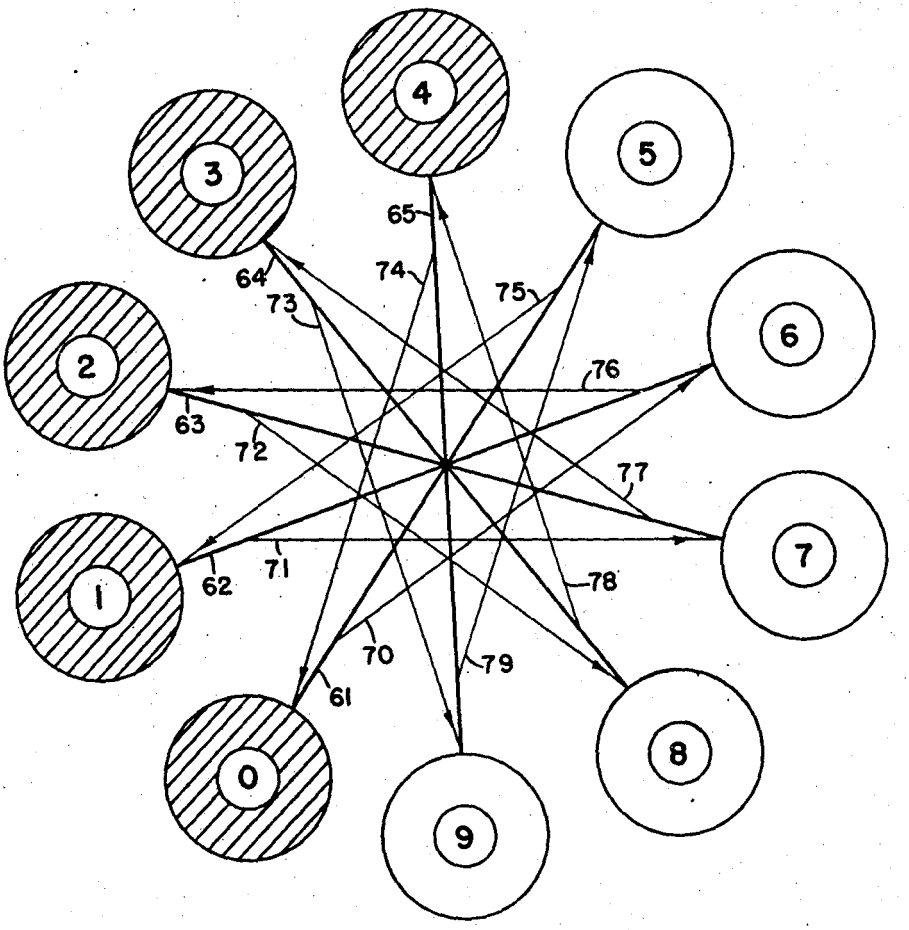
Feb. 18, 1947. E. V. GULDEN 2,416,095

ELECTRONIC DEVICE

Filed Jan. 27, 1944 2 Sheets-Sheet 1

FIG. 1



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Filed Jan. 27, 1944 2 Sheets-Sheet 2

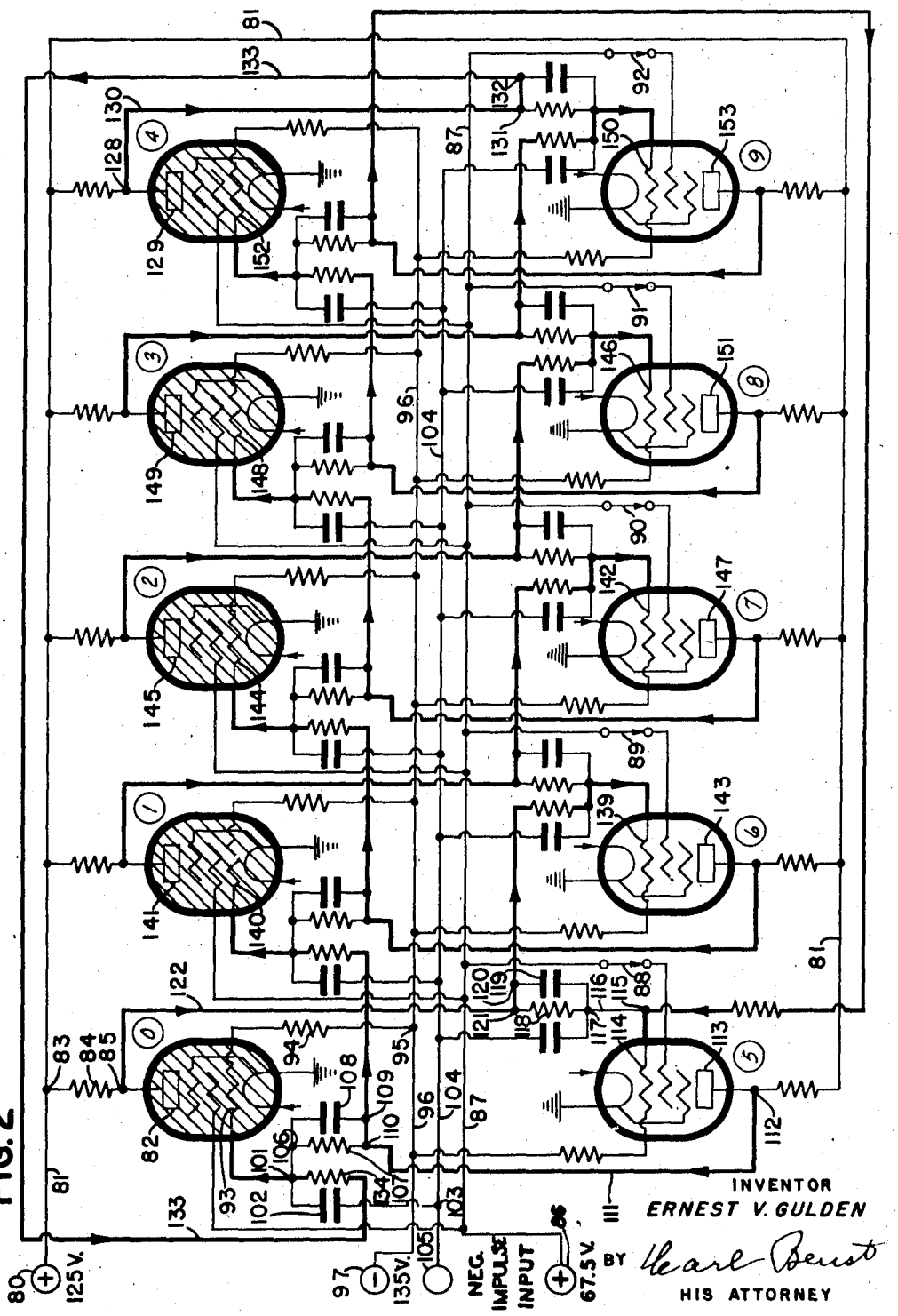

FIG. 2

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UNITED STATES PATENT OFFICE

2,416,095

ELECTRONIC DEVICE

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Application January 27, 1944, Serial No. 519,872

28 Claims. (Cl. 250—27)

1

This invention relates to a novel electronic device which is very stable in its operation and is responsive in step-by-step manner to negative potential input impulses applied thereto at high frequency and which may be operable as a means to accumulate and/or store data and also be operable as a switching control means.

The electronic device of the invention can be used to store any desired data such as characters of the alphabet, numerals of any notation, or any other arbitrary symbols or control conditions; can be used as an accumulator to accumulate amounts in any desired notation; and also can be used as a switching control means. The data, amounts, and/or switching controls are supplied to the device by means of one or more discrete negative potential impulses which may be impressed thereon at a high frequency.

