June 30, 1953 J. R. DESCH 2,644,111

ELECTRONIC COUNTER

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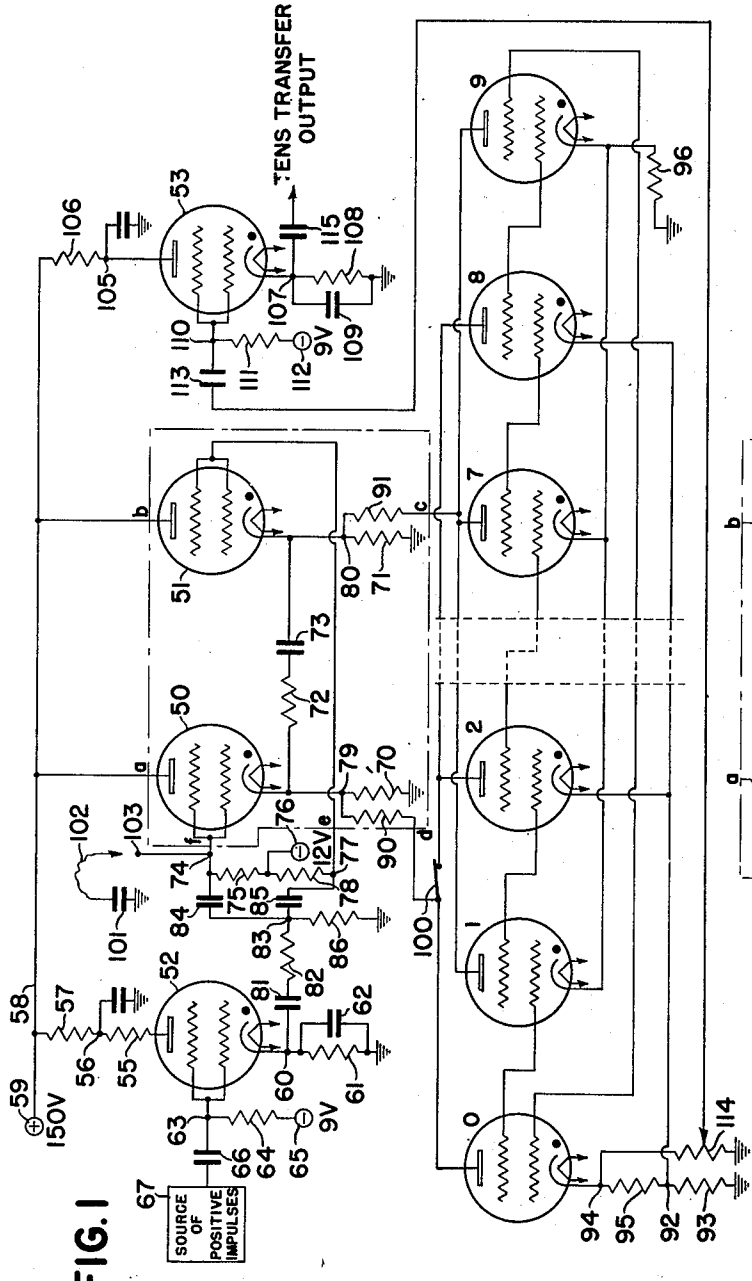


FIG. 1

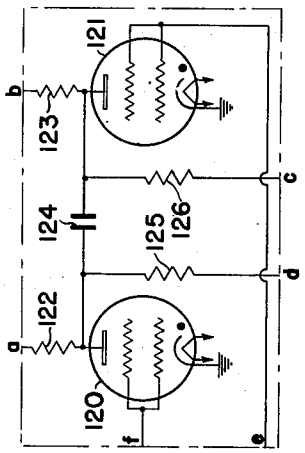

FIG. 2

INVENTOR
JOSEPH R. DESCH

BY Karl Ernst
Louis A. Kline

HIS ATTORNEYS

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## ELECTRONIC COUNTER

Joseph R. Desch, Dayton, Ohio, assignor to The National Cash Register Company, Dayton, Ohio, a corporation of Maryland

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1

This invention relates to a novel electron tube counting circuit and in particular to a circuit employing negative-grid thyratrons which are connected in a ring or chain for sequential operation one after another in response to input impulses.

