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SECONDARY EMISSION TUBE RING CIRCUIT

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FIG. 1.

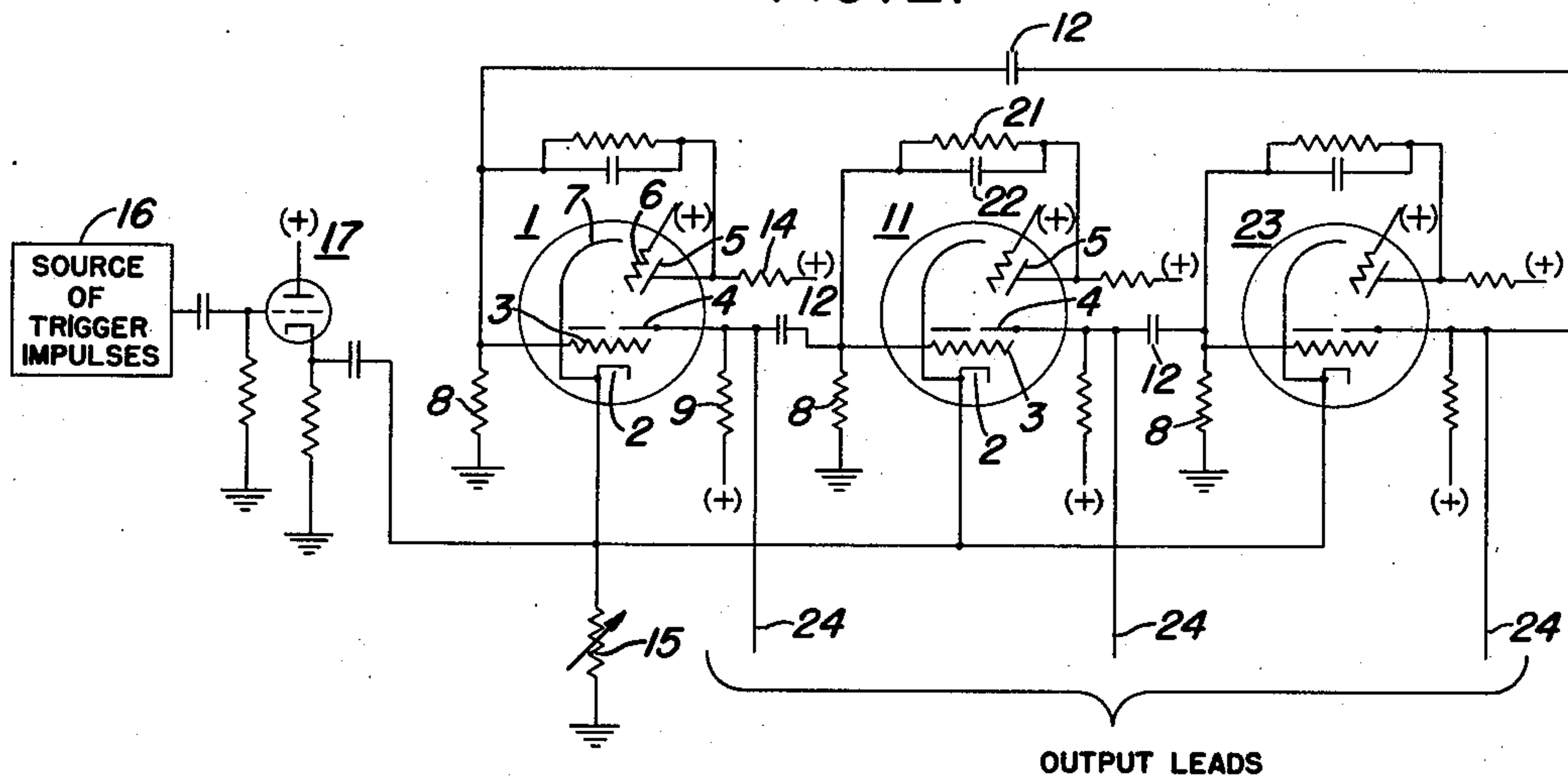
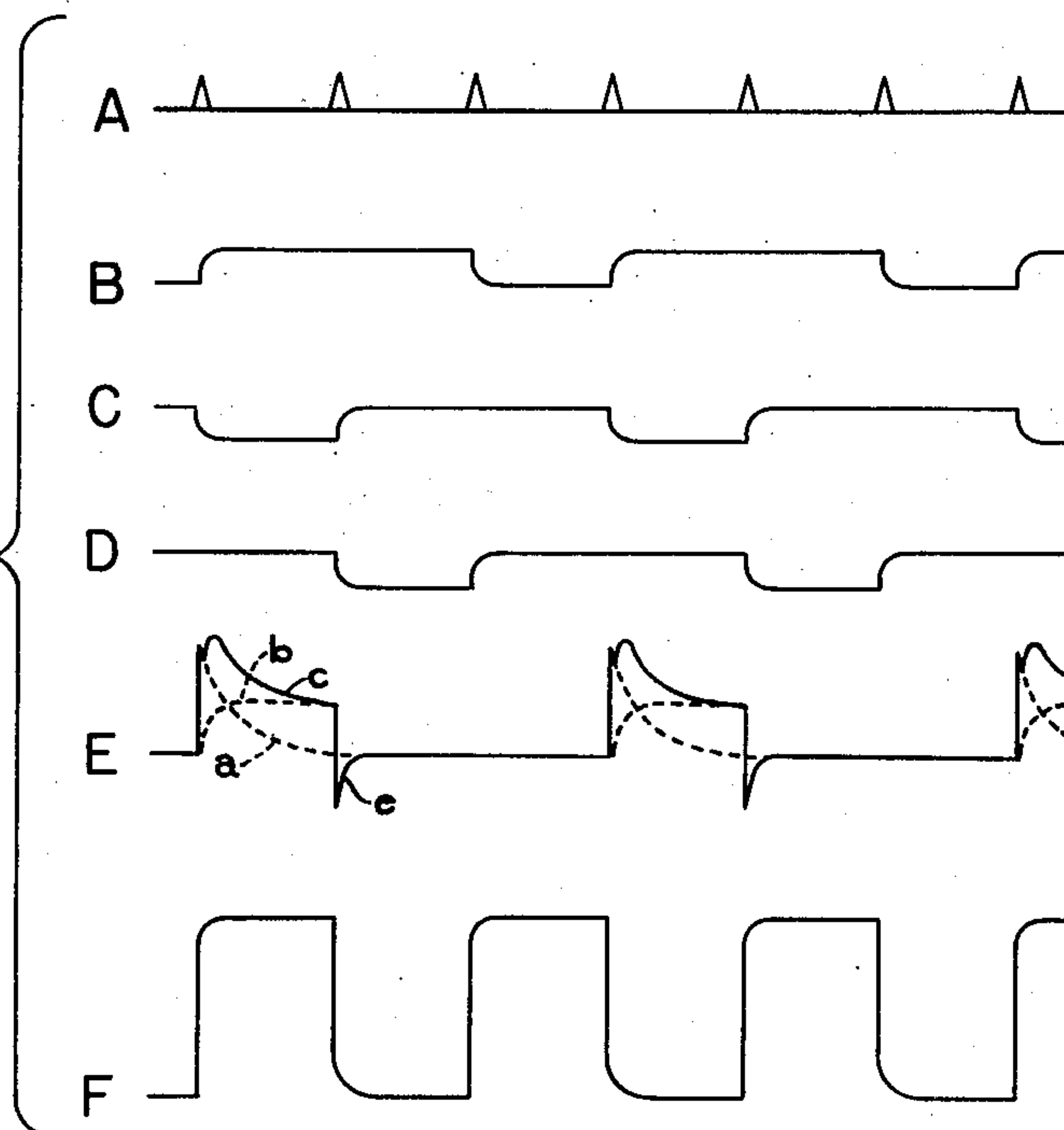