The novel device is made up of an even number of vacuum tubes, the particular number required being controlled by the data or switching conditions to be handled thereby. In the disclosed embodiment of the invention, the novel device is shown in the form of a ring for accumulating and/or storing one denomination of data based on the decimal system of numerical notation and accordingly is made up of ten vacuum tubes. Obviously, if data consisting of a plurality of characters or symbols is to be stored, or multi-digit amounts are to be accumulated, a ring would be provided for each of the plurality of characters or the digits of the multi-digit amount which might be stored or accumulated at one time. If the device is to be used as an accumulator, suitable transfer mechanism would also be provided to cause an operation in the ring of the next higher denomination each time a ring of a particular denomination completed a cycle of operation.

The tubes of the novel ring are connected to form a plurality of trigger pairs, each pair of which must have one mode of operation or another, that is, either one or the other tube of the pair must be conducting at any given instant, while the remaining tube of the pair must be non-conducting. Accordingly, at any given instant half of the tubes of the ring will be conducting and half will be non-conducting, and this condition is utilized to enable the ring to represent data.

In addition to their being connected to form trigger pairs, the tubes of the ring are also connected in an endless operative network which enables the trigger pairs to change their mode of operation one after another in succession in

2

response to input impulses which are negative potential impulses and are impressed on all the tubes of the ring at substantially the same time. The network connections extend between the anodes of the tubes of a trigger pair and the control grids of the tubes of another pair and enable potential variations on the anodes, as the tubes are rendered conducting and non-conducting, to control the potentials of the control grids. The pattern of the network connections is so arranged that at any instant only one trigger pair of the ring will be primed by having the control grid of its conducting tube connected to the anode of a conducting tube of another pair and the control grid of its non-conducting tube connected to the anode of a non-conducting tube of another pair; in all other pairs at this instant the control grid of the conducting tube of a pair will be connected to the anode of a non-conducting tube of another pair, and the control grid of the non-conducting tube of the pair will be connected to the anode of a conducting tube of another pair.

While each impulse is impressed on all the tubes of the ring, the potentials on the control grids of the tubes are at such a value that any impulse will be effective to cause a change in the mode of operation of only the trigger pair which is primed and has the potentials of the control grids of its constituent tubes at suitable values which will allow the tubes to respond to the impulse. The network connections and the trigger connections between the various tubes are such that, upon a change in the mode of operation of a trigger pair in response to an impulse, another trigger pair will be made responsive to the next impulse impressed on the ring, and thus the connections enable the change in mode of operation of various trigger pairs of the ring to take place step by step one after another in response to impulses impressed thereon.

Due to the fact that the control of the sequential operation of the ring is obtained by connections between the anodes and the control grids of the tubes of the ring, only three electrodes in each tube are required to carry out the control, and a much simpler ring than those heretofore known has been provided.

The combination of the trigger connections and the network of priming connections used in the novel ring enables a ring to be produced which can respond quickly to applied impulses and which is also very stable in its operation. Rings using the novel trigger connections and priming network connections have been operated in a very stable manner by impulses impressed there-

on at a rate of 300,000 impulses per second, and are believed to be capable of responding to impulses impressed thereon at frequencies in excess of this one.

It is an object of the invention, therefore, to provide an electronic device made up of vacuum tubes which are rendered conducting step by step in response to negative potential impulses impressed thereon at a high frequency.

Another object of the invention is to provide an electronic device, which is made up of vacuum tubes, with a simplified control to cause the operation of the tubes in step-by-step sequence in response to negative potential impulses applied to the device at a high frequency, which control requires only three electrodes in each tube.

Another object of the invention is to provide an electronic device which is formed from a plurality of vacuum tubes connected in trigger pairs and in which device the mode of operation of the several trigger pairs can be reversed, one pair at a time, in step-by-step fashion in response to negative potential impulses.

Another object of the invention is to provide an electronic device which is formed from a plurality of vacuum tubes connected in trigger pairs and also connected in a network consisting of connections from the anodes of the tubes of one pair to the control grids of the tubes of another pair in a pattern by which the pairs are selected to respond one after another in sequence to input impulses.

Another object of the invention is to provide an electronic device which is made up of a plurality of vacuum tubes, connected in trigger pairs and also connected in a network consisting of connections from the anodes of the tubes of one pair to the control grids of the tubes of another pair, the trigger connections and network connections connecting the tubes in an operative ring which has excellent stability and which is capable of responding to impulses impressed thereon, at a very high frequency.

Another object of the invention is to provide an electronic device which is formed from a plurality of vacuum tubes connected in trigger pairs and also connected in a network, consisting of connections from the anodes of tubes of one pair to the control grids of the tubes of another pair, by which the potentials of the anodes of the tubes of the device are effective to control the potentials of the control grids to determine which of the trigger pairs will change its mode of operation when an impulse is impressed on all the tubes, and are also effective to cause the pairs to change their mode of operation, one pair after another, in an endless sequence as successive impulses are impressed thereon.

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 is a diagrammatic showing of the pairing connections and the network of priming connections between the tubes of a ring.

Fig. 2 is a circuit diagram showing the connections between the tubes of a ring corresponding to a single denomination of data based on the decimal system of numerical notation.

General description

The disclosed embodiment of the novel ring contains ten vacuum tubes, which, for convenience of description, are numbered from "0" through "9."

The ring is made up of high vacuum tubes having at least an anode, a cathode, and a control grid, and being of a type having a sharp-cut-off and a low D. C. plate resistance when the grid is at zero potential. Where high-speed operation of the ring is desired, the tubes must also have as low inter-electrode capacitance as possible.

In Fig. 1, which is a diagrammatic showing of the ring, the circles represent the tubes of the ring and are numbered as above noted. The circles numbered "0," "1," "2," "3," and "4," by their shading, represent conducting tubes and are the tubes chosen arbitrarily to represent the zero or starting condition of the ring by their conduction. Non-conducting tubes of the ring are shown without shading.

Each of the tubes is operatively paired with another tube of the ring by trigger connections, which control the operation of the paired tubes in such a manner that, at any stage in the operation of the ring, one or the other of the tubes of the pair is conducting and the remaining tube is non-conducting. The line **61** (Fig. 1) represents the trigger connections by which the tube numbered "0" and the tube numbered "5" are paired. Similarly, the lines **62**, **63**, **64**, and **65** represent the trigger connections between the tubes "1" and "6," "2" and "7," "3" and "8," and "4" and "9," respectively. Since the tubes so joined in trigger pairs must have one mode of operation or another—that is, either one or the other tube of the pair must be conducting—it is apparent that, at any given instant, half of the tubes of the ring will be conducting and the other half will be non-conducting.

The pattern of the control network connections in the ring is such that the five tubes which are conducting at any stage of operation of the ring are adjacent in the numerical order, and, as input impulses cause the operation of the ring, the tubes which are conducting after each impulse has caused an operation of the ring will have values which are advanced one step as each impulse is received, which is, in effect, causing the grouping of the conducting tubes to be advanced step by step in clockwise manner about the ring, as shown in Fig. 1.

The following tabulation shows the conducting and non-conducting condition of the tubes at different stages of operation of the ring after different numbers of impulses have been impressed thereon.

Number of impulses	Tubes conducting	Tubes non-conducting
0	0, 1, 2, 3, 4	5, 6, 7, 8, 9
1	1, 2, 3, 4, 5	6, 7, 8, 9, 0
2	2, 3, 4, 5, 6	7, 8, 9, 0, 1
3	3, 4, 5, 6, 7	8, 9, 0, 1, 2
4	4, 5, 6, 7, 8	9, 0, 1, 2, 3
5	5, 6, 7, 8, 9	0, 1, 2, 3, 4
6	6, 7, 8, 9, 0	1, 2, 3, 4, 5
7	7, 8, 9, 0, 1	2, 3, 4, 5, 6
8	8, 9, 0, 1, 2	3, 4, 5, 6, 7
9	9, 0, 1, 2, 3	4, 5, 6, 7, 8
(1) 0	0, 1, 2, 3, 4	5, 6, 7, 8, 9

Accordingly, after any particular number of impulses have operated the ring from a starting or zero position, a definite set of tubes related to that number of impulses will be conducting, and,

by the use of a suitable sensing means, the number of impulses which have affected the ring can be determined.