The principal advantages of the novel circuit lie in its simplicity due to the elimination of many resistors and capacitors which had heretofore been required and in the consequent simplification in its fabrication.

In prior circuits using negative-grid thyratrons, it had been usual to have individual cathode resistors and bias supply and priming resistance networks for each of the tubes of the ring or chain, as well as individual input capacitors and capacitors in the extinguishing circuits for these tubes. The novel circuit does away entirely with bias supplying and priming resistance networks for the tubes of the ring or chain; does away with input capacitors and extinguishing capacitors for the tubes of the ring or chain; and reduces the number of cathode resistors which are required.

Briefly, the novel circuit utilizes negative-grid thyratrons of the tetrode type having at least an anode, a cathode, a control grid, and a shield grid. The tubes of the ring or chain are divided into two operational groups, with the cathodes of the tubes of each group connected together and to ground over a resistor which is common to the tubes of the group and with the anodes of each group connected together and over a resistor to a separate source of anode potential for each group.

The tubes are connected into an operative chain by floating connections between the tubes, which connections extend from the shield grid of a tube of one group to the control grid of a tube of the other group. In case of a ring, the shield grid of the last tube in one group will be connected to the first tube in the other group. In the novel circuit, the shield grids serve as probe electrodes whereby the conducting condition of a tube can be utilized to control another tube. These floating connections cause the sequential operation of the tubes to take place in the desired order by enabling the shield grid or probe electrode in a conducting tube to so influence the control grid of the next tube in the sequence that the next tube will conduct when the next input impulse is received by the circuit.

The anode potentials for the two groups of tubes are derived from a potential control means which can be operated alternately to one or the other of two stable operating conditions. The anode

2

potentials are derived from the control means in such a manner that they can vary with the different operating conditions of the means. When the control means is in one operating condition, the anode potential which is supplied to one of said groups of tubes will be high enough to cause conduction in a tube of that group; but, when the control means is in its other condition, the anode potential which is supplied to this one group of tubes will have been reduced to a value which will not support conduction in the tubes of the group. In a similar manner, the anode potential which is supplied to the other group of tubes will be high or low, depending on the operating condition of the control means. The relation between the anode potentials which are supplied to the two groups of tubes is such that, whenever the high anode potential is supplied to one group of tubes, the low potential will be supplied to the other group of tubes.

The input impulses for causing the step-by-step operation of the tubes of the chain or ring are applied to the control means, each impulse being effective to reverse the operating condition of the control means and thereby cause the above-noted variation in the potentials supplied to the anodes of the tubes of both groups.

In the novel circuit, therefore, the combination of the grouping of the tubes and the variation of the anode potentials applied to the groups from the control means, together with the floating shield-grid-control-grid connections which connect the tubes in a chain or ring, enable the tubes of the chain or ring to be operated one at a time in sequence in response to input impulses which are applied to the control means.

If the tubes are connected in a ring and a plurality of rings are to be used for forming a multi-denominational order accumulator, suitable output-signal-generating means can be utilized as tens transfer means between adjacent orders to cause a unit to be entered in the higher order when the lower order exceeds its capacity.

Furthermore, if desired, controls can be supplied for causing a particular tube to conduct to prepare the ring or chain for step-by-step operation.

It is an object of the invention, therefore, to provide a simplified electron tube counting circuit.

A further object of the invention is to provide a negative-grid thyratron counting ring in which negative bias supply and priming resistance networks can be eliminated, thereby requiring fewer impedance elements in the circuit.

A further object of the invention is to provide

a novel negative-grid thyratron counting ring which has a simplified circuit and will be easier to construct.

With these and incidental objects in view, the invention includes certain novel features of construction and combinations of parts, a preferred form or embodiment of which is hereinafter described with reference to the drawing which accompanies and forms a part of this specification.

