

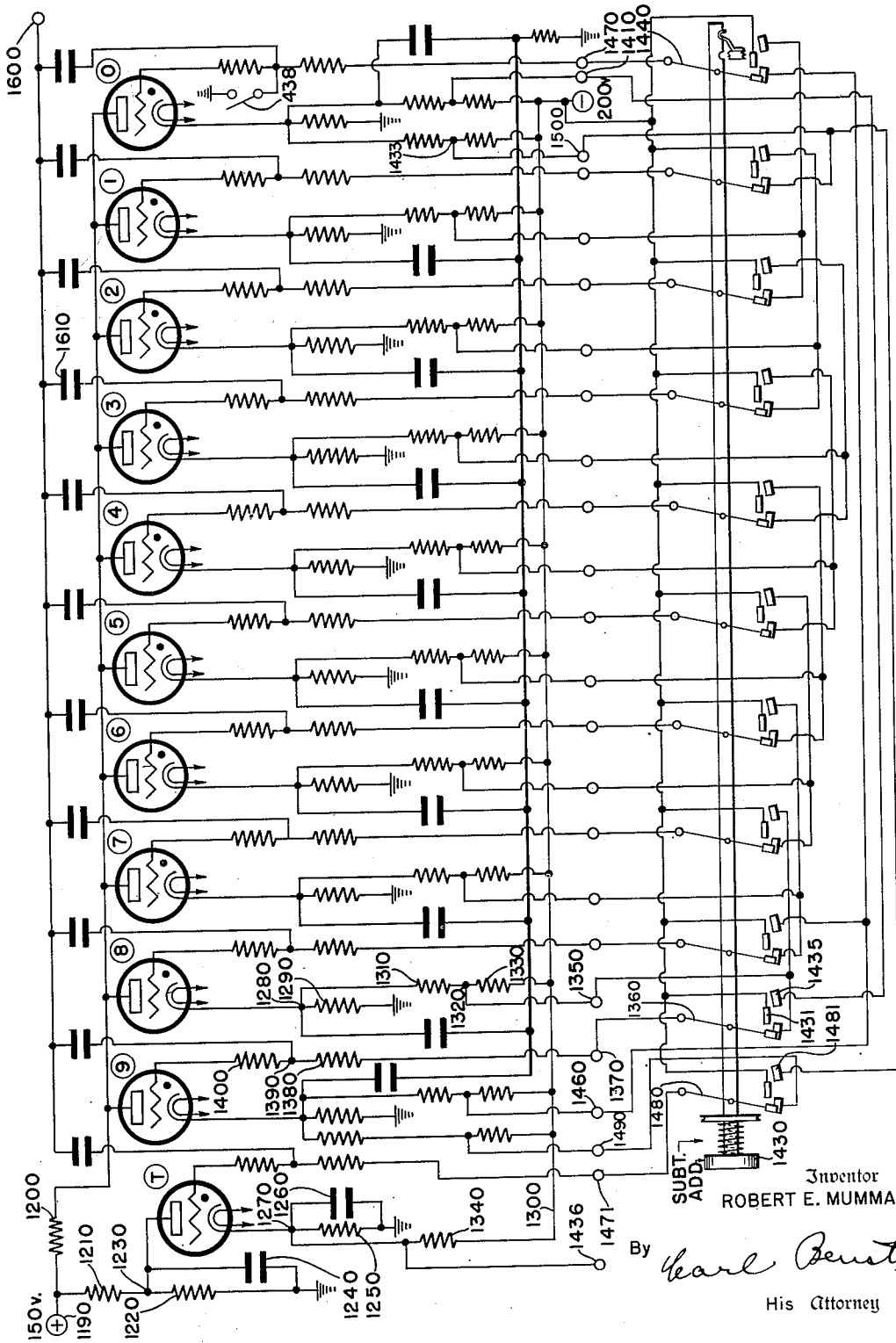
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R. E. MUMMA

2,533,739

ELECTRONIC COUNTING RING

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ELECTRONIC COUNTING RING

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

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25 Claims. (Cl. 235—92)

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This invention relates to electron tube counting rings for counting electric impulses, the rings being individually operable either forwardly or reversely for adding or subtracting operations.

