through the same contacts 82.

Due to the charging of capacitors 24 and 35, at the first instant after the closing of switch 13, the cathode 31 and anode 16 of the "S" tube rise toward 500 volts, and, as the capacitors 24 and 35 charge, the cathode 31 drops back toward ground potential and the anode 16 drops toward the 350-volt potential which point 39 has by that time assumed. At the instant that the potential difference between the anode and the cathode of tube S thus becomes 225 volts or more, conduction occurs in the tube S, and the anode potential drops to about 240 volts positive with respect to ground, due to the combined effect of resistors 25, 20, 41, and 36. Just before tube S became conductive, the potential difference between the anode and the cathode of the "I" tube was 200 volts, as has been explained, and no conduction occurred. As the "S" tube begins conducting, the potential of point 39, dropping suddenly by approximately 110 volts, causes a potential fall at point 55, bringing the cathode 32 of the "I" tube to a potential more than 225 volts negative with respect to anode 17, which condition initiates conduction in tube I. The potential change at point 55 is determined by the ratio of the resistor 41 to resistor 36, since these resistors are, in effect, a voltage divider. As conduction begins in tube I, point 43 receives a drop in potential from the normal 350 volts to 265 volts, which drop in potential is impressed on point 47 and is sufficient to begin conduction in tube II were the anode 18 of the "II" tube connected to the supply conductor 15. However, due to the opening of contacts 28, anode 18 receives no operating potential. Thus, only the "I" tube, of tubes I, II, and III, is rendered conductive, as conduction in tube II is necessary to cause tube III to break down.

If the "2" key 12 were operated in conjunction with key 13 instead of the "1" key 11, as described, the conduction would occur in the "S," "I," and "II" tubes successively, as the "II" tube would then have anode potential, whereas the "III" tube anode would be disconnected.

Therefore, operating the "1" key 11 in conjunction with the starting key 13 causes the "S" and the "I" tubes to conduct in succession, and the "2" key 12 used in conjunction with the starting key causes the "S," "I," and "II" tubes to conduct in succession. Such successive conduction may occur with any number of tubes connected as shown.

Operation of key 8 in conjunction with a key 11 or 12 and with the key 13, in that order, causes the data-representing tubes "I", "II", and "III" to be operated serially in reverse order. Operation of key 8 opens contacts 72, disconnecting anode 16 from point 39 so that the conduction in tube S will not break down tube I, closes contacts 73 to connect anode 16 through resistor 77 of 150,000 ohms to the anode supply conductor 14, closes contacts 75, which connects cathode 31 of the "S" tube by means of conductor 80, through resistor 76 of 200,000 ohms, to anode 19 of the "III" tube, opens contacts 82 disconnecting capacitors 24 and 35 from conductor 15, and closes