Of the drawing:

Fig. 1 is a circuit diagram of one of the novel counting rings which is capable of forming one denominational order of an accumulator, including provisions for presetting the ring to a predetermined condition and also including provisions for controlling an output-signal-generating means which may be used to furnish tens transfer to a higher order of the accumulator.

Fig. 2 shows a modified form of trigger pair for supplying anode potentials to the ring.

*Detailed description*

In order that the invention may be more clearly explained, it will be described as embodied in a counting ring which is suitable for use as a denominational order of a decimal accumulator. It is to be understood that the invention is not limited to its use as a counting ring or to the use of ten tubes in the ring, because it is susceptible of use wherever sequential operation of tubes is desired and with different numbers of tubes in the ring, the only limitation being that, when connected to operate as a ring, an even number of tubes be provided. It will also become obvious from the following description that additional tubes can be included in the ring circuit without requiring any additional circuit elements of resistance or capacitance.

In the following description, values of potential with reference to ground and values of resistance and capacitance, as well as tube types, will be given. It is not intended that the invention be limited to these particular potentials or to the values of resistance 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 also 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. Throughout the drawing, the heater elements of the thyratrons are shown conventionally.

The type of tube used through the circuit is the tetrode thyratron of the 2051 type, which has an anode, an indirectly-heated cathode, a control grid, and a shield grid.

Excellent results have been obtained from circuits constructed according to the invention and using the values of resistance, capacitance, and potentials to be given. These circuits also showed good tolerance to variations in the positive potential supply and in the size of the input impulses which were supplied thereto.

The circuit of Fig. 1 includes a ring of digit-representing tubes, which tubes are operable step by step in sequence; a pair of tubes **50** and **51**, which form the control means and operate as a trigger pair and supply anode potentials to the tubes of the ring; a pulse-shaping tube **52**, upon which input impulses are impressed and from which a strong uniform operating impulse is sent to the trigger pair for each input impulse which it receives; and an output signal tube **53**, which may be used for sending an impulse to another order each time the ring exceeds its capacity when the ring forms one order of an accumulator. In order to simplify the showing of the circuit, only the "0," "1," "2," "7," "8," and "9" digit-representing tubes of the ring have been shown, because the circuits and the operation of the "3" to "6" digit-representing tubes are the same as those shown and will be clear from those circuits which are shown.

The pulse-shaping tube **52**, which is connected in a self-extinguishing circuit, will conduct momentarily and will be extinguished automatically each time an input impulse is applied thereto. The anode of this tube is connected over resistor **55**, of 270 ohms, point **56**, and resistor **57**, of 1.5 megohms, to conductor **58**, to which a potential of +150 volts is applied at terminal **59**. Point **56** in this circuit is connected to ground over a capacitor of .001 microfarad. The cathode of tube **52** is connected to ground over point **60** and resistor **61**, of 68,000 ohms, and capacitor **62**, of 500 micro-microfarads, in parallel. The shield grid and control grid of tube **52** are connected together and over point **63** and resistor **64**, of 330,000 ohms, to terminal **65**, which supplies −9-volt bias potential. Point **63** in this circuit is coupled over a capacitor **66**, of 500 micro-microfarads, to a source of positive potential impulses, shown diagrammatically at **67**, which is capable of furnishing positive potential input impulses suitable to cause the pulse-shaping tube to conduct. Each time the tube **52** conducts momentarily in response to an input impulse, the potential of point **60** will rise sharply to produce a positive impulse, which impulses will be strong and uniform. These impulses are used to drive the trigger pair of the control means from which the anode potentials for the tubes of the ring are derived.

The tubes **50** and **51** of the trigger pair of the control means are connected in similar circuits, which enable the tubes to conduct alternately in response to positive potential impulses which are impressed thereon. The anodes of these tubes are connected directly to conductor **58**, which has +150 volts supplied thereto, and the cathodes of the tubes are connected to ground over resistors **70** and **71**, each of 20,400 ohms. The cathodes of these tubes are also coupled by a blow-out circuit containing a resistor **72**, of 7,800 ohms, and a capacitor **73**, of .003 microfarad, in series. The shield grid and the control grid of tube **50** are connected together and over point **74** and resistor **75**, of 250,000 ohms, to terminal **76**, which supplies −12-volt bias potential. Similarly, tube **51** has its shield and control grids connected together and over point **77** and resistor **78**, of 250,000 ohms, to terminal **76**.