The invention further provides means to join the rings into an accumulator, so that transfer of carryover data may be accomplished at the proper time according to whether an addition operation or a subtraction operation is being performed.

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

The counter ring units which form the accumulator are an improvement over those shown in my co-pending application for United States Letters Patent, Serial No. 396,505, which was filed June 4, 1941, and issued on July 30, 1946, as Patent No. 2,405,096. Each ring consists of a group of gaseous discharge electron tubes, those tubes of a group being coupled in an endless counting chain for operation one at a time, in succession, by each of commonly received electric impulses. The improvement made in the rings and the accumulator by this invention provides means for entering data additively or subtractively therein, and to do such without affecting the accumulation of data up to the time of change from adding to subtracting or vice versa. The direction of serial operation of the tubes in a denominational unit of the accumulator, formerly fixed, is now by this invention controlled by means interconnecting the tubes, so that the chain may be operated as selected in a forward or reverse manner for a given entry, the direction of operation determining whether the data is entered additively or subtractively. Denominational transfers of carryover data are made at the proper time in the operation of the counting ring, be the same in an adding operation or in a subtracting operation.

Therefore, the principal object of the invention is to provide electronic counting rings with circuits permitting forward or reverse operation as selected.

Another object of the invention is to provide counting rings of electron tubes having denominational carryover transfer means between the rings to form an accumulator, the ring to which the carryover is made being operated one step in either a forward manner or a reverse manner, as selected.

With these and incidental objects in view, the invention includes certain novel features of con-

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struction, circuits, and combinations of parts, the essential elements of which are set forth in appended claims and a preferred form or embodiment of which is hereinafter described with reference to the drawing which accompanies and forms a part of this specification.

The drawing shows a denominational bank of an accumulator with the associated denominational counting ring unit and the associated denominational transfer unit.

The gaseous triode electron tubes used in the disclosed embodiment of the invention are of the thermionic cathode type having an anode, a cathode, and a control grid and having an internal potential drop during conduction of about 15 volts, with the electrode elements so related that a tube will fire when the grid is more positive than about 12 to 20 volts negative with respect to the cathode, depending on the anode-cathode potential. Circuits for heating the cathodes are indicated only conventionally. These tube characteristics are true of all the gaseous tubes shown in the drawing.

Values of potential, resistance, and capacitance, as given, are relative and are given as one set of values which result in proper operation with the specified tubes, but are not to be deemed the only circuit values that can be used, as the principles involved in the invention permit of different levels for these relative values and of different relative values when electron tubes or other characteristics are used. Potentials given are with respect to ground potential.

The accumulator counting ring unit shown in the drawing has ten digit-representing gaseous triode electron tubes for the digits "0," "1," "2," "3," "4," "5," "6," "7," "8," and "9." A transfer tube "T" is provided for creating an electric impulse to carry over a unit of data to the next higher denominational order, which event occurs on the next impulse received after the "9" digit tube is conducting in adding entries, or on the next impulse received after the "0" tube is conducting in subtracting entries. The counting ring may be described as of the parallel cathode extinction type, as all the digit tube cathodes, each of which is connected to a potential source through a resistance, are coupled electrostatically to a common extinguishing conductor, whereby, when a tube commences to conduct, the positive potential rise of its cathode is impressed on all the other tubes of the ring, extinguishing the last conducting tube. The tubes in the ring are rendered conducting one at a time in sequence in response to electric potential impulses com-

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monly impressed electrostatically on the control grids of the digit tubes and the control grid of the "T" tube. The conducting condition of a tube primes the next tube in the ring to become conducting on the next commonly received impulse, and the act of a tube's becoming conducting, because of the electrostatic coupling of each cathode in parallel to a common conductor and the presence of a resistor in each cathode potential supply, causes the extinction of conduction in the previously conducting tube of the ring by forcing its cathode potential to a point more positive than its anode potential. The direction of the intertube priming connections determines whether the ring operates in a forward manner or in a reverse manner, and the connection of the digit tubes to the "T" tube determines on what impulse a carryover transfer is made.