As will be explained more fully herein, the potentials of the control grids and anodes of the conducting tubes will be different from the potentials of the control grids and anodes of the non-conducting tubes, and this condition may be used as a switching control or may be sensed to control some additional means such as an indicating and/or recording means to provide a visual indication or record of the data which the operating condition of the ring represents. As an example of one form of such sensing means which might be used, a rotary sensing switch having two arms for simultaneously sensing the potential of similar electrodes in the end tubes of either the group of conducting tubes or the group of non-conducting tubes could be provided, which switch could control means which would operate if the sensed potential were that of two conducting or two non-conducting tubes, whichever group were selected as controlling.

Referring to the tabulation of the conducting and non-conducting condition of the tubes given above, and using the conducting condition of the tubes as controlling, it is seen that, if the sensing switch sensed the end tubes of the group at each stage of operation, it would find a different combination of tubes for the representation of each digit; for instance, "0" and "4" conducting would represent the zero condition; "3" and "7" would indicate that three impulses had been impressed on the ring; and "9" and "3" would indicate that nine impulses had been impressed on the ring. If the operated condition of the ring indicated that three impulses had been impressed thereon, then the switch arms would sense one conducting tube and one non-conducting tube in each digit position of the switch until the digit "3" position was reached, at which time the switch would sense the "3" and "7" tubes, which are both conducting and would control any suitable indicating and/or recording means to indicate and/or record the digit "3."

It should be noted further from the above tabulation that the different modes of operation of a trigger pair have different significance in the representation of data; for instance, the trigger pair including the tubes "0" and "5" will be a part of the representation of the digits "6" through "0" when the "0" tube is conducting, but will be a part of the representation of the digits "1" through "5" when the "5" tube is conducting.

The above tabulation shows the arrangement in which the conducting tubes "0," "1," "2," "3," and "4" are considered as the zero or starting point. It is to be understood, however, that the selection of this group is arbitrary and that any other group may be used as the starting point, if desired. In order that the operation of the ring may always start at the zero or starting position, suitable means are provided, such as switches in the screen grid circuits, to interrupt the circuits of the screen grids of the "5," "6," "7," "8," and "9" tubes, which causes these tubes to become non-conducting and their related tubes "0," "1," "2," "3," and "4," respectively, to become conducting. As soon as tubes "0," "1," "2," "3," and "4" become conducting, the screen grid circuits for the tubes "5," "6," "7," "8," and "9" can be reclosed, and the ring is ready for operation.

The circuits for connecting two vacuum tubes to operate as a trigger pair are well known and include connections from each anode to a source of potential over an individual resistor whereby the potential of the anode will vary with the conducting and non-conducing condition of the tubes, and include other connections from the anode of each tube to the control grid of the other tube in the pair whereby the potential changes of the anodes of the tubes of the pair can control the potential of the control grids of the opposite tubes of the pair. A negative input impulse impressed on the control grids of both tubes of the pair by any suitable impulse generating means will be effective to cause the previously conducting tube of the pair to become non-conducting, thus causing its anode potential to rise to a value which, when applied to the control grid of the previously non-conducting tube, will reduce the bias on that tube and render it conducting. The tubes will remain in this mode of operation until the next impulse is impressed on the control grids. As is well known, the action of a trigger pair in response to an applied impulse is very fast.

In order to connect the trigger pairs in a ring for step-by-step operation and to prevent all the trigger pairs from responding to each impulse, the control grids of the tubes of the trigger pairs are given potentials which will normally prevent the trigger pairs from responding to the impressed impulses, by being interconnected in a network, the pattern of which enables only one trigger pair at a time to respond to an impressed impulse. The network connections, or priming connections, which extend over suitable resistors from the anodes of the tubes of one trigger pair to the control grids of the tubes of another pair, enable the potentials of the anodes of said one pair of tubes to modify the potential of the control grids of the other trigger pair to prime the other trigger pair in addition to exerting their control within said one pair, and thus to render said other trigger pair responsive to the next input impulse impressed on the ring.

As explained above, the disclosed embodiment of the novel ring is made up of ten tubes which are connected together "0" to "5," "1" to "6," "2" to "7," "3" to "8," and "4" to "9" to form trigger pairs. The network of priming connections for this ring is shown in Fig. 1, with the arrows pointing to the tubes whose control grids are being affected. Line **70** represents the priming connection of the anode of tube "0" to the control grid of tube "6." Similarly, line **71** represents the connection of the anode of tube "1" to the control grid of tube "7"; line **72** represents the connection of the anode of tube "2" to the control grid of tube "8"; line **73** represents the connection of the anode of tube "3" to the control grid of tube "9"; line **74** represents the connection of the anode of tube "4" to the control grid of tube "0"; line **75** represents the connection of the anode of tube "5" to the control grid of tube "1"; line **76** represents the connection of the anode of tube "6" to the control grid of tube "2"; line **77** represents the connection of the anode of tube "7" to the control grid of tube "3"; line **78** represents the connection of the anode of tube "8" to the control grid of tube "4"; and line **79** represents the connection of the anode of tube "9" to the control grid of tube "5."

The pattern of these priming connections between the tubes of different trigger pairs is so chosen that, when any five consecutive tubes of the ring are conducting, only one of these conducting tubes will have its control grid con-

nected to the anode of another conducting tube, and only the non-conducting tube paired with said one conducting tube will have its control grid connected to the anode of another non-conducting tube. These connections will cause the potential of the control grid of said one conducting tube to be less positive than that of the control grids of the other conducting tubes and will cause the potential of the control grid of the non-conducting tube which is trigger-connected to said one conducting tube to be less negative than that of the other non-conducting tubes, which conditions prime this particular trigger pair and render it responsive to the impressed impulses, so that it will change its mode of operation when the next impulse is impressed on the ring. The above-noted connections are shown in Fig. 1 by line 74, which connects the control grid of the conducting "0" tube to the anode of the conducting "4" tube, and by line 79, which connects the control grid of the non-conducting tube of the pair, or the "5" tube, to the anode of the non-conducting "9" tube, by which connections the trigger pair containing the "0" and "5" tubes is primed to respond to an input impulse.

As the trigger pair containing the "0" and "5" tubes changes its mode of operation in response to an input impulse, tube "5" becomes conducting and tube "0" becomes non-conducting, and, in a manner similar to that given above, these tubes in their changed condition will be effective, through lines 75 and 70, to prime the trigger pair containing tubes "1" and "6" for response to the next impulse impressed on all the tubes. This operation of successively priming the trigger pairs as other trigger pairs change their mode of operation enables the trigger pairs of the ring to change their mode of operation one after another in endless step-by-step sequence in response to impressed impulses.

After any number of impulses has been impressed on the ring, the group of tubes which is conducting will correspond to the value of the total number of impulses which have operated the ring since the ring was placed in its zero condition, and this group of tubes can be used to control other means if desired.

Due to the particular combination of trigger connections and priming network connections which are used, the potential on the control grids of the conducting tubes of the unprimed trigger pairs can be made sufficiently positive that these tubes will not be substantially affected by the negative input impulses, and the negative bias on the control grids of the non-conducting tubes of the unprimed trigger pairs can be made so much in excess of cut-off that the non-conducting tubes will not be materially affected by the potential changes of the anodes of the conducting tubes to which they are trigger-connected. Both of these conditions contribute to the stability of the ring against misoperation.