When tube **50** is non-conducting, its cathode, due to the high impedance of the tube, will be at ground potential, but, when the tube conducts, the potential of the cathode will rise sharply to about +135 volts, due to the division of the drops between the tube and resistor **70** in the cathode circuit. This means that point **79** in the cathode circuit will make a similar excursion upwardly as the tube begins to conduct and downwardly as the tube ceases conduction. Similarly, point **80** in the cathode circuit for tube **51** will make a potential excursion upwardly and downwardly as that tube begins to conduct and ceases to conduct.

The blow-out connection between tubes 50 and 51 insures that only one tube of the pair will be conducting at a time. As positive impulses are impressed on the grids of the tubes, they will be ineffective on the tube that is already conducting but will cause the non-conducting tube to conduct. Conduction beginning in the previously non-conducting tube will cause its cathode potential to rise sharply. This rise is sent as an impulse over the blow-out circuit to the other tube to cause the previously conducting tube to be extinguished.

Positive impulses for driving the trigger pair are derived from point 69 in the cathode circuit of the pulse-shaping tube 52, which point is coupled over capacitor 81, of 500 micro-microfarads, and resistor 82, of 100,000 ohms, to point 83, which in turn is coupled over capacitors 84 and 85, each of 50 micro-microfarads, to points 74 and 77 in the grid circuits of the trigger pair tubes. Point 83 is connected to ground over resistor 86, of 100,000 ohms. Each input impulse which is applied to the pulse-shaping tube 52 will cause a positive impulse to be sent over this coupling to cause a reversal in the conducting condition of the tubes of the trigger pair.

While the means in the control means which operates to one or another condition alternately in response to input impulses is shown as a gas-tube trigger pair, it is to be understood that the invention is not limited to the use of this particular form of means but can utilize any means which can operate to alternate conditions in response to impulses and can supply the necessary anode potential variations.

The connections involving the tubes of the ring are extremely simple and require very few circuit elements of resistance and capacitance.

These tubes are connected into two operational groups and are also connected for sequential operation. The anodes of the "even" digit-representing tubes "0" to "8" are connected together and over a resistor 90, of 22,000 ohms, to point 79 in the cathode circuit of trigger tube 50, from which they will be supplied with a high potential which will permit conduction in a tube in the group when tube 50 conducts but from which they will be supplied a low potential which will not support conduction in a tube in the group when trigger tube 50 is not conducting. Similarly, the anodes of the "odd" digit-representing tubes "1" to "9" are connected together and over a resistor 91, of 22,000 ohms, to point 80 in the cathode circuit of trigger tube 51 and will be supplied with a high potential which will permit conduction in a tube in the group when trigger tube 51 conducts but will be supplied with a low potential which will not support conduction in a tube in the group when trigger tube 51 is not conducting.

Since only one tube of the trigger pair conducts at a time, only one of the groups of tubes of the ring at a time will be supplied with high potential.

The cathodes of the "even" digit-representing tubes are connected together and over point 92 and the common resistor 93, of 22,000 ohms, to ground. The connection of the cathode of the "0" digit-representing tube of the group to the point 92 is over point 94 and an additional resistor 95, of 33,000 ohms, which enables the cathode of the "0" tube to have a potential when the "0" tube conducts which is distinctive from that when any other "even" tube conducts. This distinction in potential is used to control the operation of a transfer tube in a manner to be explained more fully hereinafter.



The cathodes of the "odd" digit-representing tubes are connected together and over the common resistor 96, of 22,000 ohms, to ground.

The connections between the tubes of the ring by which sequential operation is obtained are extremely simple and extend from the shield grid or probe electrode of a tube in one group directly to the control grid of the tube in the other group which is next to be operated. As an example, the shield grid or probe electrode of the "0" tube of the "even" group is directly connected to the control grid of the "1" tube of the "odd" group, and the shield grid or probe electrode of the "1" tube of the "odd" group is directly connected to the control grid of the "2" tube of the "even" group, etc. The connection of the tubes in a ring is completed by connecting the shield grid or probe electrode of the "9" tube to the control grid of the "0" tube.

