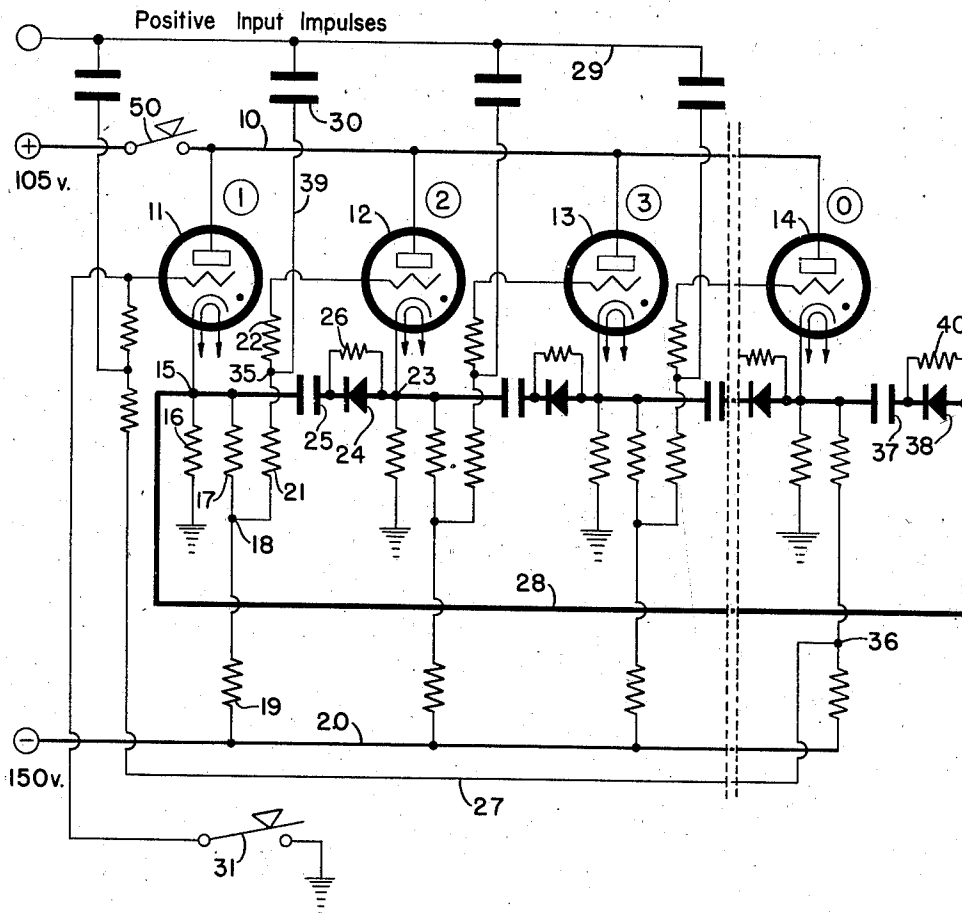


Aug. 26, 1947.

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ELECTRONIC DEVICE
Filed April 19, 1944

2,426,278



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2,426,278

ELECTRONIC DEVICE

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Application April 19, 1944, Serial No. 531,694

11 Claims. (Cl. 315—230)

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This invention relates to gaseous discharge electron tube counting rings for counting electric impulses. The novel features of the disclosed invention pertain particularly to the means for extinguishing conduction in a preceding tube of the ring when the next succeeding tube in the ring is caused to conduct, on receipt of an input impulse to be counted, without temporarily incapacitating the ring to receive and count the next impulse.

The tubes constituting a ring, assigned digit values, are connected in an endless operating chain in which one tube at a time is conducting, the conduction in a tube indicating the count by its glow. On receipt of an input electric impulse, common to all the tubes in the ring, the tube next adjacent the conducting tube, in a particular direction in the ring, termed the counting direction, will become conducting, and the one conducting just before receipt of the impulse will be extinguished. It is apparent that, whereas the step-by-step action in the ring in response to impulses is in one direction, the extinguishing action necessarily proceeds in the opposite direction in the ring.