In addition to producing a ring which is very stable, the combination of trigger connections and priming network connections also enables a ring to be produced which is capable of responding at high speeds to applied input impulses because, by the priming action, the positive potential on the control grid of the conducting tube of the primed pair can be reduced sufficiently so that the tube can respond to the input impulse and cause a trigger action to take place, and, at the same time, the negative bias on the non-conducting tube of the primed trigger pair can be reduced so that a small rise in the potential of the anode of the previously conducting tube of the pair, as that tube is affected by the input impulse, will be effective to reduce the bias on the non-conducting tube and enable conduction to begin therein, which conduction, on beginning, is effective, through the trigger connection, to cause the control grid of the other tube to become more negative and assists the input impulse in driving the control grid of the formerly conducting tube of the pair to cut-off, thus enabling the trigger pair to change its mode of operation quickly. The priming action, therefore, changes the primed trigger pair from a very stable one to one which can respond very quickly to the negative input impulses.

When the ring disclosed herein forms one denomination of an accumulator of multi-denominational amounts, suitable transfer mechanism may be provided between denominations to cause an entry of a unit to be made in a ring of the next higher denomination each time a ring of a particular denomination has completed a cycle of operation.

Circuits

The circuit diagram of the ring which has been chosen to illustrate the invention is shown in Fig. 2. The novel ring is shown as being made up of ten midget, battery-operated 1S5 vacuum tubes. The use of the 1S5 type of tubes to form the ring enables a stable, high-speed, battery-operated ring to be produced, however, this type of tube is not to be considered as the only type which can be used in the novel ring because, when the battery-operated feature is not of importance, any vacuum tube having the characteristics of sharp cut off, low D. C. plate resistance when the grid is at zero potential, and, where speed is desired, low inter-electrode capacitance will be suitable for use in the ring.

When the 1S5 type of tube is used, the plate of the diode portion of the tube may be directly connected to the control grid of the pentode portion of the tube if desired; however, in the instant circuit diagram, the diode plate and its connection to the control grid have been omitted, as they are not necessary for the proper operation of the ring or for an understanding of the invention.

The values of the various potentials referred to are given with reference to ground in the instant disclosure. It is not intended that the invention be limited to these particular potentials or to the values of resistance and capacitance specified herein, because the potentials used are merely selected as convenient potentials for the disclosure, and the values of the circuit elements of resistance and capacitance given correspond in relative value to the potentials chosen. It is obvious that other types of tubes may be used, and also that other potentials may be used, and, when this occurs, the values of the circuit elements can be adjusted accordingly to maintain the proper relationship between the various parts of the circuit. The cathodes of the 1S5 type tubes are directly heated, and their connections to a source of 1.4-volt heating potential are shown conventionally in the diagram.

Potential is supplied to the anodes of the tubes from terminal 80 (Fig. 2), which is provided with a positive potential of 125 volts and to which is connected an anode potential supply conductor 81. The anode of each tube is connected to the supply conductor 81 over a resistor of 50,000

ohms, the connection for the anode 82 of the "0" tube being representative and extending from point 83 on the supply conductor 81, over the resistor 84 and the point 85 to the anode.

The screen grids of the tubes are supplied with a positive potential of 67.5 volts from terminal 86, to which a conductor 87 is connected. Each screen grid is connected directly to this conductor; however, the connections for the screen grids of the "5," "6," "7," "8," and "9" tubes, respectively, contain switches 88, 89, 90, 91, and 92, which may be opened momentarily, in any suitable manner, to remove the potential from these screen grids to place the ring in starting condition by causing these tubes to become non-conducting and tubes "0," "1," "2," "3," and "4" to become conducting.

The cathodes and suppressor grids of the tubes are connected directly to ground.

The control grids of the tubes are connected to a negative biasing potential source, to an input impulse conductor, and to the anodes of other tubes by trigger connections and by the priming network connections.

The connections from the control grids of the several tubes to the negative potential source are similar and will be clear from the connection for the control grid 93 of the "0" tube, which is connected over resistor 94 of 1 megohm to point 95 on the negative potential supply conductor 96, which extends from terminal 97, to which is applied a negative potential of 135 volts. These connections supply the control grids with negative biasing potential.

The connections from the control grids of the several tubes to the input impulse conductor are also similar and will also be clear from the connection for the control grid 93 of the "0" tube. Grid 93 is electrostatically coupled over point 101 and capacitor 102 of 5 micro-microfarads to point 103 on the input impulse conductor 104, which is supplied at terminal 105 with negative potential impulses by any suitable impulse generating means, which impulses represent data and cause the step-by-step operation of the ring. These connections enable each input impulse to be impressed on all the tubes of the ring and cause the change in mode of operation to occur in the trigger pair which is primed.

As mentioned earlier herein, the tubes of the ring are connected to form trigger pairs in which the control grid of each of the tubes of a pair is connected to the anode of the other tube of the pair. The connections by which the tubes "0" and "5" are operatively coupled to form a trigger pair are representative of the connection between the tubes of the several pairs and are as follows. From control grid 93 of the "0" tube, one portion of trigger connection extends over points 101 and 106, resistor 107 of 870,000 ohms in parallel with capacitor 108 of 20 micro-microfarads, and thence over points 109 and 110 and conductor 111 to point 112, to which the anode 113 of the "5" tube is connected. The other portion of the trigger connection between these tubes extends from the control grid 114 of the "5" tube, over point 115, conductor 116, point 117, resistor 118 of 870,000 ohms, and capacitor 119 of 20 micro-microfarads in parallel, and thence over points 120 and 121 and conductor 122 to point 85, to which the anode 82 of the "0" tube is connected. These connections between the anodes and control grids of the "0" and "5" tubes are the ones represented by line 61 in Fig. 1 and enable the potential variations of the anodes of the tubes to be impressed on the control grids to control the operation of the tubes as a trigger pair. Similar connections connect the "1" and "6," the "2" and "7," the "3" and "8," and the "4" and "9" tubes to form trigger pairs.

The control grids are also provided with priming connections which extend from the control grids of the tubes of a trigger pair to the anodes of the tubes of another trigger pair. The priming connection for the control grid 93 of the "0" tube, shown in heavy lines in Fig. 2, corresponds to the line 74 in Fig. 1 and extends from point 128 (Fig. 2), to which the anode 129 of the "4" tube is connected, and continues over conductor 130, points 131 and 132, conductor 133, and resistor 134, of 2 megohms, to point 101, to which control grid 93 is connected. Similar priming connections are also shown in heavy lines in Fig. 2 and extend between anode 82 of the "0" tube and control grid 139 of the "6" tube; between anode 113 of the "5" tube and control grid 140 of the "1" tube; between anode 141 of the "1" tube and control grid 142 of the "7" tube; between anode 143 of the "6" tube and the control grid 144 of the "2" tube; between anode 145 of the "2" tube and control grid 146 of the "8" tube; between anode 147 of the "7" tube and control grid 148 of the "3" tube; between anode 149 of the "3" tube and control grid 150 of the "9" tube; between anode 151 of the "8" tube and the control grid 152 of the "4" tube; and between the anode 153 of the "9" tube and control grid 114 of the "5" tube.

The arrangement of the priming connections of the ring is such that, at any stage of the operation of the ring, only one trigger pair will be primed by having the control grid of its conducting tube connected to the anode of the conducting tube of another pair and by also having the control grid of its non-conducting tube connected to the anode of a non-conducting tube of another pair. With the "0," "1," "2," "3," and "4" tubes conducting as shown in Fig. 2, control grid 93 of the "0" tube is connected to anode 129 of the "4" tube, and control grid 114 is connected to the anode of the "9" tube, which makes the control grid 93 of the "0" tube less positive than the control grids of the other conducting tubes and the control grid 114 of the "5" tube less negative than the control grids of the other non-conducting tubes. This condition provides the priming action which enables this trigger pair to respond to a negative potential impulse applied to the ring. After the trigger pair containing the "0" and "5" tubes responds to an impulse, the "1," "2," "3," "4," and "5" tubes will be conducting and the trigger pair containing the "1" and "6" tubes will be primed. In this manner, each trigger pair that responds to an impulse is effective to cause another trigger pair to be primed, and thus the ring is controlled for step-by-step operation in response to input impulses.