FIG. 2.



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SECONDARY EMISSION TUBE RING CIRCUIT

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4 Claims. (Cl. 250—27)

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This invention relates to counting circuits and more particularly to closed-ring pulse counting circuits including a plurality of stages of electron discharge devices of the secondary emission type.

Objects and advantages of my invention will be apparent from the following description when read in conjunction with the drawings in which Fig. 1 is a schematic diagram of a three-stage closed-ring pulse counting circuit and Fig. 2 illustrates in diagrammatic form various typical operating conditions found in the circuit shown in Fig. 1.

Referring to the drawings, there is shown a closed-ring pulse counting circuit comprising a plurality of stages. In the illustrated embodiment of my invention three stages are shown, although any number of stages may be utilized, it being simply necessary to join the output of the last stage to the input of the first stage.

The three stages shown include electron discharge devices 1, 11 and 23, respectively, of the secondary emission type such as those described in Skellett Patent 2,293,177 wherein there is disclosed a vacuum tube or electron discharge device which may be substantially instantaneously energized or de-energized according to its initial condition. Each device comprises a plurality of electrodes including a cathode electrode 2, an input control electrode or grid 3, and a primary or first anode 4, the cathode and the first anode constituting a pair of electrodes between which a primary stream of electrons may be established. The control electrode 3 is effective in controlling the primary stage. Means is also provided for establishing a secondary electron stream within the discharge device including a secondary electron emitting electrode or dynode 5, a collector electrode or grid 6 for collecting secondary electrons released by the dynode 5 when the primary electrons passing through an aperture in the first anode 4 bombard the dynode, and a deflector 7 for collecting cathode particles which may be released from cathode 2 and for bending or deflecting from their normal paths primary electrons that pass outwardly through the aperture in the first anode 4 so that they may bombard or strike the dynode emitting surface.