The electron tubes disclosed are of the gaseous discharge grid controlled type, and each has one of the main electrodes supplied with operating potential through a resistance. For the purpose of this disclosure of the main electrodes, the cathode of each tube is selected to be supplied with operating potential through the individual resistance. The anodes may be so used to supply the extinguishing action if desired, but it is considered preferable to keep the anode supply free of resistance. Each tube has a control grid, and the cathode of one tube is connected to the control grid of the next tube in the chain in the counting direction. Each of the grids is electrostatically coupled to an input impulse conductor. Therefore, when a tube becomes conducting, the potential of its cathode rises abruptly due to the resistance, which act relieves a strong controlling bias normally supplied to the control grid of the next tube in the chain, to near the firing point, and makes such next tube easier to fire with an input impulse than any other of the non-conducting tubes. The abrupt rise in cathode potential of a firing tube is used to extinguish conduction in the preceding tube in the chain by forcing its cathode temporarily in a positive direction, above its then elevated potential caused by the cathode resistance, which rise is sufficient to make the cathode potential more positive than the potential of the anode, thus extinguishing conduction

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in the tube and allowing the grid to regain control.

In the heretofore known counting rings using the described method of extinguishing the preceding tube, the cathodes of all the tubes were either coupled in series by connecting each two adjacent cathodes with a capacitor, or each cathode was coupled to a common extinguishing conductor by means of a capacitor. In the old two types of extinguishing coupling just mentioned, not only the cathode of the preceding tube was given a positive potential surge, but the potential of the cathode of the succeeding non-conducting tube was given the same surge. Until such positive extinguishing surge subsided, the succeeding tube would not fire on receipt of an impulse on its grid because the effective negative bias potential is increased. Although such surges last only for several micro-seconds, that time definitely limits the speed with which such a ring would accurately receive and count impulses. The maximum reception rate for such rings is about fifteen thousand counts per second.

This invention provides means for preventing the extinguishing potential surge from temporarily robbing the next tube in the counting direction of its ability to fire, by permitting the potential surge to travel only in a direction retrograde with respect to the counting direction. By passing around the ring through all the inter-cathode couplings, the surge does reach the next succeeding tube in the counting direction, but the surge is by that time so attenuated as to be of no practical effect.

The invention for the purpose of causing the extinguishing surge to travel only in the retrograde direction provides for the use of inter-cathode unidirectional current conducting elements in series with each inter-cathode capacitor.

This invention, by introducing the unidirectional current conducting elements in the inter-cathode connections, has eliminated the necessity for waiting for a subsidence of the extinguishing surge before the ring will respond to an input impulse. Consequently, the acceptance rate of impulses is vastly increased, providing a faster counting ring.

The unidirectional current-conducting element is placed in series with the ordinary inter-cathode capacitors, and each unidirectional current-conducting element is shunted by a relatively high resistance to permit readjustment of the charge on the capacitor passed to it through said element.

Therefore, it is an object of the invention to

provide a gaseous discharge electron tube electric impulse counting ring with a high acceptance rate for impulses to be counted.

Another object of the invention is to provide such a ring with a unidirectional current conductor between each two cathodes.

Another object of the invention is to provide such a ring with a capacitor in series with a unidirectional current conductor between each two cathodes.

Another object of the invention is to provide such a ring with the unidirectional current-conducting elements oriented in the same direction in the ring as regards polarity.

Another object of the invention is to provide such a ring with the unidirectional current elements each shunted by a resistor.

Another object of the invention is to provide an electron tube counting ring having priming potentials propagated in one direction in the ring and having extinguishing potentials propagated in the other direction in the ring.

With these and incidental objects in view, the invention includes certain novel features, circuits, and combinations of parts, the essential elements of which will be set forth in the claims and in the description which follows and which is further disclosed in the circuit drawing to be described in connection with the specification, as the preferred form or embodiment of the invention.

The drawing shows a typical circuit embodying the invention as applied to a decimal numerical order counting ring. The tubes and circuits representing the digits 4, 5, 6, 7, 8, and 9 have been omitted, as they are duplicates of those of digits 2 and 3 which are shown.

One gaseous discharge electron tube is provided for representing each of the digits, including zero. Grid-controlled gaseous discharge tubes of commercial types may be used. For an example the tubes shown, with anode-cathode potentials of about 113 volts, are assumed to have the elements adjusted to fire when the associated grid is about 12 volts negative with respect to the cathode. The internal potential anode-cathode drop in a conducting tube is assumed to be about 15 volts. Potentials are given with respect to ground.

An anode supply conductor 10, supplied with 105 volts positive potential when switch 50 is closed, is connected directly to each anode.