While the disclosed embodiment of the invention shows the input impulses applied to the control grids of the tubes, it is not intended that the invention be limited to this arrangement as the input impulses can be applied to other of the grids of a multi-grid tube to cause the operation of the tubes of the ring.

Operation

The ring is prepared for operation by applying the required potential to terminals 80, 86, and 97 and by momentarily opening switches 88, 89, 90, 91, and 92 in the circuits for the screen grids of

tubes "5," "6," "7," "8," and "9." The removal of this screen grid potential will cause these tubes to be non-conducting, and they will be effective through the trigger connections to cause tubes "0," "1," "2," "3," and "4" to be conducting, which condition of the ring has been chosen arbitrarily as the zero or starting position. The ring may now be operated by negative potential input impulses.

As explained earlier herein, the anode of each tube is connected over an individual resistor, as 84 (Fig. 2), to a source of potential, so that conduction in the tube will cause the potential of its anode to drop.

Of all the conducting tubes at this stage of the operation, the "0" tube, whose control grid 93 is connected by a priming connection to the anode 129 of the conducting "4" tube, will be the only conducting tube having its control grid connected by a priming connection to an anode whose potential has been lowered by conduction in the tube. This will make the control grid 93 less positive than the control grids of the other conducting tubes, which grids are connected by priming connections to anodes which do not have their potential lowered by conduction within their respective tubes.

Similarly, among the non-conducting tubes, the "5" tube, whose control grid 114 is connected by a priming connection to the anode 153 of the non-conducting "9" tube, will be the only non-conducting tube having its control grid connected by a priming connection to an anode whose potential has not been lowered by conduction. This will make the control grid 114 less negative than the control grids of the other non-conducting tubes, which grids are connected by priming connections to anodes which have their potential lowered by conduction within their respective tubes. Either the reduction of the positive potential of the control grid of the conducting "0" tube or the reduction of the negative potential of the control grid of the non-conducting "5" tube of the pair, taken alone, would be effective to prime the trigger pair containing these tubes for response to negative potential input impulses. When both priming conditions are used at the same time, their priming effect is cumulative and enables a ring to be produced which can operate with excellent stability at high speeds.

When the trigger pairs are primed by using the anode potential of one tube of another pair to make the potential of the control grid of the conducting tube of the primed pair less positive and by using the anode potential of the other tube of the other pair to make the potential of the control grid of the non-conducting tube of the primed pair less negative, a ring can be produced which has excellent stability because the potentials of the control grids of the conducting tubes of the unprimed trigger pairs can be made sufficiently positive that the input impulses will have no material effect on the conductivity of these tubes and at the same time the negative bias on the control grids of the non-conducting tubes of the unprimed trigger pairs can be made so much greater than necessary for cut-off that any possible variation which might occur in the potential of the anodes to which these control grids are trigger connected will have no material effect on the non-conductivity of the non-conducting tubes. Each of these two conditions tends to prevent improper operation of the pairs by input impulses and when both are present at the same time in the ring they doubly insure against an improper operation.

When a negative potential input impulse is applied to terminal 105 and conductor 104 by any suitable impulse generating means to cause a step of operation of the ring, the impulse will be impressed on the control grids of all the tubes through capacitors, as 102, by which the control grids are electrostatically coupled to conductor 104. The impulse will not change the conducting condition of tubes "5," "6," "7," "8," and "9," which are already biased to cut-off. The impulse will cause the control grids of the "0," "1," "2," "3," and "4" tubes to become less positive, which reduces the conductivity of these tubes various amounts and causes the potential of their anodes to rise correspondingly. The impulse size has been so chosen that, while the impulse may reduce the conductivity somewhat in the conducting tubes, it will not be able to overcome the positive potential on the control grids of the "1," "2," "3," and "4" tubes and render them non-conducting. The only tube which can be materially affected by the impulse is the "0" tube, which has had its control grid made less positive by the priming action. Accordingly, when the impulse is applied to the control grid 93, the "0" tube will be affected to a greater extent than the other tubes, and the potential of its anode 82 will rise to a higher positive potential than that of the anode of any of the other previously conducting tubes. The potential rise of the anodes of the "0," "1," "2," "3," and "4" tubes is impressed, by means of the trigger connections on the control grids of the "5," "6," "7," "8," and "9" tubes, respectively, but the potential rise of the anode of the "0" tube will be the only one sufficient to cause a trigger-connected non-conducting tube, the "5" tube to become conducting. Therefore the primed trigger pair containing the "0" and the "5" tubes will be the only one which will respond to the impulse.

It will be remembered that the control grids of the non-conducting tubes "5," "6," "7," "8," and "9" are given a negative bias past cut off and that the priming connection reduced the bias on the control grid of the "5" tube of the primed pair almost to cut-off. This condition also controls the selective operation of a trigger pair because, of all the trigger pairs, only the primed pair will have the biasing potential of the control grid of its nonconducting tube reduced to a value which can be overcome by the anode potential rise of its related tube to cause a change in the mode of operation of the pair.

The operation of the trigger pair will be very rapid because the priming action has reduced the positive potential on the control grid 93 of the conducting "0" tube which enables the input impulse to initiate a trigger action, and has also reduced the bias on the control grid 114 of the non-conducting "5" tube which enables the anode rise of the "0" tube to be effective quickly to render the "5" tube conducting. As the "5" tube becomes conducting, it will be effective through the trigger connection between its anode 113 and the control grid 93 of the "0" tube, to cause the potential drop of its anode 113 to be applied to the control grid 93 of the "0" tube to assist the negative potential input impulse and hasten the driving of the "0" tube to complete cut-off. In this manner the combination of trigger connections and priming connections enables a ring to be produced which can respond quickly to applied input impulses and can be operated by impulses impressed thereon at very high frequency.

When the trigger pair containing the "0" and "5" tubes has changed its mode of operation in

response to the first impulse, it will remain in that condition and will prime the trigger pair containing the "1" and "6" tubes for operation by the next impulse which is impressed on the ring. After the trigger pairs containing the tubes "1" and "6," "2" and "7," "3" and "8," and "4" and "9" have operated in response to input impulses, the trigger pair containing tubes "0" and "5" will again be primed so that upon the receipt of the sixth impulse, this trigger pair will change its mode of operation and the "5" tube will again become non-conducting and the "0" tube will become conducting. In a similar manner further impulses will cause the further step-by-step operation of the trigger pairs, which pairs by their modes of operation provide an indication of the data which corresponds to the total number of impulses which have been received.

Accordingly applicant, by his novel combination of trigger connections and priming connections, has produced a novel ring which is made up of high vacuum tubes and which can operate with excellent stability and can respond at very high speeds to negative input impulses which are impressed thereon.

While the invention has been disclosed in connection with a ring dealing with one denomination of data based on the decimal system of notation, it is obvious that the ring can contain any number of pairs of tubes and is not limited to the use of ten tubes; that the ring can be differentially operated by impulses to represent control conditions or data other than numerical data; and that the ring can be used as a switching ring for cyclically applying potentials to some other means to control the operation thereof.

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 disclosed herein, 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 electronic devices, each of which devices includes an anode, a cathode, and a means for controlling conduction in the device; means for connecting the electronic devices in pairs, by connecting the anode of one device of the pair to the control means of the other device of the pair, to form trigger pairs in which, at any stage of operation of a pair, one or the other of the electronic devices is conducting and the other is non-conducting; means for connecting the trigger pairs so that they will be operated one pair at a time in sequence in response to negative input impulses, including connections between the anodes of the electronic devices of the pairs and the control means of the devices of other pairs for selectively modifying the controlling effect of the control means of the pairs in succession and thereby enabling the trigger pairs to be responsive and change their mode of operation one after another in succession in response to the negative impulses; and means coupled to the control means of all the electronic devices for impressing negative impulses on the control means of all the electronic devices and causing the trigger pair in which the effect of the control means has been modified, to respond to the impulse and change its mode of operation.

