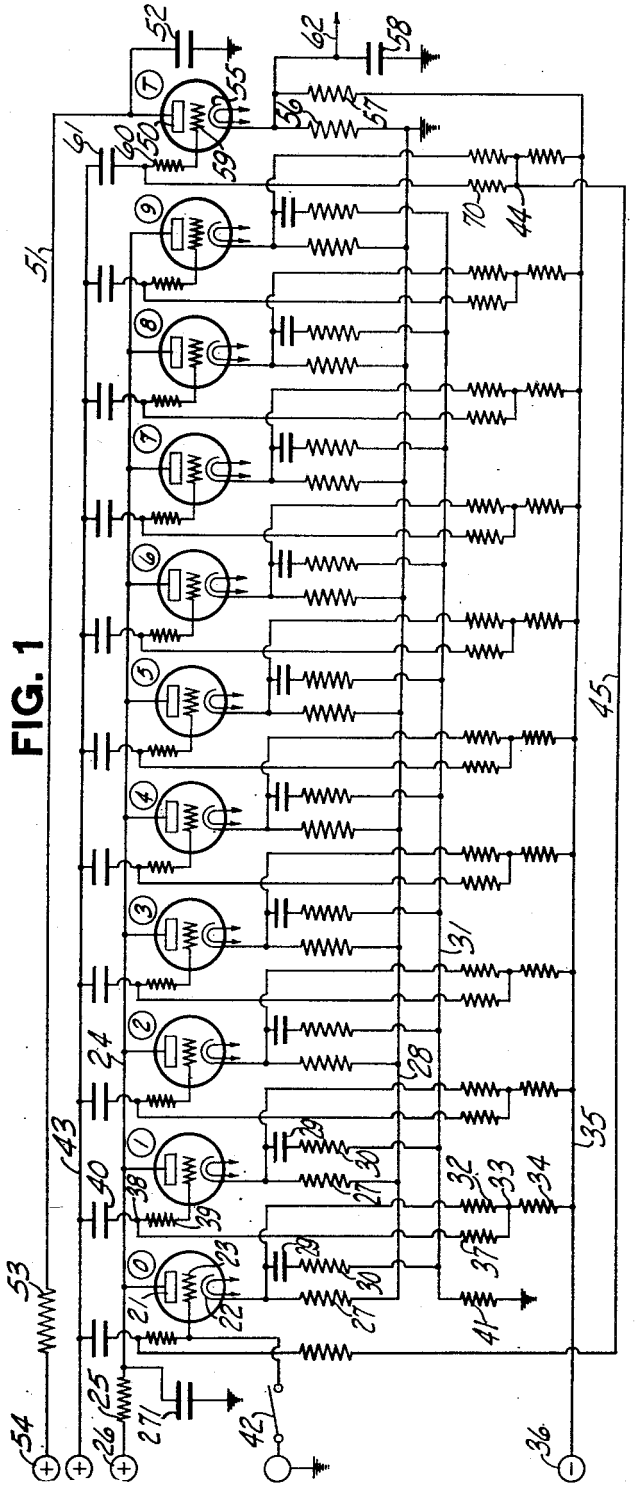
July 30, 1946. R. E. MUMMA 2,405,096

ELECTRONIC ACCUMULATOR

Filed June 4, 1941 2 Sheets-Sheet 1

FIG. 1



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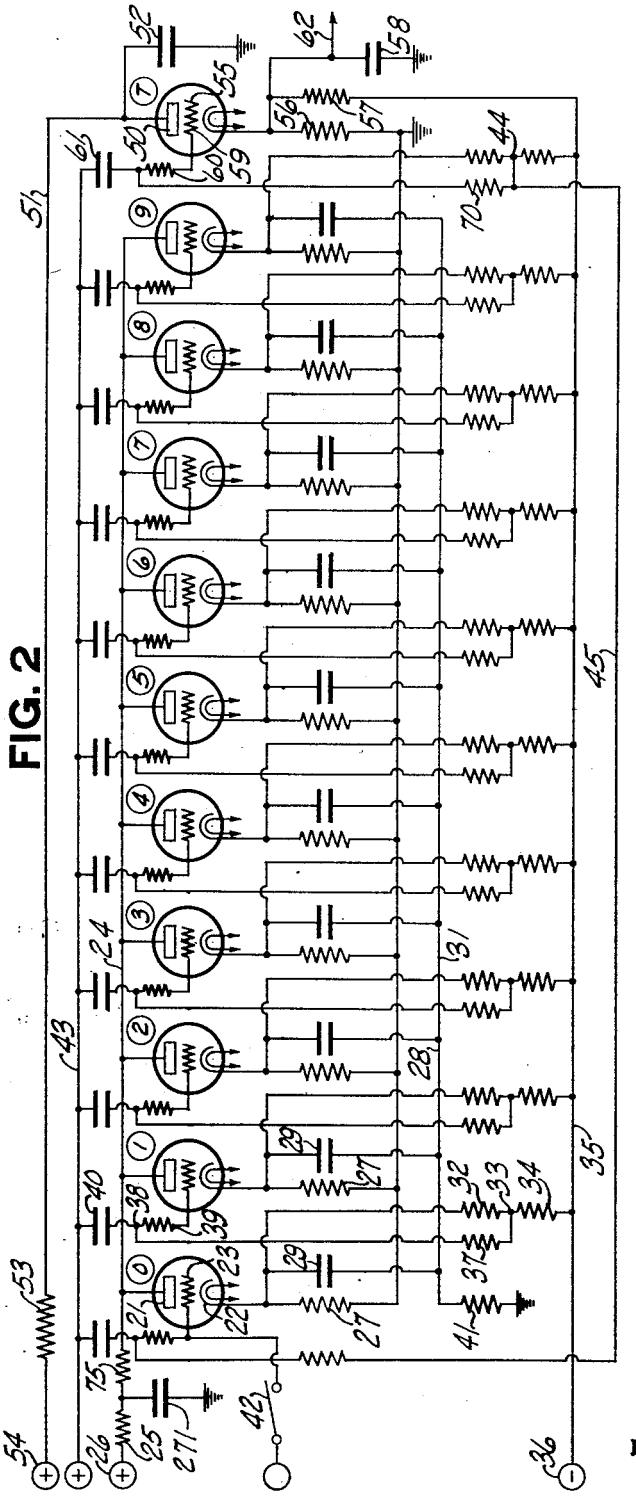

FIG. 2

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UNITED STATES PATENT OFFICE

2,405,096

ELECTRONIC ACCUMULATOR

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Application June 4, 1941, Serial No. 396,505

5 Claims. (Cl. 315—323)

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This invention relates to a ring of gaseous electron tubes connected in a network for operation one at a time in endless chain sequence in response to commonly received electric potential impulses.

The invention more particularly relates to the means whereby the commencement of conduction in one of the electron tubes of the ring causes the cessation of conduction in any other tube in the ring by causing the cathode of any conductive tube to momentarily become more positive in potential than its anode. This is accomplished by electrostatically coupling the cathodes of all the tubes of the ring in parallel and by providing each cathode potential supply system with a high resistance which causes an abrupt rise in potential in the cathode of a tube as it becomes conductive. Stabilizing means is provided in the network to prevent oscillatory potential surges from causing a tube to become conductive out of order.

Therefore it is the principal object of this invention to provide a ring of electron tubes operable one at a time in step-by-step sequence, including a novel mode of causing cessation of conduction in a conductive tube when the next tube in the sequence or any other tube of the ring becomes conductive.

Another object of the invention is to provide such a ring with novel means to stabilize the potential surges in the network connecting the tubes.

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 which is hereinafter described with reference to the drawings which accompany and form a part of this specification.

Of the drawings,

Fig. 1 shows the novel ring of electron tubes having the cathodes of the tubes electrostatically coupled in parallel, with a stabilizing means connected to each cathode.

Fig. 2 is a modified form of the invention, showing a different arrangement for stabilizing potential surges in the network by including the stabilizing means in the anode potential supply conductor.