Each control electrode 3 is connected to ground through a suitable grid resistor 8. The first anode 4 is connected to a suitable source of positive potential as through a suitable anode resistor 9 and to the grid or control electrode 3 of the electron discharge device 11 of the second stage through a suitable coupling capacitor 12,

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The junction between coupling capacitor 12 and control electrode 3 is connected to ground by means of the grid resistor 8 of the next stage, capacitor 12 and resistor 8 being of such values as to differentiate the first anode potential.

The dynode or second electron emitting electrode is connected to a suitable source of positive potential as by means of a suitable resistor 14. The auxiliary electrode 6 is connected to a suitable source of positive potential and the deflector 7 is connected to the cathode. Each of the discharge devices is similarly connected and all the cathodes are connected together and then to ground through an adjustable resistor 15.

In order to trigger the counting circuit, there is provided a suitable source of trigger pulses indicated by numeral 16, these pulses being applied to all of the cathodes through suitable coupling means as, for example, the cathode follower stage indicated by numeral 17. The trigger pulses are positive going, i. e., relatively positive with respect to the base or normal potential.

In operation, as soon as the sources of potential are connected, one of the electron discharge devices becomes conductive. Let it be assumed that device 1 is conductive. The various potentials and grid bias, as well as the potential of the positive trigger pulses appearing at the output of the source 16, are so chosen that the appearance of the first trigger pulse raises the potential of the cathodes sufficiently to cut off the primary stream or flow of electrons. The potential at anode 4 then rises substantially instantaneously to the potential of the anode supply so that, in effect, the positive-going pulses are coupled by means of coupling capacitor 12 to the grid or control electrode 3 of the next stage of the ring circuit. The appearance of a sufficiently positive potential on grid 3 causes discharge device 11 to conduct. Conduction in device 11 results in secondary emission from the dynode whereupon the potential at the dynode increases rapidly to saturation. The dynode potential is coupled or fed back to the grid circuit by means of a suitable feedback network including shunt-connected resistor 21 and capacitor 22, thus providing means intended to maintain grid 3 sufficiently positive after the disappearance of the trigger pulses to maintain the discharge device 11 in a current saturated condition until the time of the appearance of the next trigger pulse.

The secondary emission, and hence the development of feedback potential, does not begin until after the driving or trigger pulse substantially subsides because the latter maintains cut-off or

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nonconductive all tubes or discharge devices in the circuit. Thereafter, that discharge device wherein the relative grid-to-cathode potential is most positive fires or becomes conductive. Since the grid of the next tube in the ring has a relatively higher potential than the other control electrodes because of the charge remaining on capacitor 12, the next tube or electron discharge device fires.

The first anode potential of each discharge device is differentiated in order to prevent the next pulse from re-triggering the tube which has just been conducting instead of triggering on the next tube or electron discharge device. In order to provide differentiation, capacitor 12 is chosen to have as small a capacity as practicable and, preferably, the capacity is chosen just large enough to overcome the stray capacitance of the associated circuits.

Referring to Fig. 2, there is illustrated at A, typical trigger pulses recurring repetitively with equal intervals of time between successive pulses. Curves B, C, and D illustrate the first-anode potentials at discharge devices 1, 11, and 23, respectively. These potentials are less positive during the interval when the discharge device is conducting and more positive when it is nonconducting. Curve E depicts the potential at the grid or control electrode of each electron discharge device. Dotted line *a* represents the decreasing potential due to the increase in first anode potential, i. e., the differentiated change in anode potential. Dotted curve *b* represents the potential applied to the grid or control electrode by the feedback network 21—22. Inasmuch as the positive-going trigger pulses cause the cutting off of all discharge devices, the regenerative feedback potential does not begin to build up until the trigger pulses substantially disappear. The resulting potential at the grid is represented by the solid line *c* in Fig. 2E. A typical dynode potential is depicted at Fig. 2F.

The trigger pulse applied to the cathodes need not have sufficient amplitude actually to cut off the associated discharge devices if the regenerative action in the feedback circuit provides a sufficiently negative dip when the tube is triggered off, the negative dip being indicated by the letter *e* in Fig. 2E.