Each cathode is connected to ground like the cathode of tube 11 from a point, like point 15, through a resistance, like resistance 16, of 15,000 ohms, on one side, and is connected to negative supply conductor 20 through a resistance, like resistance 17, of 125,000 ohms, a point, like point 18, and a resistance, like resistance 19, of 125,000 ohms on the other side. Points, like point 18, are connected through a resistance, like resistance 21 of 500,000 ohms, a point, like point 35, and a resistance, like resistance 22 of 50,000 ohms, to the control grid of the digit tube of the next higher value.

The cathode of a digit tube is connected to the cathode of the tube of next lower digit value by means of a unidirectional current-conducting element, like element 24, in series with a capacitor, like capacitor 25 of 500 micro-microfarads. Each unidirectional current element is shunted by a resistor like resistor 26 of 150,000 ohms.

The unidirectional current-conducting elements or rectifiers, such as element 24, are shown conventionally. They may be of the electron tube

type, of the crystal type, or of the metal oxide type, depending upon the particular characteristics desired. These unidirectional current-conducting elements should be of low internal capacity to prevent a transmission of a reverse impulse by reason of such capacity. All of the unidirectional elements should be oriented so as to pass positive potential surges toward the digit tube of smaller value.

It will be seen that the ring is completed from the "0" tube 14 to the "1" tube 11 by the priming connection from the point 36 of the cathode supply of the "0" tube over conductor 27 to the grid of the "1" tube, and by connecting the cathode of the "1" tube to the cathode of the "0" tube by way of conductor 28, unidirectional current-conducting element 38 shunted by resistance 40, and capacitor 37.

Positive input impulses to be counted are received on input conductor 29, to which each of the grids is electrostatically coupled. For instance, the grid of the "2" tube is connected through before-mentioned point 35, conductor 39, and capacitor 30, of 10 micro-microfarads, to said input conductor 39. With the circuit elements specified, a positive input impulse of from 20 to 40 volts impressed upon conductor 29 will fire a tube whose grid is primed by reason of conduction in the preceding tube, to the exclusion of any other tube of the ring, said primed tube being one of higher digit value than the then conducting tube.

Only one tube at a time is permitted to be conducting by the action of the novel extinguishing system to be described. It will be assumed that at first no tube is conducting and switch 50 is closed. By the closing of switch 31, the "1" tube may be fired by having its normally highly negative grid brought to ground potential, thus rendering it more positive than the cathode, which is normally at a potential of about 8.5 volts negative. As the "1" tube fires and becomes conducting, a rise in potential occurs at point 18 to change the highly-negative bias of the grid of the "2" tube to a primed condition, where it alone, by reason of its lesser controlling potential, is singled out, by the commonly received input impulses, as the next tube to be fired. A similar but greater rise in potential at point 15, caused by the firing of the "1" tube, is conveyed over conductor 28 through the unidirectional current-conducting element 38 and through capacitor 37 to effect a considerable rise in potential of the cathode of the "0" tube. If that "0" tube had been conducting previously, its cathode would have been at a point about 15 volts negative with respect to the anode, or 90 volts positive, and the additional positive surge impressed thereon would cause the cathode to rise to a point higher than the anode potential, thus extinguishing conduction in the "0" tube. The resistor 40 permits the re-establishment of normal charges on capacitor 37 as determined by the thereafter stabilized cathode potentials of tubes 11 and 14.

The positive rise in potential of point 15 is not permitted to be impressed upon point 23 directly in the counting direction, as the unidirectional current-conducting element 24 is oriented to prevent the passage of positive surges in that direction. The high resistance 26 effectively blocks any effective surge through it to point 23.

There is an attenuated positive potential surge at point 23 as the "1" tube 11 fires, by reason

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of the positive potential rise going clear around the ring by way of the extinguishing conductor 28, elements 38, 37, etc., but in a ring as large as the ten-tube decimal ring shown, the attenuation of such an impulse going through the cathode supply network, the nine capacitors and the rectifiers, of the characteristics mentioned, would be sufficient to render its effect on point 23 of no practical consequence.

Switches like switch 31 may be provided for any tube of the ring. The switch 50 is provided for removing the anode potential supply to clear all data from the ring by causing any conducting tube to be extinguished.

The effect of the introduction of elements like elements 24 and 26 between each two cathodes is to speed up the operation of the ring, as such speed is not dependent upon the subsidence of inter-cathode surges between the conducting tube and the succeeding tube of the ring.

