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ELECTRONIC ACCUMULATOR

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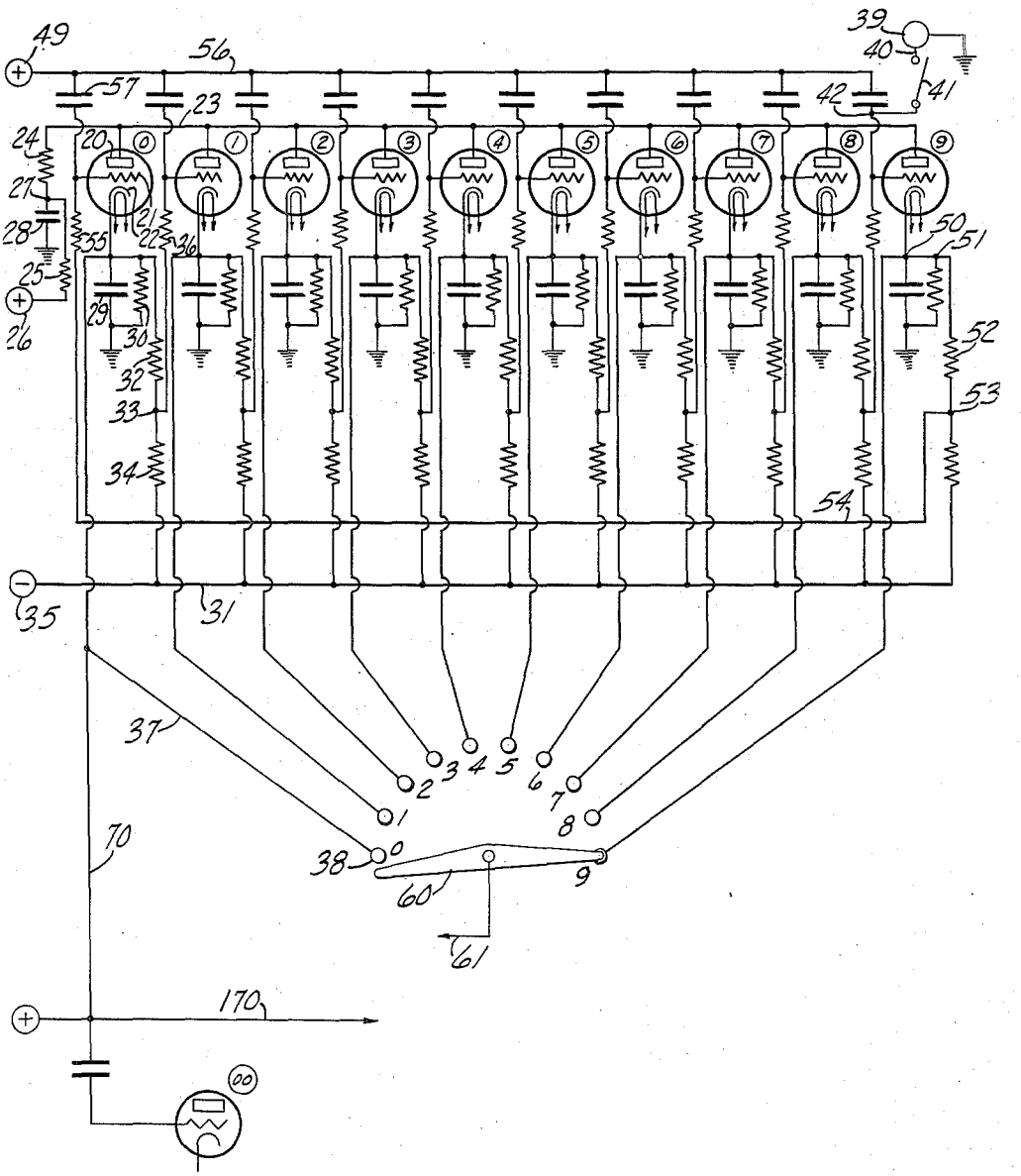


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## ELECTRONIC ACCUMULATOR

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16 Claims. (Cl. 315—230)

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This invention relates to a data-representing ring of electron tubes connected in a network for accurate step-by-step high-speed response to received electric impulses.