2. In combination, a plurality of vacuum tubes each tube containing an anode, a cathode, and a means for controlling conduction therein; means

connecting the tubes in a plurality of trigger pairs with the anode of each tube of the pair connected to the control means of the other tube of the pair; means connecting the tubes of the trigger pairs together in a ring for causing the selective operation of the trigger pairs, one pair after another in sequence, in response to negative impulses impressed on the tubes, the connections between trigger pairs extending from the anodes of the tubes of one pair to the control means of the tubes of another pair; and means, coupled to the control means in the tubes, by which negative potential impulses are impressed on the tubes, each impulse being impressed on all the tubes.

3. In combination, a plurality of electronic devices each of which devices includes an anode, a cathode, and a control electrode; means connecting the devices, anode to control electrode, to form trigger pairs; and means connecting the devices of different trigger pairs together in an endless chain operative series, said chain connections being from the anodes of both devices in a pair to the control electrodes of both devices in another pair.

4. In combination, a plurality of vacuum tubes, each having at least an anode, a cathode, and a control grid; means connecting the tubes in trigger pairs, with the anode of each tube of a pair connected to the control grid of the other tube of the pair; and means connecting the different pairs together in an endless chain operative sequence in which the anodes of the tubes of a trigger pair are connected to the control grids of the tubes of another trigger pair and can control the effect of the control grids to select the pairs for sequential operation.

5. In combination, a plurality of electronic devices, each device having at least an anode, a cathode, and a control means; means connecting the devices, anode to control means, in trigger pairs in which one or the other of the devices of a pair is conducting and the remaining device is non-conducting; priming connections extending from the anodes of the devices of one pair to the control means of the devices of another pair and connecting the different pairs together in an endless operative ring whereby the conducting and non-conducting condition of the devices of the ring select the trigger pairs for response, one pair at a time, to negative input impulses impressed on the control means of all the devices; and means common to the control means of all the devices for impressing negative potential input impulses thereon, each impulse being impressed on the control means of all the devices.

6. In combination, a plurality of pairs of electronic devices, each device having an anode, a cathode, and means to control conduction between the anode and the cathode; means connecting the devices for sequential operation, including anode-to-control-means trigger connections between the devices of each pair and priming connections between the anodes of the devices of a pair and the control means of a different pair, the priming and trigger connections cooperating to provide a blocking bias for the control means of the devices of all pairs except the one pair next to be operated and providing the control means of this one pair with a control which allows it to be operated quickly in response to an input impulse, and the pattern of the priming connections being such that the pairs are rendered operable one after another to respond to input impulses; and means common to all the devices to impress input pulses

on the control means of all the devices to cause the primed pairs to operate.

7. In combination, a plurality of electronic devices, each device including an anode, a cathode, and means to control conduction between the anode and the cathode; means connecting the devices in pairs, anode to control means, to form trigger pairs in which one of the devices is conducting and the other device is non-conducting and in which the conducting and non-conducting condition of the devices of a pair can be reversed when the pair responds to an input impulse; means for applying input impulses to the control means of all the devices of the pairs, which impulses are ineffective to cause a reversal of the conducting condition of the pairs; and means to connect the anodes of a pair to the control means of another pair to control the effectiveness of the control means and thereby selectively prime the trigger pairs one after another to enable the input impulses to be effective thereon to cause them to operate and reverse the conducting and non-conducting condition of their constituent devices.

8. In combination, a plurality of electronic devices, each device having an anode, a control grid, and means to control conduction between the anode and the cathode; means for supplying operating potentials for the anodes, cathodes, and control means of the devices; means connecting the devices to form an operative ring and to control their conduction, including anode-to-control-means trigger connections for connecting devices to form trigger pairs, in each of which pairs one of the devices is conducting and the other device is non-conducting, which condition of the devices can be reversed upon an operation of the pair, and resistance network connections between the anodes of the devices of a pair and the control means of the devices of another pair for connecting the devices in a serial pattern, the trigger connections and resistance network connections controlling the controlling means of the devices to render the pairs of devices responsive to input impulses one after another in sequence and to provide an over-bias on the remaining pairs at each stage of operation of the ring to prevent them from responding to input impulses impressed on the control means and render the devices stable against misoperation; and means to impress input impulses on the control means of the devices, each of which impulses is impressed on the control means of all the devices and causes the pair which is responsive to operate.

9. In combination, a plurality of electronic devices, each device containing at least an anode, a cathode, and control means; means normally supplying anode-cathode potential and biasing potential for the control means of said devices; means connecting the devices for controlling conducting therein, including connections connecting the devices anode to control means, in trigger pairs, and also including priming network connections between the anodes of the devices of the pairs and the control means of the devices of other pairs for modifying the control of the control means to enable the trigger pairs to be responsive and change their mode of operation one after another in succession in response to impulses impressed on the control means of all the devices; and means to impress impulses on the control means of the devices to cause their operation, each impulse being impressed on the control means of all the devices and causing the trigger pair, which is primed at that time, to operate.

10. In combination, a plurality of vacuum tubes each having at least an anode, a cathode, and a control grid; means normally supplying anode-cathode potential and grid biasing potential for said vacuum tubes; means connecting the tubes for controlling conduction therein, including connections connecting the tubes, anode to control grid, in trigger pairs and further priming network connections between the anodes of the tubes of the pairs and the control grids of the tubes of other pairs for priming the pairs by modifying the control of their grids and thereby enabling the trigger pairs to be responsive and change their mode of operation one after another in succession in response to impulses impressed on all the tubes; and means to impress negative potential impulses on the control grids of all the tubes to cause the trigger pairs which have been primed to respond to the impulses and change their mode of operation.

11. In combination, a plurality of electronic devices, each device having at least an anode, a cathode, and a control means; means for supplying operating potentials for the devices and including an individual resistance for the anode of each device whereby the potential of the anode of a device can vary with its conductivity; means connecting the devices to form an operative ring, including trigger connections for connecting the devices, anode to control means, to form trigger pairs and also including priming connections extending from the anodes of the devices of a pair to the control means of the devices of another pair for connecting the trigger pairs in a ring to enable the trigger pairs to change their mode of operation one after another in response to input impulses, said trigger and priming connections enabling the anode potentials of the devices of the ring as the devices are conducting and non-conducting, to control the potential of the control means and enable the pairs of devices to respond one after another in sequence to negative impulses impressed thereon; and means to impress negative impulses on the control means of the devices, each impulse being impressed on the control means of all the devices.

12. In combination, a plurality of vacuum tubes having at least an anode, a cathode, and a control grid; means for supplying operating potentials for the tubes and including an individual resistance for the anode of each tube whereby the potential of the anode of a tube can vary with its conductivity; means connecting the tubes to form an operative ring, including trigger connections for connecting the tubes, anode to control grid, to form trigger pairs and also including priming connections extending from the anodes of the tubes of a pair to the control grids of the tubes of another pair for connecting the trigger pairs in a ring to enable the trigger pairs to change their mode of operation one after another in response to input impulses, said trigger and priming connections enabling the anode potentials of the tubes of the ring, as the tubes are conducting and non-conducting, to control the potential of the control grids and enable the pairs of tubes to be primed and to respond one after another in sequence to negative impulses impressed thereon; and means to impress negative impulses on the control grids of the tubes, each impulse being impressed on all the control grids.

13. In combination, a plurality of electronic devices each including an anode, a cathode, and a control electrode; means connecting the devices to form trigger pairs in which, at any stage of operation of a pair, one or the other of the

devices is conducting and the remaining device is non-conducting; priming network connections between the anodes of the devices of a pair and the control electrodes of the devices of another pair for connecting the pairs to form a ring and for selectively rendering the pairs responsive, one pair after another, to input impulses; said trigger connections and priming connections cooperating to provide the control electrodes of the conducting devices of unprimed pairs with a positive potential which will prevent negative potential input impulses from causing an operation of these pairs and cooperating to provide the control electrode of the conducting device of the primed pair with a positive potential which will allow this pair to respond quickly to a negative potential input impulse; and means common to all the devices for impressing negative potential input impulses on the control electrodes thereof, each impulse being impressed on the control electrodes of all the devices and causing the primed pair to operate and change its mode of operation.