An explanation of the structure and operation of one ring will give an understanding of the structure and operation of all the rings of an accumulator constructed of a plurality of these rings connected in a series.

With reference to the drawing, the digit-representing tubes are numbered according to their digit value in the denomination. Each is a gaseous triode of the type described as standard in the device. Anode potential of 150 volts is applied at terminal 1190, which is routed to the digit tube anodes through resistor 1200 of 10,000 ohms. Terminal 1190 is connected to ground through resistor 1210 of 120,000 ohms and resistor 1220 of 100,000 ohms in parallel with capacitor 1240 of .01 microfarad. Point 1230, which supplies anode potential for the "T" tube, is thereby given a normal positive potential of about 68 volts. The cathode potential of the "T" tube is derived from point 1270, which is connected to ground through resistor 1250 in parallel with capacitor 1260 of 25 micro-microfarads, and connected to the negative 200-volt supply conductor 1200 through resistor 1340 of 230,000 ohms. When said "T" tube becomes conducting, due to the high current caused by the charging of capacitor 1260 subsiding, there immediately ensues an oscillatory phenomenon in the anode-cathode circuit due to the distributed inductance, which causes the cathode to rise in potential to a point, which results in a temporary cessation of anode-cathode potential and extinguishment of conduction in the tube.

Each of the digit tube cathodes obtains its potential from a point, like the "8" tube cathode point 1280, which is connected on one side to ground through a resistor, like resistor 1290, of 25,000 ohms, and connected on the other side to the negative 200-volt supply conductor 1300 through a resistor, like resistor 1310, of 63,000 ohms, a point like point 1320, and a resistor, like resistor 1330, of 50,000 ohms. Each digit tube grid is given a normal controlling bias by being connected to a point in the cathode supply circuit of an adjacent tube, said cathode point being that of the adjacent tube of lower digit value in case the ring is adjusted for adding entries, and said cathode point being that of the adjacent tube of higher digit value in case the ring is adjusted for subtracting entries. For instance, grid priming supply point 1320 of the "8" tube cathode is connected, in adding operations, through terminal 1350, switch 1360, and terminal 1370, to prime the "9" tube grid through resistor 1380 of 100,000 ohms, point 1390, and resistor 1400 of 10,000 ohms. When the switch key 1430 is moved from "add" position to "subtract" posi-

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tion, the "9" tube grid is primed by the "0" tube cathode priming supply terminal 1410, as switch 1360 is moved to contact 1435. During the travel of a switch, such as switch 1360, from one contact to another, it is supplied with sufficient negative potential through a contact, like contact 1431, connected to the negative supply conductor 1300, to maintain a controlling bias on the grid of the associated tube, preventing anomalous firing of the accumulator tubes.

The transfer tube "T" grid is primed by potential applied to terminal 1471, which in the adding position of key switch 1430 obtains its priming potential through switch 1480, in the position shown, and terminal 1490 leading to the "9" tube cathode. In subtracting operations, the switch 1480 is moved to its other contact 1481, and thus terminal 1471 receives its prime from point 1500, connected to prime supply point 1433 of the cathode of the "0" tube. The movement of key 1430 from "add" position to "subtract" position, in a similar manner, causes the cathode priming point of each tube in the bank to change contacts so as to prime the next lower digit tube instead of the next higher digit tube. There is a key 1430 for each bank of the accumulator.

Positive potential impulses impressed on the input terminal 1600 are impressed commonly on the grid of each of the digit tubes and the transfer tube, each through an input capacitor such as capacitor 1610 of .00005 microfarad. Each of the impulses will cause the primed tube to conduct and consequently will cause the digit tubes to become conducting one at a time in sequence in an endless chain manner.