The invention more particularly pertains to a plurality of gaseous electron discharge tubes arranged in an operative network whereby they are rendered conductive one at a time in an endless chain sequence in response to each of a plurality of commonly received electric potential impulses received at variable intervals, which response may be at frequencies as great as 200,000 a second.

Each of the electron tubes of the ring may be given a designation such as, for instance, a digit in a numerical denominational order, a letter of an alphabet, a code symbol, or any other sort of data either serial in nature as in the disclosed embodiment, where the tubes are given digit values of a decimal denominational order, or any non-serial designation as, for instance, a letter, a word, or a symbol of a code. Any number of tubes may be included in a given ring.

Therefore the principal object of the invention is to provide a novel network connecting a plurality of gaseous electron tubes into an operative ring, which tubes are responsive step by step, one at a time as signified by conduction in a tube, to each of commonly received electric impulses.

Another object of the invention is to provide novel means for causing the commencement of conduction in one tube to extinguish any then conducting tube, so that only one tube of the ring may be conductive at any one time.

Another object of the invention is to provide such an endless chain operating ring of electron tubes where the potential change of the cathode of one tube, as it is changing its mode of operation from conduction to non-conduction or vice versa, is not impressed on the cathodes of the other tubes of the ring.

Another object of the invention is to provide such an endless chain operative ring of electron tubes wherein the extinguishing of a conductive tube is caused by means of a drop in anode potential as another tube of the ring is rendered conductive.

Wtih these and incidental objects in view, the invention includes certain novel circuit features 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 drawing which accompanies and forms a part of this specification.

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The drawing shows a ring of ten gaseous electron tubes designated for the particular embodiment of the invention as representing the ten digits of a denominational order of the decimal system.

*General description*

Ten gaseous grid-controlled electron tubes are shown in the drawing and are designated "0" "1," "2," "3," "4," "5," "6," "7," "8," and "9," each tube having an anode, like anode **20** of the "0" tube, a control grid, like grid **21**, and a thermionic cathode, like cathode **22**. The cathode heater elements are shown conventionally. The electron tubes chosen for this disclosure are of a type having an internal potential drop of about 15 volts when conducting and a critical grid potential of 15 volts negative with respect to the cathode. The potentials applied to the anode, cathode, and grid are selected as convenient potentials for the disclosure, and the circuit elements of resistance and capacitance correspond in relative value to the anode and cathode potentials chosen. As will appear, the relation between the circuit elements and potentials are important to the proper operation of the network and must be correlated. The invention is not to be limited, however, to the actual values given or to the particular tube characteristics of the tubes described.

An anode supply conductor **23**, common to all the anodes, is connected through resistor **24** of 2,500 ohms and resistor **25** of 2,500 ohms to a supply terminal **26**, which is given a potential of 130 volts positive with respect to ground. Point **27** is grounded through a stabilizing capacitor **28** of .1 microfarad capacity to slow down initial application of potential to the anode supply conductor.

Each cathode is grounded or connected to some stable source of potential through a capacitor of .001 microfarad, like capacitor **29**, in parallel with a resistor of 15,000 oms, like resistor **30**. Each cathode is also connected to a common supply conductor **31** through a resistance of 25,000 ohms, like resistance **32**, a point, like point **33**, and a second resistance of 25,000 ohms, like resistance **34**. Conductor **31** is given a potential of 180 volts negative with respect to ground through terminal **35**.

Points corresponding to point **33** are each connected to the grid of the next tube in the ring sequence through a resistor of 50,000 ohms, like resistor **36**.

Each cathode is connected by a conductor, like

conductor 37, to a sensing contact, like contact 38, which contact represents the tube with whose cathode it is connected.