As is apparent, the cathode rise in potential of any selected tube can be tapped for the purposes of priming a transfer tube for transferring an impulse of a positive polarity to the input conductor of another similar ring for causing transfer of one unit of carry-over data to that other ring once each complete cycle.

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 form or embodiment disclosed herein, as it is susceptible of embodiment in various forms all coming within the scope of the claims which follow.

What is claimed is:

1. In an electron tube counting ring including a plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a discharge control element, connected cathode of one tube to the control element of the next tube in the ring, in an endless operative chain wherein the tubes are rendered conducting serially in response to electric impulses to be counted which are impressed on the control elements, the combination of means for supplying operating potential to each cathode through a resistance; and unidirectional current-conductive means shunted by a relatively high resistance coupling the cathodes of each two adjacent tubes in the endless chain for passing the positive potential rise, appearing at the cathode of a tube as it commences to conduct, to the cathode of one of the next adjacent tubes but not to the other next adjacent tube.

2. In an electron tube counting ring including a plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a discharge control element, connected cathode of one tube to the control element of the next tube in the ring, in an endless operative chain wherein the tubes are rendered conducting serially in response to electric impulses to be counted which are impressed on the control elements, the combination of means for supplying operating potential to each cathode through a resistance; and unidirectional current-conducting means shunted by a relatively high resistance coupling the cathodes of each two adjacent tubes in the endless chain for passing the positive potential rise, appearing at the cathode of a tube as it commences to conduct, to the cathode of the tube to which said commencing tube's control element is connected.

3. In an electron tube counting ring including

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a plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a discharge control element connected cathode of one tube to the control element of the next tube in the ring, in an endless operative chain wherein the tubes are rendered conducting serially in response to electric impulses to be counted which are impressed on the control elements, the combination of means for supplying operating potential to each cathode through a resistance; and unidirectional current-conducting means shunted by a relatively high resistance coupling the cathode of a given tube to the cathode of the tube to which the given tube's control element is connected for passing positive potential surges originating at the cathode of the given tube.

4. In an electron tube counting ring including a plurality of gaseous discharge electron tubes, each having at least an anode, a cathode, and a discharge control element, connected cathode of one tube to the control element of the next tube in the chain, in an endless operative chain wherein the tubes are rendered conducting serially in response to electric impulses to be counted which are impressed on the control elements, the combination of means for supplying operating potential to each cathode through a resistance; and means coupling each two adjacent cathodes so as to effectively pass positive potential surges originating at a cathode in a direction in the chain retrograde to that of the direction of the counting operation of the chain.

5. In an electron tube counting ring including a plurality of gaseous discharge electron tubes, each having at least an anode, a cathode, and a discharge control element, connected cathode of one tube to the control element of the next tube in the chain, in an endless operative chain wherein the tubes are rendered conducting serially in response to electric impulses to be counted impressed on the control elements, the combination of means for supplying operating potential to each cathode through a resistance; and means coupling each two adjacent cathodes by means of a capacitor in series with a unidirectional current-conducting element shunted by a relatively high resistance, said element being oriented to pass positive potential surges from the cathode to which it is directly connected to the capacitor in series with it, but not in a reverse direction, said positive potential surges proceeding by reason of such orientation in a direction in the chain retrograde with respect to the direction of the counting action therein.

6. In an electron tube counting ring for counting electric impulses, which ring includes a plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element, the combination of means supplying anode potential to said tubes; means for supplying each cathode with potential through a resistance; means connecting the tubes in a counting direction from the cathode of one tube to the control element of an adjacent tube to form an endless operating chain; means supplying a normally controlling potential to each control element, which controlling potential is reduced as to the grid of any tube when the tube to whose cathode the grid is connected is conducting; means coupling the control elements to an input conductor; and means coupling the cathodes of each two adjacent tubes so as to effectively pass positive potential surges from the cathode of one tube to the cathode of the next tube only in a

direction in the chain contrary to the counting direction.