contacts 81 grounding capacitors 24 and 35. This switching action of key 8 causes the rise in potential of cathode 31 of tube S, on conduction of tube S to be impressed on the anode of the last tube of the series, tube III in this embodiment, which causes the sequential operation of tubes I, II, and III to commence with the "III" tube and to proceed toward the "I" tube until stopped by reason of the operation of a key, like key 11, which disconnects the anode of the tube next higher in order from the source of anode potential. Considering the specific example of operating the key 11, the key 8, and the key 13, in the order given, the "S" tube will begin conducting, followed by conduction in the "III" tube. Operation of key 8 connects point 78 with point 90 by closing contacts 75, disconnects the anode 16 from point 39 by the opening of contacts 72, and connects anode 16 to conductor 14 through resistor 77 of 150,000 ohms by the closing of contacts 73. Under these conditions, when starting key 13 is closed, anode 16, which is connected to the 500-volt conductor 14, and cathode 31 are temporarily grounded by the charging of the now grounded capacitors 24 and 35. The anodes and the cathodes of tubes I, II, and III assume their potentials, as has been explained in the example or normal operation, and capacitors 53, 54, 67, 68, 69, and 70 are charged as capacitors 24 and 35 are being charged. Thereafter, point 78 and cathode 31 rise toward 150 volts positive, and anode 16 rises toward 500 volts positive. Tube S breaks down when anode 16 and cathode 31 reach a potential difference of 225 volts, and conduction begins therein, whereupon the cathode 31 rises still further to about 260 volts due to the combined action of resistors 77, 25, 76, and 23. Under these conditions, point 90 and anode 19 of tube III, before tube S begins conducting, and while capacitor 24 is charging, are about 350 volts positive, being connected to point 78 through resistor 76 of 200,000 ohms, which is grounded through resistor 25 of 150,000 ohms and connected to the 500-volt conductor 15 through resistor 23 of 150,000 ohms. Cathode 34 being at 150 volts positive with respect to ground and anode 19 being at 350 volts positive, tube III will not conduct. As tube S begins conducting, point 78 reaches 260 volts, causing anode 19 to rise toward 400 volts,, which causes tube III to break down. On tube III conducting, point 52 rises in potential from 150 volts positive with respect to ground to 245 volts, which potential rise in part is impressed on point 48 and, if plate 18 of tube II were not disconnected by reason of key 11 being depressed, would be sufficient to cause the tube II to break down, followed by tube I breaking down, as cathode 33 would rise from 150 volts to about 240 volts.

The normal sequential operation of the tubes from I to III is initiated and maintained by the drop in potential of the anode as a tube begins conducting, breaking down the following tube, whereas in the reverse sequential operation the cathode rise in potential is so utilized.

The operation-initiating impulse is taken from the anode of the starting tube S for normal operation and from the cathode of the starting tube S for reverse operation.

In considering tubes I, II, and III, extended into a series of ten, each tube representing a digit in a denomination of the decimal system, including a zero tube following the tube representing nine, it will be apparent that operation of such a series in reverse will cause a number of tubes to conduct in sequence, which represents the complement, on the base of nine, of the digit represented by the data key depressed. For instance, if a key associated with the tube representing "five" is operated in conjunction with keys like 8 and 13, the tubes S and 0 and tubes representing IX, VIII, and VII would be operated in the order named, the tube 0 and the supposed tubes IX, VIII, and VII being four in number, which is the complement of five on the base of nine. Thus, by the use of the same data key, represented by the keys 11 and 12, either data representing a number or its complement may be derived in the form of electric potential impulses impressed on output conductors 9 and 10 in a manner to be described.

The starting tube S and the three data tubes I, II, and III and their interconnections shown in the drawing are sufficient to illustrate how any number may be so interconnected.

Between point 43 and ground wire 30 is a capacitor 53 of .01 microfarad, which acts as an energy reserve by charging before tube I breaks down, causing a strong sharp positive potential impulse at point 55 when the "I" tube begins to conduct. Anode 17 is kept from dropping to its final potential while capacitor 53 is discharging, thus causing the cathode 32 to rise momentarily to about 300 volts above ground potential, after which it drops back to about 190 volts. Similar capacitors 54 and 67 are shown connected to the anodes of the "II" and the "III" tubes, respectively, and are provided for the same purpose in connection with the potential impulse produced at points 47 and 52. It will be apparent that anodes 17, 18, and 19 will drop in potential after the discharge of capacitors 53, 54, 67, 68, 69, and 70, due to conduction in the associated tubes, causing a negative impulse at points 43, 48, and 66.

Output conductor 10, grounded through a 100,000-ohm resistor 65, is connected to each of the cathodes of the tubes I, II, III, etc., each through a capacitor of .002 microfarad, like capacitors 56, 57, and 58, and receives a positive potential impulse of approximately 150 volts each time one of the tubes I, II, III, etc., becomes conductive. Output conductor 9, grounded through a 10,000-ohm resistor 91, is connected to each of the anodes through a capacitor like capacitors 68, 69, and 70, each of .002 microfarad, and conductor 9 receives a negative potential pulse each time one of said tubes becomes conductive.