In considering the operation of the ring, it is necessary that one tube be always in a conductive state. Means has been provided for causing conduction to commence in the "9" tube by grounding its control grid through terminal 39, conductor 40, switch 41, and point 42. Any other tube may be caused to become conductive in the same manner.

The normal potentials of the various points of the network as determined by the circuit elements and the supply potentials are as follows, assuming that one tube of the ring is conductive: In a non-conducting tube, the anode is at 60 volts positive potential, the cathode is at 41 volts negative potential, and the grid of a tube not next in sequence to a conducting tube is 110 volts negative. If the grid in question is next in the sequence to a conductive tube, the potential rise in the potential supply conductor for the cathode of the conducting tube is impressed on points like point 33 and causes such grid in the tube next in sequence to assume a potential of 60 volts negative.

Having no tube of the ring conducting at the commencement of operation, the anode of the "9" tube is at 130 volts positive, its cathode is at about 41 volts negative, and its grid is at 110 volts negative; therefore, if the grid of the "9" tube is temporarily grounded, the tube will fire and become conductive, and under that circumstance the other tubes will assume the normal potentials which have been given, the grid of the "0" tube, which is next in sequence to the "9" tube, by reason of the connection of the grid of the "0" tube to the cathode of the "9" tube through points 50 and 51, resistor 52, point 53, conductor 54, and resistor 55, thus making the grid of the "0" tube 60 volts negative.

If a potential impulse of 70 volts positive is impressed through terminal 49 onto common conductor 56 and from the common conductor onto all the grids, each being connected thereto by a capacitor like capacitor 57 of 10 micro-microfarads, it brings the primed "0" tube grid more positive than the 56-volt negative critical point, whereupon the "0" tube fires and becomes conductive.

At the moment of firing, the cathode of the "0" tube is practically at ground potential as capacitor 29 is charging, and the potential of the anode supply conductor 23 drops temporarily to within 15 to 20 volts of the cathode potential of the "0" tube, because of the resistance in the anode supply circuit. As at that moment the cathode of the "9" tube is about 65 volts above ground, the dropping of its anode to 15 volts above ground immediately begins deionization of the "9" tube, and the grid of the "9" tube regains control. The time taken to charge the capacitor assures recovery of the grid to normal controlling potential.

At the next commonly received impulse, the "1" tube is fired and the "0" tube is extinguished. Each received impulse causes a step of operation, as has been described, in the sequential operation of the ring of tubes.

As the cathodes are at 41 volts negative when the associated tube is non-conducting and at 65 volts positive when the associated tube is conducting, there is impressed on each sensing contact, such as contact 38, a potential differential of more than 100 volts to indicate when the corresponding tube is conducting, and a wiper arm 60 may be used to sense and impress the voltage on a conductor such as 61 to cause the operation of an indicator, such as that described in applicant's application for United States Letters Patent, Serial No. 364,716, filed November 7, 1940.



The ring may be made one denomination of a plural denominational accumulator of numerical data such as that described in the copending application of applicant and Joseph R. Desch for United States Letters Patent, Serial No. 325,040, filed March 20, 1940, by providing a conductor 70, which is connected at one end to the cathode of the "0" tube and at its other end to the input conductor 170 of a second ring of tubes, identical with those shown, representing the tens denominational order as signified by the "00" tube, whereby a denominational carry-over of "one" will occur after one complete operation of the units denominational order ring wherein the "0" tube has been conductive once. The second ring of tubes is not shown in full, but it is represented by the "00" tube.

A plural ring network may also be used to represent non-numerical data so as to represent letters of the alphabet or other code symbols. An example of such use would be in denominating the "0" and the "00" tubes of the illustrated embodiment as "a" and "a" and having 26 tubes in each ring to represent the letters of the English alphabet.