In the ring circuit as shown, the shield grid in a conducting tube will be more positive than the control grid, and this condition is utilized to obtain directional control in the sequential operation of the tubes and cause tube which has its control grid connected to a shield grid of a conducting tube to be fired before the tube which has its shield grid connected to the control grid of the conducting tube when high anode potential is supplied to the non-conducting group of tubes.

It is to be particularly noted that, while the tubes of the ring are of the negative-grid thyratron type, there are no negative bias supply and priming resistance networks provided for these tubes, the only connection to the control grids of any of these tubes being the floating direct connection to the shielding grid or probe electrode of the next preceding tube in the ring; and that addition of tubes to the ring does not require the use of any more resistors or capacitors.

Provision has been made for presetting the circuit to a starting condition, which in the instant embodiment will be that condition in which the "0" tube of the ring will be conducting. The circuit which connects the anodes of the "even" tubes has a switch 100 therein, which is normally closed but which can be opened in a presetting operation to prevent the application of anode potential to any of the "even" tubes except the "0" tube. With the switch 100 open, the trigger pair is operated to cause tube 50 to conduct. This supplies high anode potential to the "0" tube only, which will conduct. After the "0" tube has been rendered conducting, the switch 100 is closed to supply anode potential to the remaining "even" tubes, and the ring is ready for normal operation. With the "0" tube conducting, the drops across the anode resistor 90 and the cathode resistors 93 and 95 will reduce the anode-cathode potential applied to the other "even" tube to a value that will prevent initiation of conduction in any of the other "even" tubes when the switch 100 is closed.

Trigger tubes 50 can be fired in the presetting operation by grounding its control grid or by applying a positive impulse to the grid. One means for applying positive potential to the grid is shown in Fig. 1 and consists of a capacitor 101, of .01 microfarad, which has one side grounded and which has a lead 102 connected to the other side. This lead 102 can be touched to the conductor 58 to charge the capacitor 101

and can then be touched to point 103, which is connected to the control grid of tube 50, to apply a positive impulse to this tube.

Any suitable output means can be controlled by the ring to cause a signal to be sent out each time an order exceeds its capacity. In the embodiment used to explain the invention, the output means will be in the form of tens transfer means which utilizes a negative-grid thyratron in a self-extinguishing circuit and is operated momentarily to send an output signal each time the "0" tube conducts. This signal can be used to cause a unit value to be entered in a high order each time an order exceeds its capacity.

The output tube 53 has its anode connected over point 105 and resistor 106, of 1 megohm, to conductor 58, which has +150 volts applied thereto. Point 105 is connected to ground over a capacitor of .005 microfarad. The cathode is connected to ground over point 107 and resistor 108, of 68,000 ohms, in parallel with capacitor 109, of .001 microfarad.

The shield grid and control grid of the output tube 53 are connected together and over a point 110, resistor 111, of 1 megohm, to the −9-volt bias supply terminal 112. Point 110 in this circuit is coupled over a capacitor 113, of 100 micro-microfarads, to an adjustable tap on a 1-megohm potentiometer 114, which is connected between ground and point 94 in the cathode circuit of the "0" tube. Due to the resistor 95 in the cathode circuit and the coupling of point 94 to ground over the potentiometer 114, point 94 will be more positive when the "0" tube conducts than when any of the other "even" tubes conduct. The tap on the potentiometer is adjusted so that the output tube 53 will conduct momentarily each time the "0" tube becomes conducting, but will not conduct when any of the other "even" tubes becomes conducting.

Each time the output tube 53 conducts, the potential of point 107 in its cathode circuit will rise, and this rise is transmitted over a suitable capacitor 115 as an output impulse which can be used to cause a unit value to be entered in the higher order. A suitable switch can be included in the output circuit, to be opened during presetting to prevent any undesirable output impulses from being sent out during presetting as a result of firing the "0" tube.