With the foregoing arrangement only one electron discharge device can be conductive at any one time because with a common cathode resistor, if more than one discharge device begins to conduct, an unstable condition arises wherein the voltage drop across common cathode resistor 15 becomes so high that the various electron discharge devices tend to be driven beyond cut-off.

In the illustrated arrangement, the output leads 24 are shown connected to the first anodes and, as seen in Fig. 2, B, C, and D, negative-going pulses appear in the output. In order to obtain positive-going pulses the output leads may be connected to the dynodes. (See Fig. 2F.)

In a typical circuit employing the principles of my invention, resistors 8 were 47,000 ohms, resistors 9 were 10,000 ohms, resistors 21 were 100,000 ohms, variable resistor 15 was 10,000 ohms, resistors 14 were 100,000 ohms, capacitors 12 were 50 micromicrofarads, and capacitors 21 were 10 micromicrofarads. The trigger pulses had an amplitude of approximately 20 volts, a repetition rate of 100 kilocycles and a duration of approximately half a microsecond.

While there has been described what is at present considered the preferred embodiment of

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my invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim is:

1. In combination, a source of positive-going electric pulses and circuit means for counting the number of pulses appearing in the output of said source; said circuit means including a plurality of interconnected electron discharge devices; each of said devices comprising a pair of electrodes between which a primary electron stream may be established, one of said pair of electrodes constituting an anode, a control electrode disposed between said pair of electrodes, and an auxiliary electrode constituting a source of secondary electrons; a source of anode potential; said devices being interconnected such that only one of said devices is rendered conductive by the presence of anode potential in the absence of said positive-going electrical pulses; means responsive to the receipt of one of said pulses for establishing primary and secondary electron streams in another of said devices; and means responsive to the flow of secondary electrons in said another device for feeding back from the auxiliary electrode of said another device to the control electrode of said another device potential of such nature as to maintain said another device conductive after the disappearance of said one pulse.

2. In combination, a source of positive-going electric pulses and circuit means for counting the number of pulses appearing in the output of said source; said circuit means including a plurality of interconnected electron discharge devices; each of said devices comprising a pair of electrodes between which a primary electron stream may be established, one of said pair of electrodes constituting an anode, a control electrode disposed between said pair of electrodes, and an auxiliary electrode constituting a source of secondary electrons, a source of anode potential; said devices being interconnected such that only one of said devices is rendered conductive by the presence of anode potential in the absence of said positive-going electrical pulses; means responsive to the receipt of one of said pulses for establishing primary and secondary electron streams in another of said devices; means responsive to the flow of secondary electrons in said another device for feeding back from the auxiliary electrode of said another device to the control electrode of said another device potential of such nature as to maintain said another device conductive after the disappearance of said one pulse; and means responsive to the receipt of the next pulse for rendering said another discharge device non-conductive and still another of said discharge devices conductive.

3. In combination, a source of positive-going electric pulses and circuit means for counting the number of pulses appearing in the output of said source; said circuit means including a plurality of interconnected electron discharge devices; each of said devices comprising a pair of electrodes between which a primary electron stream may be established, one of said pair of electrodes constituting an anode, a control electrode disposed between said pair of electrodes, and an auxiliary electrodes constituting a source of secondary electrons, a source of anode po-

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tential; said devices being interconnected such that only one of said devices is rendered conductive by the presence of anode potential in the absence of said positive-going electrical pulses; means responsive to the receipt of one of said pulses for establishing primary and secondary electron streams in another of said devices; means responsive to the flow of secondary electrons in said another device for feeding back from the auxiliary electrode of said another device to the control electrode of said another device potential of such nature as to maintain said another device conductive after the disappearance of said one pulse, and means utilizing said feedback potential for driving the control electrode of said another device to a sufficiently low potential with respect to the cathode of said another device at the time of receipt of the next pulse that said another discharge device is prevented from again becoming conductive at the time of receipt of a third pulse.

4. In combination, a source of positive-going electrical pulses and circuit means for counting the number of pulses appearing in the output of said source; said circuit means including a plurality of interconnected electron discharge devices; each of said devices comprising a pair of electrodes between which a primary electron stream may be established, an auxiliary electrode constituting a source of secondary elec-

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trons; one of said pair of electrodes constituting an input terminal, the other of said pair of electrodes being electrically connected to the control electrode of another of said discharge devices; means responsive to the receipt of one of said pulses for establishing primary and secondary electron streams in said another of said devices; means responsive to the flow of secondary electrons in said another device for feeding back from the auxiliary electrode of said another device to the control electrode of said another device potential of such nature as to maintain said another device conductive after the disappearance of said one pulse; and means responsive to the receipt of the next pulse for rendering said another discharge device nonconductive and still another of said discharge devices conductive.

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