General description

Each of ten gaseous electron tubes "0," "1," "2," "3," "4," "5," "6," "7," "8," and "9" (Fig. 1), representing the digits of a denominational order of the decimal system of numerical notation, is

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provided with an anode, like anode 21 of the "0" tube, a cathode, like cathode 22 of the "0" tube, and a control grid, like grid 23 of the "0" tube. The cathodes are preferably of the thermionic type, the filament heaters being shown conventionally. The characteristics of the gas and the characteristics of the elements of the particular tube selected for the embodiment of the invention herein disclosed are such as to provide an internal potential drop of about 15 volts in a conductive tube, and to demand a controlling potential bias on the control grid at least 15 volts negative with respect to the cathode.

The gaseous electron tube T will be described hereinafter in connection with the use of the ten-tube ring constituted by the tubes "0," "1," "2," "3," "4," "5," "6," "7," "8," and "9" as one denomination of a plural denominational accumulator of numerical data.

Considering the network of Fig. 1, all the anodes are connected to a supply conductor 24, which is connected, through a current-limiting resistor 25 of 300 ohms, to a terminal 26 supplying a potential of 100 volts positive with respect to ground. Conductor 24 is also grounded through a capacitor 27 of .1 microfarad.

Each cathode, like cathode 22, is connected through a resistor of 25,000 ohms, like resistor 27, to a common grounded conductor 28 associated with all the cathodes. Each cathode is also connected through a resistor of 60,000 ohms, like resistor 32, a point, like point 33, and a resistor of 50,000 ohms, like resistor 34, to a common potential supply conductor 35, which in turn is connected to a 180-volt negative supply terminal 36. Each cathode, like cathode 22, is also connected through a capacitor of .01 microfarad, like capacitor 29, and a resistor of 2,500 ohms, like resistor 30, to a common conductor 31. Conductor 31 is grounded through a resistor 41 of 25,000 ohms. Points, like point 33, are connected to the grid of the next tube in sequence of the ring through a resistor of 400,000 ohms, like resistor 37, through a point, like point 38, and through a resistor of 100,000 ohms, like resistor 39.

Each grid is connected through the 100,000-ohm resistor like resistor 39, and through the point, like point 38, and through a capacitor of 10 micro-microfarads, like capacitor 40, to a common signal input conductor 43.

With no tube of the ring conducting, the anodes of the tubes are at 100 volts positive potential, the cathodes are at about 33 volts negative, and the grids are at about 113 volts negative. Under these circumstances, if grid 23 of the "0" tube is

grounded temporarily, by closing switch 42, the "0" tube will fire and become conductive.

After one tube is conducting, the ring is ready for operation.

From the resistance values given, it is apparent that, when the "0" tube is conducting, the anode 21 is at a potential of about 100 volts, and the cathode 22 is at a potential of about 85 volts. This makes the grid of the "1" tube more positive than any of the other grids, due to the change in potential of point 33. The actual potential of the grid of the "1" tube, when the "0" tube is conducting, is about 60 volts negative, whereas the cathode of the "1" tube is 33 volts negative, thus requiring a positive impulse of but 12 to 15 volts to be impressed on the grid of the "1" tube to cause it to fire and become conductive, whereas all the other non-conductive tubes require a positive impulse of at least 65 volts to be impressed on their grids before they will fire. Thus, if a positive potential impulse of 70 volts is impressed on input conductor 43, which is impressed on all the grids through the capacitors, like capacitor 40, which attenuates the input impulse to about 30 volts, the "1" tube alone will be fired and become conductive, as its grid was the only grid of the nine non-conductive tubes that was near enough to the critical point to lose control by a 30-volt positive impulse being impressed thereon.

As tube "1" fires, conductor 31 immediately rises to about 77 volts above ground potential due to the potential drop over resistance 41 as capacitor 29 of the "1" tube charges. The rise in potential of conductor 41 is impressed on all the cathodes through the .01-microfarad capacitors 29, which rise in potential extinguishes the "0" tube, as its cathode is at that time 85 volts above ground, and the additional positive surge impressed thereon makes the cathode of the "0" tube more positive than its anode for a short time, during which time deionization of the "0" tube commences and the grid of the "0" tube resumes control, thus extinguishing conduction in the "0" tube.