It is to be understood that the output signal means which is disclosed herein is merely illustrative and that other forms which can be operated or conditioned by positive impulses can also be used with the novel ring.

In the circuit of Fig. 1, the anode potentials for the two groups of tubes of the ring are derived from the cathodes of the trigger pair, but the invention is not limited to this arrangement. In Fig. 2 is shown a modified form of trigger pair in which anode potentials are derived from the anodes of the tubes of the pair. The trigger pair of Fig. 2 can replace the trigger pair which is enclosed in the dot-and-dash outline in Fig. 1, the connections *a*, *b*, *c*, *d*, *e*, and *f* from the dot-and-dash outline in both figures being the same.

In the trigger pair of Fig. 2, the tubes 120 and 121 have their anodes connected over resistors 122 and 123, each of 20,400 ohms, and over connections *a* and *b* to the positive potential supply conductor (as 58 in Fig. 1) and have their anodes coupled by a blow-out capacitor 124, of .01 microfarad. The cathodes of the tubes are grounded, and their shield grids and control grids are connected together and over connections *e* and *f* to their bias supply and input couplings to the pulse-shaping tube (as 52 in Fig. 1).

The anode of tube 120 is connected over resistor 125, of 10,000 ohms, and connection *d* to the anodes of the "even" digit-representing tubes of the ring. The anodes of this group of tubes of the ring will have a high potential applied thereto when tube 120 is non-conducting and a low potential when tube 120 conducts. Similarly, the anode of tube 121 is connected over resistor 126, of 10,000 ohms, to the anodes of the "odd" group of tubes of the ring and will supply a high potential to the tubes of this group when it is non-conducting and a low potential when it is conducting. When the trigger pair of Fig. 2 is incorporated in the circuit of Fig. 1 to replace the trigger pair shown therein, a voltage of about +300 volts is applied to terminal 59, and in presetting the ring to zero condition the right-hand tube of the trigger pair tube 121 is rendered conducting. Otherwise the circuit constants and operation of the circuit are the same as when the trigger pair of Fig. 1 is used in the circuit.

While only two forms of trigger pairs are shown as control means for supplying desired anode potentials to the groups of tubes of the ring, other forms of trigger pairs also may be used; all that is required is that they be capable of furnishing the necessary potential variations at two points in their circuit from which the potentials for the two groups of tubes can be derived.

*Operation*

The operations will be explained with reference to the circuit of Fig. 1.

With the various operating and bias potentials applied and with the cathodes properly heated, the circuit may be set in its zero condition by opening switch 100 in the anode circuit for the "even" group of tubes and by touching the lead 102 first to conductor 58 and then to point 103 to fire tube 50 of the trigger pair. As tube 50 conducts, its cathode potential will be high, and this will supply the high anode potential to the "0" digit-representing tube of the ring. After the "0" tube conducts, the switch 100 is closed to supply anode potential to the other tubes of the "even" group. When the "0" tube is conducting, the drop across the tube will be just enough to sustain conduction but will not be high enough to initiate conduction in a tube; hence, when switch 100 is closed after the "0" tube is conducting, none of the other "even" tubes will begin to conduct.

When trigger tube 50 was fired, it caused trigger tube 51 to be extinguished, if it were the first tube to conduct when potential was supplied. With tube 51 non-conducting, it will supply low anode potential to all the "odd" tubes, and all of these tubes will be non-conducting.

At the end of the presetting operation, the "0" tube of the ring and the trigger tube 50 will be conducting.

It will be recalled that the digit-representing tubes are connected in a ring by floating direct connections between the shield grid or probe electrode of a tube in one group and the control grid of a tube in the other group. This means that the shield grid or probe electrode of the "0" tube in the "even" group is connected to the control grid of the "1" tube in the "odd" group; the shield grid or probe electrode of the "1" tube of the "odd" group is connected to the "2" tube in the "even" group, etc.