As the "T" tube fires and becomes conducting when the ring has exceeded its capacity, an impulse is taken from its cathode and by terminal 1436 is conveyed to the input conductor for the ring of next higher denomination. Such next higher ring is not shown but, as has been stated, is like the ring shown in the drawing.

Assuming the anode potential to be applied to the ring and assuming that no tubes are conducting or a significant digit tube is conducting, a switch like switch 438 may be closed temporarily to cause the "0" tube to become conducting by grounding its grid, registering zero and priming the "1" tube to become conducting on receipt of the next input impulse in case the switch 1430 is in adding positions or priming the "9" tube and the "T" tube to become conducting on receipt of the next impulse in case the switch 1430 is in subtracting position. The firing of the "0" tube will extinguish any other significant digit tube which may be conducting when switch 438 is operated.

Thus, the ring may be operated either forwardly for adding or reversely for subtracting, the occurrence of the transfer unit being provided for at the proper count. As many rings may be connected in a series as desired to form an accumulator of any desired size. The transfer carryover impulse will operate the next ring either forwardly or reversely according to its adjustment. It is obvious that, in addition operations, all rings connected in a series would be adjusted for forward operation and that, in subtraction operations, all rings connected in a series would be adjusted for reverse operation.

While the device shown and described herein 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 disclosed herein, for it is susceptible

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of embodiment in various forms all coming within the scope of the claims which follow.

What is claimed is:

1. A plurality of units each including an electrode pair and an inter-electrode discharge control means; means to establish operative chain connections between the units, by connecting one of the electrodes of each pair to the control means of an adjacent unit of the chain; and switching means operable to disestablish such connections and establish new connections between said one electrode of each unit and the control means of the adjacent unit of the former chain in a reverse direction.

2. A plurality of units each including an electrode pair and an inter-electrode discharge control means; means connecting the units in an operative endless chain by connecting one of the electrodes of each pair to the control means of an adjacent unit of the chain; and add-subtract control means to modify the connections between tubes to disestablish said connections and establish new connections between said one electrode of each unit and the control means of the adjacent unit of the former chain, but in a reverse direction.

3. A plurality of digit-representing counting units each including an electrode pair and an inter-electrode discharge control means; means connecting the units in an operative chain by connecting one of the electrodes of each pair to the control means of one of the adjacent units; and switching means operable to disestablish such connections and establish new connections between said one electrode of each unit and the control means of other adjacent unit of the former chain to form a chain operative in a reverse direction.

4. A plurality of gaseous electron units each including an electrode pair and an inter-electrode discharge control means; and means connecting the units in an operative chain by connecting one of the electrodes of each pair to the control means of an adjacent unit, said means including switching devices operable to disestablish such connections and establish new connections between said one electrode of one unit and the control means of an adjacent unit of the former chain but in a reverse direction.

5. A plurality of electronic units each including an electrode pair; means to supply each pair with operating potential, said means including circuit elements to cause an electrode of each pair to change its potential when conduction commences between the members of the pair; control means for each pair, which control means is normally supplied with potential sufficient to prevent conduction between the members of the associated pair; means connecting the potential-changing electrode of a pair to the control means of another adjacent unit to form an endless operative chain of the units, the condition of conduction in a unit causing a potential change in the control means of the connected unit, and said connecting means including switching means operable to disestablish the above-mentioned electrode-control means connections and establish similar electrode-control means connections between the units in a manner reverse in direction in the chain to said first-mentioned connections; and means operable to supply a blocking bias potential to the control means of the various pairs during the changing of the connections to maintain the conducting status of the units dur-

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ing the establishing and disestablishing of the connections.