A resistor, like resistor 30, is in series with each cathode capacitor, like capacitor 29, to stabilize the extinguishing circuit against anomalous potential changes of an oscillatory nature.

It is apparent that the rise in potential of conductor 31, as a tube of the ring becomes conductive, is impressed on the cathodes of all the tubes, and therefore the extinguishing action of conduction causes cessation of conduction not only in the preceding tube of the sequence but in any tube of the ring although not adjacent in the sequential series.

At point 44, the potential rise which would be caused by the firing of the "9" tube is conveyed to and impressed on the grid of the "0" tube by conductor 45, completing the endless chain or ring connection of the ten tubes. As this embodiment of the invention shows a decimal denominational order representing ring of tubes, means is provided for creating a multiple denominational numerical accumulator by providing a means for actuating another denominational order ring of tubes each time the described denominational order ring completes one complete operation wherein each tube has been conductive once. A denominational carry-over or transfer is accomplished by causing the tube T to become conductive on the next impulse received on input conductor 43 after the "9" tube has been rendered conductive, the same next received impulse also causing the "0" tube to become conductive.

Means is provided to cause the tube T to fire and become conductive for an instant and then to cease conduction automatically.

The circuit and operation of tube T, which tube is like the digit-representing tubes in characteristics, will now be described.

The anode 50 of tube T is connected to conductor 51, which is grounded on one end through a capacitor 52 of .1 microfarad and connected at its other end through a resistor 53 to a terminal 54 given a positive potential of 75 volts. The cathode 55 is grounded through resistor 56 of 50,000 ohms and is connected to the 180-volt negative conductor 35 through resistor 57 of 250,000 ohms, and is connected to ground through capacitor 58 of .00025 microfarad. Control grid 59 is connected through resistor 60 of 100,000 ohms and resistor 70 of 100,000 ohms to point 44, and is connected to the input conductor 43 through capacitor 61 of 10 micro-microfarads. Under these conditions, the T tube, when non-conducting and when there is a tube conducting in the ring but not adjacent in the sequence, will have an anode potential of 75 volts positive with respect to ground, a cathode potential of 30 volts negative with respect to ground, and a grid potential of 113 volts negative with respect to ground, under which conditions the tube will not fire and become conductive. If the "9" tube is conductive, the grid 59 becomes "primed" by assuming a potential of 60 volts negative with respect to ground in response to the potential of point 44, which point also determines the potential of the grid of the "0" tube. Hence, if the "9" tube is conductive and a positive potential impulse of 70 volts is impressed on input conductor 43, both the tube T and the tube "0" will fire. The tube "0" will remain conductive until the next potential impulse is impressed on conductor 43. The tube T will automatically extinguish itself by reason of the capacitor 58 and the high resistances 56 and 57 creating a condition in the cathode circuit causing a momentary high current in the tube which suddenly becomes negligible and is caused to cease altogether for an instant while the grid regains control as the T tube commences deionization. The cessation of current in the tube is probably due to the very low current being counteracted by temporary induction phenomena in the cathode supply circuit.

The temporary cathode rise in potential of the T tube due to the high resistance in the cathode supply is impressed on conductor 62, which may be considered the input conductor, corresponding to conductor 43, for a second ring of tubes similar to the one just described. For such a plural denominational system, reference is made to applicant's copending application for United States Letters Patent, Serial No. 346,087, filed July 18, 1940, and applicant's joint application with Joseph R. Desch, Serial No. 325,040, filed March 20, 1940.

Fig. 2 discloses a ring of tubes connected in a network similar to Fig. 1 but with the following changes. The stabilizing resistors, like resistor 30 of Fig. 1, have been eliminated. A single resistor 75 of 2,500 ohms is inserted in the common anode supply line. This resistor 75, in conjunction with the cathode capacitors, stabilizes potential surges in the network and prevents any anomalous firing of the tubes by transient oscillatory phenomena. The principle of operation of the two embodiments of the invention is otherwise the same.