Thus, by depressing the "1" or "2" key in conjunction with starting key 13, one or two positive potential impulses may be sent out on the conductor 10, and one or two negative potential impulses may be sent out on conductor 9. With the values given for the resistors and the capacitors, the total time elapsing for the operation of the several tubes shown is a matter of a few micro-seconds.

In the example of normal operation given with the "1" key 11 depressed, the anode plate 18 of the "II" tube was given no positive potential; consequently tube II did not become conductive, and the cathode 34 of the "III" tube did not receive the negative potential impulse necessary to cause tube III to fire. Thus, the operation of keys 11 or 12 not only interrupts the anode potential of the next higher tube, rendering conduction therein impossible, but also interrupts the delivery of the initiating impulse, which otherwise would cause a conduction in the following tubes in sequence.

Any method other than starting key 13 may be

used to connect the anode source of potential to conductor 15, and any method other than keys 11 and 12 may be used to interrupt the successive operation of the tubes, without departing from the principle governing the automatic and successive operation of the tubes. It will also be apparent that the negative or positive impulse necessary to initiate a normal or reverse sequential operation of the data tubes may be derived from any desired source other than tube S.

While the form of mechanism herein shown and described is admirably adapted to fulfill the objects primarily stated, it is to be understood that it is not intended to confine the invention to the one form or embodiment herein disclosed, for it is susceptible of embodiment in various forms all coming within the scope of the claims which follow.

What is claimed is:

1. In combination, a plurality of cold cathode gas discharge tubes; means including a resistance connecting the anode of one tube with the cathode of another tube; common means for supplying anode-cathode potential to the tubes slightly under that necessary to cause conduction therein, said means including a resistance between each anode and the common supply means; and means to cause the cathode potential of one tube to become more negative to the point of causing conduction in said tube, said ensuing conduction causing a drop in anode potential, due to the resistance between the anode and the supply means, which drop in potential is impressed on the cathode of the tube to which the anode is connected, such cathode drop in potential in the second-mentioned tube causing conduction to commence therein, and by the same method to cause conduction in all the tubes in sequence.

2. In combination, a plurality of cold cathode gas discharge tubes each having an anode and a cathode; a positive electric supply conductor; a negative electric supply conductor, the potential difference between said positive and negative conductors being greater than the breakdown potential of a tube; a plurality of similar parallel circuits joining said conductors, each circuit including resistances greater than the internal resistance of a conductive tube, and the anode of one tube and the cathode of another tube being connected to each one of said circuits with a portion of the resistance between the connecting points so as to give any one tube an anode-cathode potential slightly less than the breakdown requirements; and means to cause a discharge in the first one of the tubes, whereby the resulting potential drop of the anode causes a potential drop in the connected cathode of the next tube, causing it to discharge and in turn to cause a discharge throughout the remainder of the plurality of tubes in sequence.

3. A plurality of diode gas discharge tubes arranged in a sequential operative series; means including a resistance between each two tubes to connect the tubes in the series, the anode of a tube being connected to the cathode of an adjacent tube; common means to supply anode-cathode potential to all tubes, said means including a resistance between each anode and the common supply means and a resistance between each cathode and the common supply means, the supplied anode-cathode potential in a given tube normally being less than that necessary to cause conduction therein; and means to change the potential of one of the electrodes of the first tube in the series to a point where conduction takes place in said tube, the ensuing change in the potential of the other electrode due to the mentioned resistance between it and its supply means being impressed on the connected electrode of the next tube of the series, causing it to change potential to a point where conduction begins in said next tube, which in turn causes the firing of the next tube in the series.

4. In combination, a plurality of electron tubes; means connecting the tubes in a series so that the operation of the tube at either end of the series will cause the remainder of the tubes to be operated in sequence automatically to the other end of the series; a first conductor common to all the tubes; means to produce a positive electric potential impulse on said conductor each time a tube is operated; a second conductor common to all the tubes; and means to produce a negative impulse on said conductor each time a tube is operated.