When a tube conducts, its shield grid or probe

electrode, being in the ionized medium, will become more positive and will cause the control grid of the next tube in the ring, to which it is directly connected, to become more positive. Hence, with the "0" tube conducting, the control grid of the "1" tube will be the only one connected to a shield grid or probe electrode in a conducting tube and will be more positive than the rest.

The first impulse from the impulse source 67 will cause the pulse-shaping tube 52 to operate and send a strong positive impulse to the trigger pair to reverse its operating status. As tube 51 is fired and becomes conducting, its cathode potential will rise from the low to the high value, and during this rise the "1" tube will be rendered conducting first because its control grid was more positive than that of any of the other "odd" group tubes. As soon as the "1" tube begins to conduct, the drop across resistors 91 and 96 will reduce the voltage across the tube sufficiently to prevent any other "odd" group tube from firing. Only the "1" tube in the "odd" group will be conducting.

The potential rise of the cathode of tube 51 is impressed across the blow-out capacitor 73 and the resistor 72 and on the cathode of tube 50 to cause tube 50 to be extinguished in the well-known manner. As tube 50 is extinguished, the potential of its cathode will drop from its high value to its low value, and conduction can no longer be supported in the "0" tube, which will be extinguished.

The next input impulse on tube 52 will cause another reversal of the operating status of the trigger pair, and, since the control grid of the "2" tube is more positive than any of the other "even" group tubes, this tube will conduct. The reversal of the trigger pair will apply the low potential to the "odd" group of tubes and will extinguish the "1" tube.

Additional impulses will cause the reversal of the trigger pair to bring about the step-by-step operation of the other tubes in the ring, the "9" tube preparing the "0" tube for operation as the next tube of the sequence. With the operation of the "0" tube, the cycle starts all over again.

When the "0" tube conducts, its cathode potential rise is impressed on the grids of the tens transfer tube 53 to cause this tube to be fired and generate a tens transfer output impulse, which, in operations other than presetting, can be impressed on suitable apparatus to cause an operation thereof.

While the circuits shown and described herein are admirably adapted to fulfill the objects primarily stated, it is to be understood that it is not intended to confine the invention to the embodiments herein disclosed, for it is susceptible of embodiment in various other forms.

What is claimed is:

1. In a device of the class described, the combination of a first plurality of electron tubes; a second plurality of electron tubes; said tubes being of the negative-grid thyratron type, each having at least an anode, a cathode, a probe electrode, and a control electrode; a first common anode-cathode potential supply connected to the first plurality of tubes and forming them into a first operational group; a second common anode-cathode potential supply connected to the second plurality of tubes and forming them into a second operational group; means to control said first and second potential supplies to provide a high anode potential to one group to cause conduction in a tube of that group and at the same time a low anode potential to the other group to prevent conduction in a tube of that group, said control means being operable to reverse the high and low condition of the anode potential supplied to the groups each time an impulse is received; means connecting all the tubes into an operational series, using tubes from the first and second groups alternately, each connection extending directly from the probe electrode of a tube in one group to the control electrode of a tube in the other group; and input means for causing an operation of the potential supply control means to reverse the high and low conditions of the anode potential supplied to the groups; the supplying of anode-cathode potentials in two groups and the varying of their anode potentials in response to impulses together with the serial connections between tubes, causing the tubes to be operated one at a time in sequence.

2. The device as claimed in claim 1 in which the connections to the control electrodes of the negative-grid thyratron tubes are floating connections and do not include any negative bias supply resistance network.

3. The device as claimed in claim 1 in which the connections connecting the tubes in the operational series are simply conductors and do not include impedance elements.

4. The device as claimed in claim 1 in which the anode-cathode supply for each group of tubes includes an anode resistance and a cathode resistance which are common to all the tubes of the group.

5. The device as claimed in claim 1 in which the anode-cathode potential supply for each group includes an anode resistance and a cathode resistance which are common to all the tubes of the group and in which the series connections between the tubes are direct connections which do not include any resistors or capacitors, whereby an extremely simple ring is provided.

6. The device as claimed in claim 1 in which the means for controlling the potential supplies is operable alternately to one or another of two stables states of operation and includes a potential supplying resistance network, said network in one of said states supplying high potential to the first group and low potential to the second group and in the other of said states supplying low potential to the first group and high potential to the second group.