14. In combination, a plurality of electronic devices, each device including at least an anode, a cathode, and a control means; means connecting the devices to form trigger pairs by conductively coupling the anode of each device of the pair to the control means of the other device of the pair so that, at any instant, but one device of a pair will be conducting and so that, when primed, a pair can respond to an input impulse and can change its mode of operation; means also conductively coupling the control means of a device of one pair to anode of a device of another pair to form an endless operating chain of the devices and to enable the pairs of devices to be primed, the pattern of the priming connections being displaced from the pattern of trigger connections in such a manner that, at any stage of operation of the pairs of devices, the conducting device of only one pair will have its control means connected to the anode of a conducting device of another pair and the non-conducting device of said one pair will be the only non-conducting device having its control means connected to the anode of a non-conducting device of another pair, which condition causes said one pair to be primed to respond to an input impulse and to change its mode of operation, said one pair when operated being effective to cause a further pair to be primed; and means common to all the devices to impress input impulses on the control means thereof to cause the sequential change in the mode of operation of the pairs.

15. In combination, a plurality of vacuum tubes including at least an anode, a cathode, and a control grid; means for supplying operating potentials for the tubes and including an individual resistance for the anode of each tube whereby the potential of the anode of a tube will vary with its conductivity; means connecting the tubes anode to control grid to form trigger pairs in which, at any stage of operation of a pair, one or the other of the tubes is conducting and the other is non-conducting; and priming connections between the trigger pairs to connect the tubes in an operating ring and render the pairs selectively operable to change their mode of operation one after another, said priming connections extending from the anodes of the tubes of one pair to the control grids of the tubes of another pair and being of such a pattern that, at any stage of oepration of the ring, only one conducting tube will have its control grid connected to the anode of another conducting tube, making the positive potential on the control grid of said one conducting tube less positive than that of the control grids of other conducting tubes and rendering the trigger pair containing said one conducting tube responsive to an input impulse.

16. In combination, a plurality of vacuum tubes including at least an anode, a cathode, and a control grid; means for supplying operating potentials for the tubes and including an individual resistance for the anode of each tube whereby the potential of the anode of a tube will vary with its conductivity; means connecting the tubes anode to control grid to form trigger pairs in which, at any stage of operation of a pair, one or the other of the tubes is conducting and the other is non-conducting; and priming connections between the trigger pairs to connect the tubes in an operating ring and render the pairs selectively operable to change their mode of operation one after another, said priming connections extending from the anodes of the tubes of one pair to the control grids of the tubes of another pair and being of such a pattern that, at any stage of operation of the ring, only one non-conducting tube will have its control grid connected to the anode of another non-conducting tube, making the negative potential of the control grid of said one non-conducting tube less negative than that of the other non-conducting tubes and rendering said one non-conducting tube responsive to a trigger action to enable the trigger pair to respond to a negative potential input impulse impressed thereon.

17. In combination, a plurality of vacuum tubes including at least an anode, a cathode, and a control grid; means for supplying operating potentials for the tubes and including an individual resistance for the anode of each tube whereby the potential of the anode of a tube will vary with its conductivity; means connecting the tubes anode to control grid to form trigger pairs in which, at any stage of operation of a pair, one or the other of the tubes is conducting and the other is non-conducting; and priming connections between the trigger pairs to connect the tubes in an operative ring and render the pairs selectively operable to change their mode of operation one after another, said priming connections extending from the anodes of the tubes of one pair to the control grids of the tubes of another pair and being of such a pattern that, at any stage of operation of the ring, only the primed trigger pair will have the control grid of its conducting tube connected to the anode of a conducting tube of another pair to make the potential of the control grid of the conducting tube of the primed pair less positive than the control grids of the other conducting tubes, and only the primed trigger pair will have the control grid of its non-conducting tube connected to the anode of a non-conducting tube of another pair to make the potential of the control grid of the non-conducting tube of the primed pair less negative than the control grids of the other non-conducting tubes, whereby the primed pair can respond to an input impulse and can change its mode of operation.

18. In combination, a plurality of electronic devices, each device including an anode, a cathode, and a control means; means connecting the devices to form trigger pairs in which, at any stage of operation of a pair, one or the other of the devices is conducting and the remaining device is non-conducting; priming network connec-

tions including conductive couplings between the anodes of the devices of a pair and the control means of the devices of another pair for connecting the pairs in a ring and for rendering the pairs selectively operable one after another in response to input impulses; said priming network connections being of such a pattern that they are effective at any stage of operation of the ring to cause the control means of the devices of all the pairs except the primed pair to have potentials applied thereto which prevent these pairs from responding to input impulses and changing their mode of operation; and means coupled to the control means of all the devices to apply input impulses to all the devices, each impulse being impressed on the control means of all the devices and causing the devices of the primed pair to operate and change their mode of operation.

19. In combination, a plurality of electronic devices, each device having at least an anode, a cathode, and a control electrode; means connecting the devices to form trigger pairs in which one device of a pair is conducting and the other device of the same pair is non-conducting and in which the conducting and non-conducting conditions of the devices of a pair will be reversed each time it operates in response to an input impulse; priming network connections, including connections between the anodes of the devices of a pair and the control electrodes of the devices of another pair, for connecting the pairs in a ring and for selectively rendering the pairs responsive one after another to input impulses, said network connections causing the control electrodes of all the pairs except the primed pair to be over-biased and stable against operation to allow only the primed pair to respond quickly to an input impulse and the pattern of the network connections causing the primed pair, when operated, to be given an over-bias and one of the previously over-biased pairs to be primed and made responsive to an input impulse whereby the ring is controlled for step-by-step operation of the pairs; and means to impress input impulses on the control electrodes of all the devices.

20. In combination, a plurality of electronic devices, each device having at least an anode, a cathode, and a control electrode; means to provide operating potentials for the devices; means to connect the devices, anode to control electrode, to form trigger pairs in which, at any stage of operation of a pair, one device of the pair is conducting and the other device is non-conducting and in which the conducting and non-conducting condition of the devices of a pair will be reversed each time it operates in response to an input impulse; priming network connections between the anodes of the devices of a pair and the control electrodes of the devices of another pair for connecting the pairs to form a ring and to render the pairs responsive one after another in endless sequence in response to input impulses, said priming connections causing at least one control electrode in all pairs except the primed pair to have a potential which will prevent these pairs from operating in response to input impulses and causing the control electrodes of the primed pair to have potentials which will allow the primed pair to respond quickly to an input impulse, and said priming network connections having a pattern by which the pairs are primed for operation one after another; and means common to all the devices for supplying the control electrodes of the devices with input impulses which can cause an operation of the primed pair but which are not sufficient to overcome the blocking potential in the unprimed pairs.

21. In combination, a plurality of pairs of electronic devices, each device of which includes an anode, a cathode, and a control electrode; means connecting the pairs of devices for trigger action in which conduction in either device of the pair causes the other device to become non-conducting and in which the conducting and non-conducting conditions of the devices of a pair can be reversed when the pair operates in response to a negative potential input impulse; priming network connections connecting the anodes of the devices of a pair to the control electrodes of the devices of another pair for controlling the pairs to render them responsive one after another to negative potential impulses impressed thereon, said priming network connections causing the potential of the control electrodes of the conducting devices in all but the primed pair to have a positive potential which the negative potential input impulses cannot overcome and cause an operation of the pairs, and said network connections being of such a pattern that, as each pair responds to an impulse, another pair is primed to respond to another impulse; and means common to all the devices for supplying negative potential input impulses to the control electrodes thereof to cause the operation of the primed pairs.