7. In an electron tube counting ring for counting electric impulses, which ring includes a plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element, the combination of means supplying anode potential to said tubes; means for supplying each cathode with potential through a resistance; means connecting the tubes in a counting direction from the cathode of one tube to the control element of an adjacent tube to form an endless operating chain; means supplying a normally controlling potential to each control element, which controlling potential is reduced as to the grid of any tube when the tube to whose cathode the grid is connected is conducting; means coupling each control element to a common input conductor; and means coupling the cathodes of each two adjacent tubes so as to effectively pass positive potential surges from the cathode of one tube to the cathode of the next tube only in a direction in the chain contrary to the counting direction, said last means including a unidirectional current-conducting element shunted by a relatively high resistance.

8. In an electron tube counting ring for counting electric impulses, which ring includes a plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element, the combination of means supplying anode potential to said tubes; means for supplying each cathode with potential through a resistance; means connecting the tubes in a counting direction from the cathode of one tube to the control element of an adjacent tube to form an endless operating chain; means supplying a normally controlling potential to each control element, which controlling potential is reduced as to the grid of any tube when the tube to whose cathode the grid is connected is conducting; means coupling each control element to a common input conductor; and means coupling the cathode of each two adjacent tubes so as to pass positive potential surges from the cathode of one tube to the cathode of the next tube only in a direction in the chain contrary to the counting direction, said last means including a unidirectional current-conducting element shunted by a relatively high resistance.

9. In an electron tube counting ring for counting electric impulses, which ring includes a plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element, the combination of means supplying anode potential to said tubes; means for supplying each cathode with potential through a resistance; means connecting the tubes in a counting direction from the cathode of one tube to the control element of an adjacent tube to form an endless operating chain; means supplying a normally controlling potential to each control element, which controlling potential is reduced as to the grid of any tube when the tube to whose cathode the grid is connected is conducting; means coupling each control element to a common input conductor; and means coupling the cathodes of each two adjacent tubes so as to pass positive potential surges from the cathode of one tube to the cathode of the next tube in a direction in the chain contrary to the counting direction, said last means including, in order, between a given cathode and the cathode of the tube next

adjacent in a direction contrary to the counting direction a unidirectional current-conducting element shunted by a relatively high resistance, and a capacitor.

10. In an electron tube counting ring for counting electric impulses, which ring includes a plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element, the combination of means supplying anode potential to said tubes; means for supplying each cathode with potential through a resistance; means connecting the tubes in a counting direction from the cathode of one tube to the control element of an adjacent tube to form an endless operating chain; means supplying a normally controlling potential to each control element, which controlling potential is reduced as to the grid of any tube when the tube to whose cathode the grid is connected is conducting; means coupling the cathodes of each two adjacent tubes so as to pass positive potential surges from the cathode of one tube to the cathode of the next tube in a direction in the chain contrary to the counting direction, said last means including in order between a given cathode and the cathode of the tube next adjacent in a direction contrary to the counting direction a unidirectional current-conducting element shunted by a relatively high resistance, and a capacitor; and means to impress positive electric impulses on the control elements of all the tubes, firing a tube whose controlling potential is reduced.

11. In an electron tube counting ring for counting electric impulses, which ring includes a plurality of gaseous discharge electron tubes each having at least an anode, a cathode, and a control element, the combination of means supplying anode potential to said tubes; means for supplying each cathode with potential through a resistance; means connecting the tubes in a counting direction from the cathode of one tube to the control element of an adjacent tube to form an endless operating chain; means supplying a normally controlling potential to each control element, which controlling potential is reduced as to the grid of any tube when the tube to whose cathode the grid is connected is conducting; means coupling the cathodes of each two adjacent tubes so as to pass positive potential surges from the cathode of one tube to the cathode of the next tube in a direction in the chain contrary to the counting direction, said last means including in order between a given cathode and the cathode of the tube next adjacent in a direction contrary to the counting direction, a unidirectional current-conducting element shunted by a relatively high resistance, and a capacitor; means to impress positive electric impulses on the control elements of all the tubes, firing a tube whose controlling potential is reduced; and means to prepare the ring for operation by rendering a selected tube conducting.

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The following references are of record in the file of this patent:

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Number	Name	Date
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Certificate of Correction

Patent No. 2,426,278.

August 26, 1947.

ROBERT E. MUMMA

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 2, line 24, after the word "means" strike out "for"; column 4, line 25, for the numeral "39" read 29; column 5, line 48, claim 1, for "current-conductive" read *current-conducting*; column 5, line 58, claim 2, after "anode" strike out the period and insert instead a comma; column 7, line 44, for "cathode" read *cathodes*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 14th day of October, A. D. 1947.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.