While the form of the invention 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 shown, 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 gaseous electron tubes each having an anode and a cathode; and means connecting the tubes in a network so that they will be operated one at a time in step-by-step sequence, said means including a discharge control grid in each tube normally preventing a discharge, each of which grids is connected to the cathode of the preceding tube of the sequence, a positive potential supply, a common conductor to which all the anodes are connected, a high resistance connected in series between the positive potential supply and the common conductor, a negative potential supply, an isolated resistance network for each cathode, said network being connected to the negative potential supply and to the cathode to provide the cathode with a negative potential, and capacitors of which there is one in series between each cathode and a source of stabilized potential which has a value intermediate the potential of the positive and negative potential supplies.

2. In combination, a plurality of gaseous electron tubes each having an anode and a cathode; and means connecting the tubes in a network for sequential operation one at a time, said network including a discharge control grid in each tube normally preventing a discharge, each of which grids is connected to the cathode of the preceding tube of the sequence, a positive potential supply, a common anode positive potential supply conductor to which the anodes are connected and which is connected over series resistance to the positive potential supply, and two electric energy supplies for each cathode, one of said supplies be-

ing a grounded capacitor and the other of said supplies being a negative potential supplying resistance network which is isolated from the potential supplying networks of other cathodes.

3. In combination, a plurality of gaseous electron discharge tubes each having an anode and a cathode; and means connecting the tubes for sequential operation one at a time, said means including a discharge control grid in each tube normally preventing a discharge, each of which grids is connected to the cathode of the preceding tube of the sequence, an anode positive potential supply means common to all the tubes, a high resistance in series between the supply means and a common conductor to which all the anodes are connected, an isolated cathode negative potential supply network for each cathode, each network having resistance therein, and a grounded capacitor connected to each cathode to momentarily prevent the potential of a cathode from changing when conduction begins in its tube whereby the act of conduction beginning in any tube causes the potential of the common conductor and all the anodes connected thereto to momentarily be depressed toward ground and thereafter to assume a normal potential determined by the resistance in the anode and cathode potential supplies.

4. In combination, a plurality of gaseous electron discharge tubes each having an anode, a cathode, and a discharge control grid; means connecting the anodes together and through a high series resistance to a source of positive potential; an isolated potential supplying resistance network for each cathode connecting the cathode to a source of negative potential; means to give each grid a controlling potential bias; common means to give all the grids input positive potential impulses, each grid being connected to the common means through an individual capacitor; said controlling potential supplying means for each grid including a portion of the cathode potential supplying resistance network of another tube whereby the grid potential bias is lessened as the connected cathode becomes conductive and rises in potential due to resistance in its potential supplying network, and said input potential impulses being of such an amplitude as to cause only the grid connected to a conducting cathode to lose control; and a grounded capacitor connected to each cathode whereby on conduction commencing in any tube a momentary delay in the rise in cathode potential occurs, during which delay the potential of the anodes receives a momentary drop toward the potential of the cathode whose potential rise has been delayed, thus bringing the anode of any previously conducting tube below the potential of its related cathode, to extinguish conduction in that tube.

5. In combination, a plurality of electronic devices each having an anode, a cathode, a control grid normally biased to prevent a discharge and connected to the cathode of another device, and an ionizable gas medium, said devices being connected cathode to grid in an operative ring for step-by-step operation one at a time in sequence; an anode potential supply; a common resistance in series between the anode potential supply and all the anodes; an isolated potential supply resistance network for each cathode; and a capacitor coupling each cathode to a stabilized potential intermediate the anode supply potential and the cathode supply potential to momentarily prevent the potential of the cathode from changing when conduction begins in the device, thereby to cause a momentary potential drop in the potential of all the anodes sufficient to deionize a previously conducting device each time conduction commences in another device.