22. In combination, a plurality of pairs of electronic devices, each device of which includes an anode, a cathode, and a control electrode; means connecting the pairs of devices for trigger action in which conduction in either device of the pair causes the other device to become non-conducting and in which the conducting and non-conducting condition of the devices of a pair can be reversed when the pair operates in response to a negative potential input impulse; priming network connections connecting the anodes of the devices of a pair to the control electrodes of the devices of another pair for controlling the pairs and rendering them responsive one after another to negative potential impulses impressed thereon, said priming network connections causing the control electrodes of the non-conducting devices in all but the primed pair to be given a negative potential sufficient to prevent trigger action within the pair so that only the primed pair can respond to the impulse and can change its mode of operation, and said network connections being of such a pattern that, as each pair responds to an impulse, another pair is primed to respond to another impulse; and means common to all the devices for supplying negative potential input impulses to the control electrodes thereof to cause the operation of the primed pairs.

23. In combination, a plurality of electronic devices, each device having at least an anode, a cathode, and control means; means to connect the devices, anode to control means, to form trigger pairs in which, at any stage of the operation of a pair, one device of the pair is conducting and the other device is non-conducting and in which the conducting and non-conducting condition of the devices of a pair will be reversed each time it operates in response to an input impulse; priming network connections between the anodes of the devices of a pair and the control means of the devices of another pair for connecting the devices in a ring in a pattern for step-by-step operation one pair after another, said priming connections causing, at any stage of the operation of the ring, the control means of

the conducting devices in all the pairs but the primed pair to be given a positive potential so much in excess of that required to cause conduction therein that these devices cannot respond to negative potential input impulses, and, at the same time causing the control means of the non-conducting devices of these pairs to be given a negative potential so much in excess of cut-off that these devices cannot respond to a trigger action within the pairs, whereby to produce a ring which is stable against misoperation, and said priming connections causing the control means of the devices of the primed pair to be given potentials which will enable the primed pair to respond quickly to a negative potential impulse impressed on the control means thereof the devices whereby to produce a ring which can respond to impulses impressed thereon at a high frequency; and means common to all the devices for impressing negative potential impulses on the control means thereof to cause the operation of the pairs which have been primed.

24. In combination, a plurality of vacuum tubes, each tube having at least an anode, a cathode, and a control grid; means connecting the tubes to form trigger pairs in which one tube of a pair is conducting and the other tube of the same pair is non-conducting and in which the conducting and non-conducting conditions of the tubes of a pair will be reversed each time it operates in response to an input impulse; priming network connections, including connections between the anodes of the tubes of a pair and the control grids of the tubes of another pair, for connecting the pairs in a ring and for selectively rendering the pairs responsive one after another to input impulses, said network connections causing the control grids of all the pairs except the primed pair to be over-biased and stable against operation to allow only the primed pair to respond quickly to an input impulse, and the pattern of the network connections causing the primed pair, when operated, to be given an over-bias and one of the previously over-biased pairs to be primed and made responsive to an input impulse whereby the ring is controlled for step-by-step operation of the pairs; and means to impress input impulses on the control grids of all the tubes.

25. In a battery operated vacuum tube ring, the combination of a plurality of battery operated vacuum tubes, each tube having an anode, a cathode, and means to control conduction between the anode and the cathode; means for supplying operating potentials for the anodes, cathodes, and control means of the tubes; means connecting the tubes to form an operative ring and to control their conduction, including anode-to-control-means trigger connections for connecting tubes to form trigger pairs, in each of which pairs one of the tubes is conducting and the other tube is non-conducting, which condition of the tubes can be reversed upon an operation of the pair, and resistance network connections between the anodes of the tubes of a trigger pair and the control means of the tubes of another trigger pair for connecting the tubes in a serial pattern in a ring, the trigger connections and resistance network connections controlling the controlling means of the tubes to render the pairs of tubes responsive to input impulses one after another in sequence and to provide an over-bias on the remaining pairs of tubes at each stage of operation of the ring to prevent them from responding to input impulses impressed on the control means and render the trigger pairs stable against misoperation; and means to impress input impulses on the control means of the tubes, each of which impulses is impressed on the control means of all the tubes and causes the pair which is responsive to operate.

26. In a stable, high-speed, vacuum tube ring, the combination of a plurality of pairs of vacuum tubes, each tube of which includes an anode, a cathode, and control means; means connecting the pairs of tubes for trigger action in which conduction in either tube of the pair causes the other tube to become non-conducting and in which the conducting and non-conducting conditions of the tubes of a pair can be reversed when the pair operates in response to a negative potential input impulse; priming network connections connecting the anodes of the tubes of a pair to the control means of the tubes of another pair for controlling the pairs to render them responsive one after another to negative potential impulses impressed thereon, said priming network connections causing the potential of the control means of the conducting tubes in all but the primed pair to have a positive potential which the negative potential input impulses cannot overcome and cause an operation of these pairs by rendering these tubes non-conducting and said network connections being of such a pattern that, as each pair responds to an impulse, another pair is primed to respond to another impulse; and means common to all the tubes for supplying negative potential input impulses to the control means thereof to cause the operation of the primed pairs.

27. In a stable, high speed, vacuum tube ring, the combination of a plurality of pairs of vacuum tubes, each tube of which includes an anode, a cathode, and a control grid; means connecting the pairs of tubes for trigger action in which conduction in either tube of the pair causes the other tube to become non-conducting and in which the conducting and non-conducting condition of the tubes of a pair can be reversed when the pair operates in response to a negative potential input impulse; priming network connections connecting the anodes of the tubes of a pair to the control grids of the tubes of another pair for controlling the pairs and rendering them responsive one after another to negative potential impulses impressed thereon, said priming network connections causing the control grids of the non-conducting tubes in all but the primed pair to be given a negative potential sufficient to prevent trigger action within the pair so that only the primed pair can respond to the impulse and can change its mode of operation, and said network connections being of such a pattern that, as each pair responds to an impulse, another pair is primed to respond to another impulse; and means common to all the tubes for supplying negative potential input impulses to the control grids thereof to cause the operation of the primed pairs.

28. In combination, a plurality of vacuum tubes, each tube having at least an anode, a cathode, and a control grid; means to connect the tubes, anode to control grid, to form trigger pairs in which, at any stage of the operation of a pair, one tube of the pair is conducting and the other tube is non-conducting and in which the conducting and non-conducting condition of the tubes of a pair will be reversed each time it operates in response to an input impulse; priming network connections between the anodes of the tubes of a pair and the control grids of the tubes of another pair for connecting the tubes in a ring

in a pattern for step-by-step operation one pair after another, said priming connections causing, at any stage of the operation of the ring, the control grids of the conducting tubes in all the pairs but the primed pair to be given a positive potential so much in excess of that required to cause complete conduction that these tubes cannot be rendered non-conducting by negative potential input impulses, and at the same time causing the control grids of the non-conducting tubes of these pairs to be given a negative potential so much in excess of cut-off that these tubes cannot respond to a trigger action within the pairs whereby to produce a ring which is stable against misoperation, and said priming connections causing the control grids of the tubes of the primed pair to be given potentials which will enable the primed pair to respond quickly to a negative potential impulse impressed on the tubes whereby

to produce a ring which can respond to impulses impressed thereon at a high frequency; and means common to all the tubes for impressing negative potential impulses on the control grids thereof to cause the operation of the pairs which have been primed.

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Disclaimer

2,416,095.—*Ernest V. Gulden*, Dayton, Ohio. ELECTRONIC DEVICE. Patent dated Feb. 18, 1947. Disclaimer filed May 23, 1949, by the assignee, *The National Cash Register Company*, and by the inventor.

Hereby enter this disclaimer to claims 3, 4, 6, 7, 8, 9, 14, 17, 18, 19, 20, 24, and 25 of said patent.

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