5. A plurality of cold cathode gas discharge tubes arranged in a sequential operative series; means to connect the tubes in the series, the anode of the preceding tube being connected through a resistance to the cathode of the succeeding tube; means to supply anode-cathode potential to all tubes, said means including a resistance in the anode supply conductor of one tube arranged in series through said connecting means with a resistance in the cathode supply in the following tube, the anode-cathode potential in any tube being less than that necessary to cause conduction; means to lower the cathode potential of the first tube in the series to a point where conduction takes place in said tube, the ensuing drop in anode potential due to the mentioned resistance in its supply conductor being impressed on the cathode of the following tube, which lowers said cathode in potential to a point where conduction begins in said following tube, causing its anode to drop in potential, thus firing the next tube in sequence; and a common output conductor connected to all the cathodes each by means of an electric field whereby the potential rise in any of the cathodes as said tube begins to conduct is impressed upon said output conductor.

6. A plurality of cold cathode discharge tubes arranged in a sequential operative series; means to connect the tubes in the series, the anode of the preceding tube being connected through a resistance to the cathode of the succeeding tube; means to supply anode-cathode potential to all tubes, said means including a resistance in the anode supply conductor of one tube arranged in series through said connecting means with a resistance in the cathode supply in the following tube, the anode-cathode potential in any tube being less than that necessary to cause conduction; means to lower the cathode potential of the first tube in the series to a point where conduction takes place in said tube, the ensuing drop in anode potential due to the mentioned resistance in its supply conductor being impressed on the cathode of the following tube, which lowers said cathode in potential to a point where conduction begins in said following tube, causing its anode to drop in potential, thus firing the next tube in sequence; a common output conductor connected to all the cathodes by means of an electric field whereby the potential rise in any of the cathodes as said tube begins to conduct is impressed upon said output conductor; and means to disconnect the operating potential from

the tube following the one it is desired to operate last in the series.

7. In combination, a series of electron tubes each having an anode and a cathode; a common conductor; means connecting each anode to the common conductor; and means associated with each tube which when operated connects the common conductor to a second conductor and disconnects the anode of the tube next in the series from said first-mentioned conductor.

8. In combination, a plurality of electron tubes arranged in a series; means connecting the tubes so that they are automatically operable in sequence from one end of the series to the other end of the series in either direction; means to control the direction of operation; and a plurality of means each when operated acting to interrupt the operation at a certain tube in the series, each of said means determining how many tubes shall operate in sequence in one direction and how many tubes shall operate in sequence in the other direction, said determined numbers of tubes being complementary to the total number of tubes in the series less one.

9. In combination, a series of electron tubes each having an anode and a cathode; means connecting the tube for automatic sequential operation beginning at either end of the series, said operation being commenced at one end of the series by applying a positive potential impulse to the anode of the beginning tube at that end, and

said operation being commenced at the other end of the series by applying a negative potential impulse to the cathode of the beginning tube at said other end; an operation-initiating electron tube; and means for connecting the initiating tube to one end or the other of said series, said means being arranged so that the operation of the initiating electron tube when connected to one end of the series will supply a positive electric initiating impulse to the anode of the beginning tube and when connected to the other end of the series will supply a negative electric initiating impulse to the cathode of the beginning tube at said other end.

10. In combination, an electrical network comprising two electric potential supply conductors connected by a plurality of resistance paths arranged in parallel; a plurality of electron gas discharge tubes having a breakdown requirement less than the potential difference between the supply conductors; and means connecting one of the electron tubes between each pair of adjacent resistance paths at points so that the potential difference between the anode and the cathode is slightly less than the breakdown requirement and so that the potential difference between each of the electrodes and its supply conductor is the same, a breakdown caused in one of the tubes causing a breakdown in the next adjacent tube on either side.

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