6. A plurality of gaseous electronic units each including an electrode pair; means to supply each pair with operating potential, said means including circuit elements to cause an electrode of each pair to change its potential when conduction commences between the members of the pair; control means for each pair, which control means is normally supplied with potential sufficient to prevent conduction between the members of the associated pair; and means connecting the potential-changing electrode of a pair to the control means of another adjacent unit to form an endless operative chain of the units, the condition of conduction in a unit causing a potential change in the control means of the connected unit, and said connecting means including circuit change-over devices operable to disestablish the electrode-control means connections and establishing similar electrode-control means connections between the units in a manner reverse in direction in the chain to said first-mentioned connections.

7. A plurality of electronic units each having at least an anode, a cathode, and a control member; and means connecting the units in an endless operative chain wherein they may be rendered conducting one at a time in sequence in response to electric impulses impressed commonly on the control members, said means including a connection from the cathode of one unit to the control member of an adjacent unit in the chain, and said connecting means including circuit changing means operable to disestablish all such cathode-control member connections and establish similar connections from each cathode to the control member of that adjacent unit of the chain situated in the opposite direction in the chain from said adjacent unit to whose control member the cathode was first connected.

8. A plurality of gaseous electronic units each having at least an anode, a cathode, and a control member; means connecting the units in an endless operative chain wherein they may be rendered conducting one at a time in sequence in response to electric impulses impressed commonly on the control members, said means including a connection from a cathode of one unit to the control member of an adjacent unit in the chain, said connecting means also including switching means operable to disestablish all such cathode-control member connections and establish similar connections from each cathode to the control member of that adjacent unit of the chain situated in the opposite direction in the chain from said adjacent unit to whose control member the cathode was first connected; and means coupled to the units during the changing of connections to control the units to maintain non-conducting units against conduction while allowing the conducting unit to continue to conduct.

9. An electron tube counting ring including the combination of connections between adjacent tubes in the ring making it operable in one direction around the ring; and switch means to change said connections to make the ring operable in the reverse direction said switch means to maintain the operating status of the tubes of the ring during said change.

10. An electron tube counting ring including the combination of a plurality of electron tubes arranged by connections between the tubes in an endless operating chain; means to impress

electric signals on all the tubes, which tubes, by reason of said connections, are caused to become conducting around the chain in one direction one tube at a time in sequence in response to said signals; and circuit change-over means for changing the connections between tubes to cause the sequential operation of the tubes to occur in the opposite direction around the chain.

11. An electron tube counting ring including the combination of a plurality of gaseous electron tubes arranged by connections between the tubes in an endless operating chain; means to impress electric impulses on all the tubes, which tubes, by reason of said connections, are caused to become conducting step by step around the chain in one direction one tube at a time in sequence, there being one step of operation in response to each of said impulses; and switching means operable for changing the connections to cause the sequential operation of the tubes to occur in the opposite direction around the chain said changing means including means to maintain the operating status of the tubes of the ring during said change in connections.

12. An electronic impulse-counting device including the combination of a denominational set of electron tubes, there being a tube to represent each digit in the denomination including zero, and an extra tube for denominational carryover counts; means connecting the digit tubes in an operational ring wherein the digit tubes count electric impulses impressed commonly thereon by becoming conducting one at a time in endless succession, one digit tube responding to each impulse; means connecting the extra tube to the ring to be controlled thereby and operated at a certain time in the cycle of operation of the ring; and add-subtract control means operable to selectively control the direction of successive operation in the ring so as to accommodate additive entries of data or subtractive entries of data and to change the connection of the extra tube to the ring to cause the extra tube to be operated at a different time in the cycle of operation of the ring in subtractive operations from its time of operation in additive operation.

13. An electronic impulse-counting device including the combination of a denominational set of gaseous electron tubes, there being a tube to represent each digit in the denomination including zero, and an extra tube for denominational carryover counts; means for connecting the digit tubes in an operational ring wherein the digit tubes count electric impulses impressed commonly thereon by becoming conducting one at a time in endless succession; means connecting the extra tube to the ring to be controlled thereby and operated at a certain time in the cycle of operation of the ring and add-subtract control means for the connecting means to selectively control the direction of successive operation in the ring so as to accommodate additive entries of data or subtractive entries of data and for controlling the connection of the extra tube to the ring to cause the extra tube to be operated at one time in the cycle of operation of the ring in additive entries and at another time in the cycle in subtractive entries.