6. In combination, a plurality of gaseous electron discharge tubes, each tube representing a unit of data and having an anode, a cathode, and a discharge control grid; means connecting the tubes so that they can be fired and rendered conducting selectively one after another in step-by-step sequence in response to data-representing impulses impressed on the tubes; means to impress data-representing impulses on the tubes; a network for connecting the anodes of the tubes together and through a common load in series to an anode potential supply, whereby the firing and conduction in any tube will cause the potential of all the anodes to drop to a predetermined potential; an independent isolated potential supply circuit for the cathode of each tube to supply normal potential to the cathode and including means to enable the conduction in any tube to cause the potential of the cathode of that tube to rise without affecting the potential of any other cathode; and means in each independent cathode potential supply circuit to momentarily prevent the potential rise in the cathode of a tube as it fires; the relation between the anode potential network and the independent cathode potential supply circuits causing the potential of the anode of a tube, as it is fired, to drop below the predetermined potential and thus to bring the potential of the anodes of all the other tubes to a value which is below that of the cathode of a previously conducting tube to thereby extinguish the previously conducting tube.

7. In combination, a plurality of gaseous electron discharge tubes, each tube representing a unit of data and having an anode, a cathode, and a discharge control grid; means connecting the tubes so that they can be fired and rendered conducting selectively one after another in step-by-step sequence in response to data-representing impulses impressed on the tubes, said means comprising circuits connecting the cathode of one tube to the grid of the next tube in the sequence whereby conduction in one tube renders the next tube in the sequence responsive to be fired by the next data-representing impulse; means to impress data-representing impulses on all the tubes; an independent isolated cathode negative potential supply circuit for each tube whereby the effect of conduction in one tube does not affect the potential of the cathode of any other tube; a capacitor coupling to ground for each cathode; and a common anode positive potential supply conductor to which the anodes of the tubes are connected and which is connected through a series resistor to a source of potential supply, whereby the firing of any tube will cause a sufficient drop in the potential of the anodes of all the tubes to cause any conducting tube to be extinguished.

8. In combination, a plurality of gaseous electron discharge tubes, each tube representing a unit of data and having an anode, a cathode, and a discharge control grid; means connecting the tubes so that they will be successively primed to be fired and rendered conducting one after another in step-by-step sequence in response to data-representing impulses, said connections extending between the cathode of one tube and the control grid of the next tube in the sequence so that the potential rise of the cathode of the one

tube as the tube is conducting will be impressed on the control grid of the next tube and render the next tube responsive to the next impulse impressed thereon; means to impress data-representing impulses on the tubes; a network for connecting the anodes of all the tubes together and through a common series load to a common potential supply, whereby the firing and conduction in any tube will cause the potential of all the anodes to drop to a predetermined potential; an independent isolated potential supply network for the cathode of each tube to supply normal potential to the cathode and including means in each cathode network to supply a load in the independent cathode potential supply network of any tube whereby the potential of the cathode of a tube will rise when that tube is conducting but the potential rise will not affect any other cathode; and means in each of the independent potential supply networks for momentarily delaying the rise in potential of the cathode of a tube as the tube is fired; the relation between the anode network and the independent cathode networks being such that the potential of the anode of a tube as the tube is fired will momentarily drop below said predetermined potential due to the delay in its cathode potential rise and will cause a corresponding drop in the potential of the other anodes, reducing the potential of the anode of a previously conducting tube below its cathode potential and causing conduction within this tube to cease.

9. In combination, a plurality of banks of electron tubes, each tube having at least an anode and a cathode; means interconnecting the tubes of each bank so that the tubes in a bank can be fired and be rendered conducting selectively one after another in step-by-step sequence in response to input impulses; an input impulse circuit for each bank of tubes by which impulses can be impressed on the tubes; a potential supply circuit for the anodes of the tubes of each bank; an isolated potential supply circuit for the cathode of each of the tubes to supply normal potential to the cathode and including means to enable the conduction in a tube to cause the potential of the cathode of that tube to rise without affecting the potential of any other cathode; and connections between the cathode of one tube of one bank and the input impulse circuit of another bank to impress the cathode potential rise of only said one tube as it is fired and rendered conducting on the impulse circuit of said other bank as an input impulse to cause a step of operation to be made in said other bank.