It is to be understood that the designation of

the tubes by digit values is not to be a limiting factor in determining the scope of the invention, as the tubes may be given any designations, such as letters of the alphabet, words, or code symbols. Neither is the scope of the invention to be limited by the particular number of tubes shown, as any number of tubes may be connected in the network, either with or without the use of the transfer tube T.

The endless chain ring of tubes is well adapted for use in electronic accumulators of numerical data such as those described in the applications for United States Letters Patent to which reference has been made, as a bank of data-accumulating tubes.

While the forms of the invention herein shown and described are admirably adapted to fulfill the objects primarily stated, it is to be understood that they are not intended to confine the invention to the forms or embodiments 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 two or more gaseous electron tubes each having an anode and a cathode arranged in an endless operating chain network; means for causing conduction to take place in the tubes in sequence; and means to have the sequential conduction take place in but one tube at a time by having the act of conduction commencing in a tube causing, by means of potential variations in the network, the extinguishing of every other then conductive tube, said means including connecting the cathodes of the tubes each through a capacitor to a common conductor.

2. In combination, a plurality of gaseous electron discharge tubes each having an anode, a cathode, and a control element; means for supplying a continuous operating potential to the anodes and the cathodes, said cathode supply including a high resistance; means to supply controlling bias potential to the control element from a point in the cathode potential supply means of the cathode of another tube; means to cause conduction to commence in one tube; means to impress electric potential impulses on all the control elements to cause a step of sequential operation of the tubes by causing the control element connected to the cathode supply of a conductive tube to lose control; and means connecting the cathodes of all the tubes in parallel, each being connected to a common conductor through a capacitor, so as to cause a rise in potential of the conductor when a tube fires and becomes conductive, which rise in potential of the conductor is impressed on the cathodes of all the other tubes, thereby extinguishing any conductive tube by causing its cathode potential to temporarily be more positive than its anode potential.

3. In combination, a plurality of gaseous electron discharge tubes each having an anode, a cathode, and a control element; means for supplying operating potential to the anodes and the cathodes, said cathode supply including a high resistance; means to supply controlling bias potential to the control element from a point in the cathode potential supply means of the cathode of another tube, said tubes being so connected from the cathode supply of one tube to the control element of another tube in a series; means to cause conduction to commence in one tube; means to impress electric potential impulses on all the control elements to cause a step of sequential operation of the tubes by causing the control element connected to the cathode supply of a conductive tube to lose control; and means connecting the cathodes of all the tubes in parallel, each cathode being connected to a common conductor through a capacitor, so as to cause a rise in potential of the conductor when a tube fires and becomes conductive, which rise in potential of the conductor is impressed on the cathodes of all the other tubes, thereby extinguishing any conductive tube by causing its cathode potential to temporarily be more positive than its anode potential, said means including a resistor in series with each cathode capacitor.

4. In combination, a plurality of gaseous electron discharge tubes each having an anode, a cathode, and a control element; means for supplying operating potential to the anodes and the cathodes, said cathode supply including a high resistance; means to supply controlling bias potential to the control element from a point in the cathode potential supply means of the cathode of another tube; means to cause conduction to commence in one tube; means to impress electric potential impulses on all the control elements to cause a step of sequential operation of the tubes by causing the control element connected to the cathode supply of a conductive tube to lose control; means connecting the cathodes of all the tubes in parallel, each being connected to a common conductor through a capacitor, so as to cause a rise in potential of the conductor when a tube fires and becomes conductive, which rise in potential of the conductor is impressed on the cathodes of all the other tubes thereby extinguishing any conductive tube by causing its cathode potential to temporarily become more positive than its anode potential; and means to stabilize the extinguishing circuit against anomalous potential surges including a resistance in the common anode supply conductor.

5. In combination, a plurality of electron tubes each having an anode and a cathode; means connecting the tubes for operation serially in response to commonly received potential impulses; means connecting the tubes in parallel whereby the commencement of operation of one tube causes the stopping of any operating tube, said parallel connecting means including a capacitor in series with each cathode, said capacitors being connected to a common conductor; and a surge current limiting means for the parallel connections comprising a common resistor in series with all the anodes.

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