14. In combination, a plurality of electron tubes each having at least an anode, a cathode, and a control electrode; means to supply anode-cathode potential to the tubes, including a resistance in each cathode supply circuit; means to supply normally controlling bias potential to the control electrodes; means to impress poten-

tial impulses on all the control electrodes, tending to cause them to lose control; means connecting the tubes in an endless operative chain by connecting the cathode of a preceding tube to the control electrode of a succeeding tube, the combined effect on a control electrode of the cathode rise in potential of a preceding tube occurring at the same time as an impressed impulse, causing the tube to become conducting; means to cause a beginning tube to become conducting; and switching means operable to change the cathode-control electrode connections to cause the cathode of a succeeding tube to be connected to the control electrode of the preceding tube in the chain so as to make the chain reversely operable.

15. In combination, a plurality of gaseous electron tubes each having at least an anode, a cathode, and a control electrode; means to supply anode-cathode potential to the tubes, including a resistance in each cathode supply circuit; means to supply normally controlling bias potential to the control electrodes; means to impress potential impulses on all the control electrodes, tending to cause them to lose control; means connecting the tubes in an endless operative chain by connecting the cathode of a preceding tube to the control electrode of a succeeding tube, the combined effect on a control electrode of the cathode rise in potential of a preceding tube occurring at the same time as an impressed impulse, causing the tube to become conducting; means to cause a beginning tube to become conducting; switching means operable to change the cathode-control electrode connections to cause the cathode of a succeeding tube to be connected to the control electrode of the preceding tube in the chain so as to make the chain reversely operable; and bias potential supply means operable to supply a blocking bias to the tubes during an operation of the switching means to prevent non-conducting tubes from becoming conducting.

16. An electronic counter of electric impulses, including a ring of electron tubes; connections between the tubes for causing their sequential operation in endless chain one at a time in response to electric impulses impressed commonly thereon; means to impress electric impulses commonly on the tubes; and switching means operable for switching the connections between the tubes to cause the sequential operation to proceed in a reverse direction said switching means including means to maintain the operating status of the tubes of the ring during the switching of said connections.

17. An electronic counter of electric impulses, including a ring of gaseous electron tubes; connections between the tubes for causing their sequential operation in endless chain in response to electric impulses impressed commonly thereon, one tube responding to each impulse; means to impress electric impulses commonly on the tubes; and circuit change-over means operable for switching the connections between the tubes to cause the sequential operation to proceed in a reverse direction.

18. A plurality of units each including an electrode pair and a control member; means connecting the units in an operative chain by connecting one of the electrodes of a preceding unit to the control member of a succeeding unit; an extra unit including an electrode pair and a control member; means connecting an electrode of a last unit of the chain to the control member of the extra unit; and means operable to dis-

establish the electrode-control member connections of the chain and to establish connections between an electrode of a succeeding unit with the control member of the preceding unit and to disestablish the connection of the electrode of the last unit of the chain with the extra unit control member and to establish a connection between an electrode of the first unit of the chain and the control member of the extra unit.

19. A plurality of gaseous electronic units each including an electrode pair and a control member; means connecting the units in an operative chain by connecting one of the electrodes of a preceding unit to the control member of a succeeding unit; an extra gaseous electronic unit including an electrode pair and a control member; means connecting an electrode of a last unit of the chain to the control member of the extra unit; and means operable to disestablish the electrode-control member connections of the chain and to establish connections between an electrode of a succeeding unit with the control member of the preceding unit and to disestablish the connection of the electrode of the last unit of the chain with the extra unit control member and to establish a connection between an electrode of the first unit of the chain and the control member of the extra unit.