7. The device as claimed in claim 6 in which the means for controlling the potential supplies includes a trigger pair in said resistance network, said trigger pair being operable alternately to one and the other of said stable states in response to input impulses.

8. In a device of the class described, the combination of a plurality of digit-representing electron tubes of the negative-grid thyratron type, each tube having at least an anode, a cathode, a probe electrode, and a control grid; a common anode-cathode potential supply connected to all the "odd" digit-representing tubes and forming them into an operational group; a common anode-cathode potential supply connected to all the "even" digit-representing tubes and forming them into an operational group; means to control the potential supplied by the two potential supplies to cause the potential at each supply to vary between a high anode potential which will cause a tube to conduct and a low anode potential which will prevent conduction in a tube and to further control the potential supplies so that when high potential is supplied to the "even" tubes, low po-

tential will be supplied to the "odd" tubes, and vice versa, said control means operable in response to impulses and upon each operation reversing the high and low anode potentials supplied to the "odd" and "even" groups of tubes; means connecting the tubes in digital sequence, each connection being a floating connection and extending directly from the probe electrode of a tube to the control grid of the tube of next higher digital value and eliminating any negative bias supply for the control grid; and means to apply input impulses to the potential supply control means to cause its operation to vary the potentials supplied to the ring, whereby to cause the sequential operation of the tubes of the ring.

9. The device as claimed in claim 8 in which an anode resistor and a cathode resistor are included in the anode-cathode potential supply of each group and are common to the tubes of the group; and in which the connections for connecting the tubes in the digital sequence are only conductors, whereby a ring requiring a minimum of resistors is produced.

10. The device as claimed in claim 8 in which the means to control the potential supplies is a trigger pair having two stable states of operation and operable alternately to one and the other of the two states and including a potential supplying resistance network for supplying high potential to the "odd" group of tubes and low potential to the "even" group of tubes when the trigger pair is in one of its operating states and for supplying low potential to the "odd" group and high potential to the "even" group when the trigger pair is in the other of its operating states.

11. In a device of the class described, the combination of a plurality of tubes of the negative-grid thyratron type, each tube including at least an anode, a cathode, a probe electrode, and a control grid; a circuit connecting the cathodes of half of the tubes together and over a common impedance to a cathode potential supply to form a first group of tubes; a circuit connecting the cathodes of the other half of the tubes together and over a common impedance to a cathode potential supply to form a second group of tubes; a circuit connecting the anodes of the first group of tubes together and over a common impedance to a first source of anode potential; a circuit connecting the anodes of the second group of tubes together and over a common impedance to a second source of anode potential; means to control the potential at the two anode potential sources so that the potential at each source can vary from a high potential which will enable conduction to begin in a tube in the group to a low potential which will not support conduction in any tube in the group and to control the potentials so that, whenever high potential is supplied to one group, low potential will be supplied to the other group; means connecting all the tubes in an operational series using tubes from the first and second groups alternately in the series, the series connections being floating, negative-bias-free connections extending directly from the probe electrode of a tube to the control grid of the next tube in the series; and means for applying input impulses to the anode potential control means to cause it to operate to reverse the high and low potential supplies each time an impulse is received, said reversal of potential conditions, together with the series connections, causing the sequential step-by-step operation of the tubes in the ring; said anode circuits and cathode circuits with their common impedances, together with the direct series connections between tubes, enabling a ring to be produced with a minimum of impedance elements.

12. The device as claimed in claim 11 in which the series connection between tubes is merely a conductor and contains no resistors.

13. The device as claimed in claim 11 in which the means for controlling the potential at two potential sources is operable alternately to one or another of two conditions in response to input impulses, said means in one condition causing the high potential to be applied to the first group and low potential to be applied to the second group and to reverse the high and low potentials when in said other condition.

14. The device as claimed in claim 13 in which the means which is operable to one or another of two conditions is a trigger pair which includes a resistance network which is controlled to supply the potential variations.

JOSEPH R. DESCH.

No references cited.