10. In combination, a plurality of denominational banks of electron tubes, the tubes of each bank representing units of data and each tube having an anode, a cathode, and a discharge control grid; means interconnecting the tubes of each bank so that the tubes in a bank can be fired and rendered conducting selectively one after another in step-by-step sequence in response to input impulses; an input impulse circuit for each bank of tubes by which impulses can be impressed on the tubes to cause their step-by-step operation; potential supply circuits for the anodes of the tubes of each bank; an independent isolated potential supply circuit for the cathode of each tube to supply normal potential to the cathode and including means to enable the conduction in any tube to cause the potential of the cathode of the tube to rise without affecting the potential of the cathode of any other tube; and a circuit for connecting the cathode of one tube of one bank to the input impulse circuit of another bank to impress the cathode potential rise of only said one tube, as it is fired and rendered conducting, on the impulse circuit of said other bank and cause a step of operation to be made in said other bank.

11. In combination, a plurality of banks of gaseous electron tubes, the tubes of each bank corresponding to units of data and each tube having at least an anode and a cathode; means interconnecting the tubes of each bank so that the tubes in a bank can be fired and be rendered conducting selectively one after another in step-by-step sequence in response to input impulses; an input impulse circuit for each bank of tubes by which impulses can be impressed on the tubes; potential supply circuits connecting the anodes of the tubes of each bank together; an independent isolated potential supply circuit for the cathode of each tube to supply normal potential to the cathode and to enable the conduction in any tube to cause the potential of the cathode of that tube to rise without affecting the potential of any other cathode of its bank; and a circuit for connecting the cathode of one tube of one bank to the input impulse circuit of another bank to impress the cathode potential rise of only said one tube on the impulse circuit of said other bank as an input impulse to cause a step of operation to take place.

12. In combination, a plurality of denominational banks of gaseous electron tubes, the tubes of each bank corresponding to the digits of a notation and each tube having an anode, a cathode, and a discharge control grid; cathode-control grid circuits between the tubes of each bank so that the tubes in a bank can be fired and be rendered conducting selectively one after another in step-by-step sequence in response to input impulses; an input impulse circuit for each bank of tubes by which impulses can be impressed on the tubes; potential supply circuits connecting the anodes of the tubes of each bank together and connecting the anodes of each bank over a resistance to a source of potential; an independent isolated potential supply circuit for the cathode of each tube to supply normal potential to the cathode; means in each isolated cathode potential supply circuit to supply a load in the circuit to enable the conduction in any tube to cause the potential of the cathode of the tube to rise without affecting the potential of the cathode of any other tube in a bank; and a circuit directly connecting the cathode of one tube of one bank to the input impulse circuit of another bank to impress the cathode potential rise of only said one tube on the impulse circuit of said other bank and cause an entry of a unit to be made in said other bank each time said one tube becomes conducting.

13. An impulse counting device comprising a chain of gas-filled tubes each having two control electrodes constituting a control gap and a main electrode constituting with one of the electrodes of the control gap a main gap, the tubes being connected in series with a control electrode of one tube connected to a control electrode of the next succeeding tube and also to a source of potential through a condenser and resistance, a source of potential connected to the main electrode of each of the tubes, means for connecting a source of impulses through respective condensers to the control electrodes of all the tubes, and means for initially ionizing one of the tubes to start a cycle of operations in which the tube next

in the series to the ionized tube ionizes on an impulse and de-ionizes the tube previously ionized.

14. An impulse counting device as claimed in claim 13 in which the chain of electronic devices is a closed chain.

15. An impulse counting device including a chain of gas-filled electron tubes each having an anode and a cathode constituting a main gap, and a control electrode which in conjunction with the cathode constitutes a control gap; means connecting the tubes in series with the cathode of one tube connected to the control electrode of the next succeeding tube and also to a source of potential through a resistor in parallel with a condenser; a source of potential connected in series through a resistor to all of the anodes; means for connecting a source of impulses through respective condensers to the control electrodes of all the tubes; and means for initially ionizing one of the tubes to start a cycle of operation in which the tube next in the series to the ionized tube ionizes on an impulse and de-ionizes the tube previously ionized.

16. The impulse counting device of claim 15 in which the chain of electron tubes is a closed chain.



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