20. An electronic electric impulse-counting device including the combination of a denominational set of electron tubes, there being a tube to represent each digit in the denomination including zero, and an extra tube for denominational carryover counts; means connecting the digit tubes in an operational ring wherein the digit tubes count electric impulses impressed commonly thereon by becoming conducting one at a time in endless succession, one digit tube responding to each impulse; means operable to selectively control the direction of successive operation in the ring so as to accommodate additive entries of data or subtractive entries of data; and means connecting the extra tube to the ring so that it becomes conducting on the first impulse received by the ring after conduction occurs in the highest value digit tube when the ring is selectively controlled for adding and becomes conducting on the first impulse received by the ring after conduction occurs in the zero tube when the ring is selectively controlled for subtraction.

21. An electronic electric impulse-counting device including the combination of a denominational set of gaseous electron tubes, there being a tube to represent each digit in the denomination including zero, and an extra tube for denominational carryover counts; means connecting the digit tubes in an operational ring wherein the digit tubes count electric impulses impressed commonly thereon by becoming conducting one at a time in endless succession, one digit tube responding to each impulse; means to selectively control the direction of successive operation in the ring so as to accommodate additive entries of data or subtractive entries of data; and means connecting the extra tube to the ring so that it becomes conducting on the first impulse received by the ring after conduction in the highest value digit tube when the ring is selectively controlled for adding, and becomes conducting on the first impulse received by the ring after conduction in the zero tube when the ring is selectively controlled for subtraction.

22. An electronic electric impulse-counting device including the combination of a plurality of

gaseous electron tubes each having at least an anode, a cathode, and a control member, there being one tube for each significant digit of a numerical denomination and for zero; means to supply sufficient anode-cathode potential to support conduction in any tube, said means including a cathode resistor for each tube; means to supply biasing potential to all the control members normally sufficient to prevent conduction in the tubes; means connecting the digit tubes including the zero tube in ascending order, cathode of a lower value digit tube to the control member of a higher value digit tube; the cathode of the highest significant digit tube being connected to the control member of the zero tube and the cathode of the zero tube being connected to the control member of the lowest significant digit tube; an extra gaseous electron tube having at least an anode, a cathode, and a control member; means supplying anode-cathode potential to the extra tube including a cathode resistor; means supplying normally controlling bias potential to the extra tube; means connecting the cathode of the highest significant digit tube to the control member of the extra tube; means to impress an electric input impulse on the control members of all the tubes in the chain and on the control member of the extra tube, any such impulse tending to cause, but falling short of causing, all the tubes to become conducting; means to cause one of the chain tubes to become conducting, the consequent rise in its cathode potential being sufficient to make the tube to whose control member the cathode is connected responsive by becoming conducting on receipt of the next commonly impressed input impulse; means to cause the act of conduction occurring in a tube of the chain to extinguish any other then conducting tube of the chain; means including circuit elements of capacitance and inductance cooperating with the anode-cathode supply circuit of the extra tube to cause it to self-extinguish immediately it becomes conducting, by reason of receipt of an impulse at the same time the highest significant digit tube is conducting; and a switching means to disestablish the cathode-control member connections between the tubes in the chain and between the extra tube of the chain and the chain and to reestablish them so that in the chain a digit tube cathode will be connected to the control member of the next lower value digit tube, and so that the cathode of the zero tube will be connected to the control member of the highest significant digit tube and to the control member of the extra tube, whereby the tubes in the chain may be operated in a forward direction or in a reverse direction as selected and to cause the extra tube to become conducting on the impulse received after the highest significant digit tube is conducting in the forward operation, and to cause the extra tube to become conducting on the impulse received after the zero tube is conducting in the reverse operation.

23. An electronic electric impulse-counting device including the combination of a plurality of gaseous electron tubes each having at least an anode, a cathode, an a control member, there being one tube for each significant digit of a numerical denomination and for zero; means to supply sufficient anode-cathode potential to support conduction in any tube, said means including a cathode resistor for each tube; means to supply biasing potential to all the control members normally sufficient to prevent conduction in

the tubes; means connecting the digit tubes including the zero tube in ascending order, cathode of a lower value digit tube to the control member of a higher value digit tube; the cathode of the highest significant digit tube being connected to the control member of the zero tube and the cathode of the zero tube being connected to the control member of the lowest significant digit tube; an extra gaseous electron tube having at least an anode, a cathode, and a control member; means supplying anode-cathode potential to the extra tube including a cathode resistor; means supplying normally controlling bias potential to the extra tube; means connecting the cathode of the highest significant digit tube to the control member of the extra tube; means to impress an electric input impulse on the control members of all the tubes in the chain and on the control member of the extra tube, any such impulse tending to cause, but falling short of causing, all the tubes to become conducting; means to cause one of the chain tubes to become conducting, the consequent rise in its cathode potential being sufficient to make the tube to whose control member the cathode is connected responsive by becoming conducting on receipt of the next commonly impressed input impulse; means to cause the act of conduction occurring in a tube of the chain to extinguish any other then conducting tube of the chain; means including circuit elements of capacitance and inductance cooperating with the anode-cathode supply circuit of the extra tube to cause it to self-extinguish immediately it becomes conducting, by reason of receipt of an impulse at the same time the highest significant digit tube is conducting; a switching means to disestablish the cathode-control member connections between the tubes in the chain and between the extra tube of the chain and the chain and to reestablish them so that in the chain a digit tube cathode will be connected to the control member of the next lower value digit tube, and so that the cathode of the zero tube will be connected to the control member of the highest significant digit tube and to the control member of the extra tube, whereby the tubes in the chain may be operated in a forward direction or in a reverse direction as selected and to cause the extra tube to become conducting on the impulse received after the highest significant digit tube is conducting in the forward operation, and to cause the extra tube to become conducting on the impulse received after the zero tube is conducting in the reverse operation; and a second chain of tubes similar to the first chain of tubes, having its input impulse means connected to the cathode of the extra tube of the first chain.

24. An electronic electric impulse-counting de- including groups of electronic units, each group representing a denominational order of a numerical system and there being in each order group a unit for each digit including zero; an extra unit for each group for transferring denominational carryovers, said unit, when responsive, creating an electric impulse; input means for each group of units and the associated transfer unit for commonly impressing thereon electric impulses to be counted; selective circuits for each group of units and its associated transfer unit for rendering the group units responsive to input impulses step by step one at a time in sequence in an endless operative chain in ascending or descending digit value order as selected, said selective means connecting the extra unit so as to be responsive on an impulse making the zero unit responsive in the ascending order operation, and to be responsive on an impulse making the lowest significant digit unit responsive in the descending order operation; and means connecting the extra unit of a group with the input means of the next higher denominational group so that, when said extra unit is responsive, it transmits an impulse to the said next higher denominational group one step.

25. An electronic numerical accumulator including a plurality of electron tube denominational rings each responsive to denominational input electric impulses by step-by-step endless chain response of the tubes in a ring, one tube being responsive to each impulse and denominational carryover transfer means for each of the chain, said transfer means producing an impulse for each complete cycle of operation of the chain; means connecting the transfer means of a lower order to the ring of next higher order that said next higher order ring may be given a step of operation for each complete cycle of the lower ring; and a switching means in each ring for determining the direction of operation of the tubes in the endless chain in the ring, said switching means also selecting the time of operation of the associated transfer means in a cycle.

ROBERT E. MUMMA.

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

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2,405,096	Mumma	July 30, 1946
2,428,990	Rajchman	Oct. 14, 1947

Certificate of Correction

Patent No. 2,533,739

December 12, 1950

ROBERT E. MUMMA

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 6, line 69, after the word "means" insert *including means*; column 11, line 26, for "ersponsive" read *responsive*; column 12, line 1, for the syllable and hyphen "de-" read *device*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 13th day of February, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.