

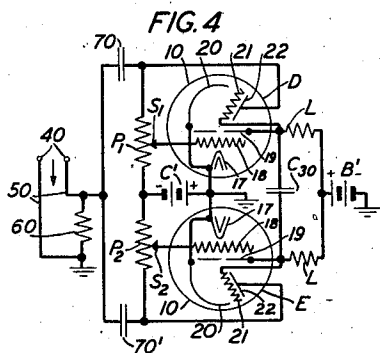
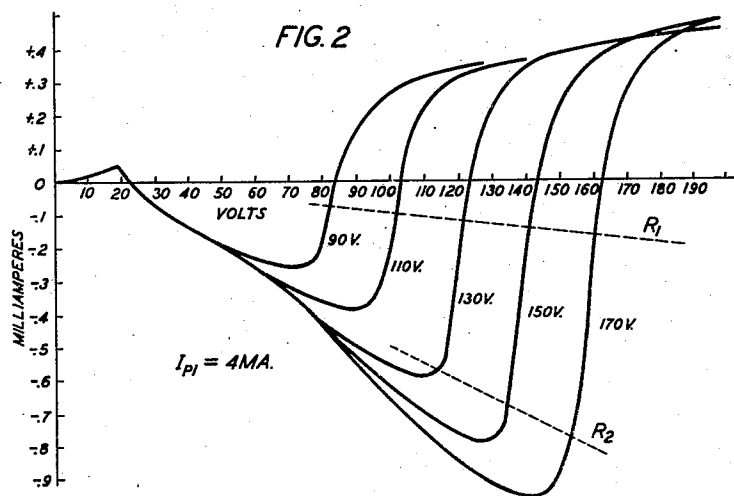
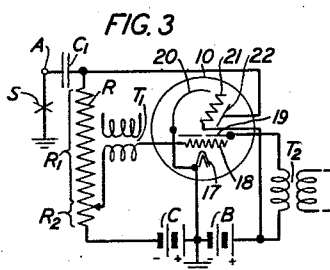
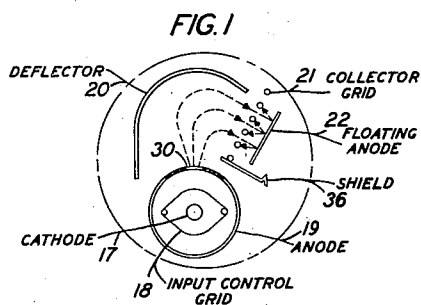
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IMPULSE GENERATOR CIRCUITS

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IMPULSE GENERATOR CIRCUITS

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18 Claims. (Cl. 250—27)

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This invention is a continuation-in-part of my application Serial No. 321,852, filed March 2, 1940, which matured into Patent 2,293,177, dated August 18, 1942. It relates particularly to impulse generator circuits.

The object of this invention is to devise an effective impulse generator operating on pure electron discharge and capable of sharp, sudden changes from the one condition of current flow to another.

The invention will be better understood from the following specification taken with the accompanying drawing, in which:

Figs. 1 and 2 are explanatory of the characteristics of a speech tube shown in my earlier application;

Fig. 3 shows the circuit of one pulse generator disclosed in the said earlier application; and

Fig. 4 is a modification thereof.

Fig. 5 shows a modification of Fig. 4.

In my earlier application I disclosed a particular form of tube making use of secondary emission. The essential elements of that tube are shown in Fig. 1 (which corresponds substantially to Fig. 3 of the parent application) which discloses a highly evacuated envelope containing a cathode 17, a primary anode 19, and a control grid 18. In one portion of the anode there is an opening 30 through which, as explained herein-after, electrons from the cathode may flow. The envelope also contains a deflector electrode 20, a collector grid 21, a floating anode 22, and a shield 36.

The cathode 17 is preferably of the equipotential type constituting a source of primary electrons when the cathode is heated. The cathode may be connected to the heater which would be of the filamentary type enclosed within the cathode.

The input or control grid 18 surrounds and is coaxial with and spaced from the cathode, and preferably comprises a pair of axially extending frame members on which a large number of turns of closely spaced, fine wire is securely wound.

The anode 19 comprises a metallic cylinder that surrounds and is spaced from the grid and is coaxial with the latter. The aperture 30 may be an elongated slot that permits a preassigned percentage, for example, ten per centum, of the electrons emitted by the cathode to pass through.

The deflector 20 comprises a bent metallic sheet spaced from the anode 19 and so disposed with respect to the aperture 30 that the electrons passing through the aperture are directed toward the deflector which may be electrically connected

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to the cathode in order to be at cathode potential. The deflector causes electrons that pass out through the aperture to follow trajectories of the character indicated by the dotted lines in Fig. 1, and to pass through the collector grid 21 to impinge on the floating anode 22 which is a secondary electron emitting source.

The collector grid 21 would ordinarily comprise an elongated rectangular wire frame, including a plurality of wires spaced apart and arranged in parallel to one another, and disposed paraxially of the tube and in a plane at a substantial angle to the plane through the center of the cathode and the center of the aperture 30. The collector grid also includes a planar metallic or shield portion 36 spaced from the anode 19 and extending substantially at right angles to the remainder of the collector grid.

As explained in my earlier application, the tube as thus constructed may be utilized as an amplifier, a detector, an oscillator, or a modulator. It also has the characteristic that it may be rendered operative or non-operative for such uses substantially instantaneously as the result of applying to or removing a control potential from the auxiliary anode or the input control grid. Furthermore, after the device has been rendered operative or "triggered-on," the space current is and remains under control of the grid 18 until the device is "triggered-off"; that is, the device may be employed in the usual way in which the conventional three-element vacuum tube or triode would be used.

The trigger action of the device depends on the floating properties of the auxiliary anode 22. Fig. 2 shows a family of current versus potential characteristics of this floating anode for a tube constructed in accordance with the invention. The different curves correspond to different potentials on the collector grid. As the potential is increased, the current passes through the zero axis twice. At each of these two points, the number of primary electrons is equal to the number of secondaries which are drawn off the surface. If the floating anode is at the higher zero potential, the external circuit may be entirely disconnected and the element will float in a perfectly stable manner at this voltage. At the lower zero potential, however, the equilibrium is unstable and if the external circuit is disconnected the potential will "fall" either way. If it falls down, the element returns to zero; and if it falls up, it jumps to the second zero potential and floats stably there.

If the floating anode is connected to ground

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through a high resistance, electrons will flow to it from the ground through this resistance because of its positive potential and these electrons will counteract the effect of an equal number of secondaries simply by replacing the charge carried away by the latter. On effect of reducing the secondary to primary ratio is that the second zero point or stable floating potential is reduced. The floating anode will now float at a potential slightly less than it did when free. This new floating potential is determined by the intersection of the volt-ampere characteristic with the line whose slope is equal to the load resistance. For example, the dotted lines R_1 and R_2 of Fig. 2 have the slopes of one megohm and two-tenths megohm, respectively, and the potentials of the point at which they cross the curves are of the floating potentials for these resistance values. Resistances smaller than about 1.4×10^5 ohms do not intersect the curves at all and the critical resistance is, therefore, near this value. It is given by the formula

$$R_c = \frac{E_m}{I_m}$$

so that, in general, we have that

$$R > \frac{E_m}{I_m}$$

where E_m and I_m are the voltage and current of the negative maximum of the characteristic. The floating anode will not float at values of resistance less than R_c for then the number of electrons supplied through the resistance will be in excess of the number of secondaries needed to maintain the effective secondary-to-primary ratio at a value equal to unit, and the floating anode will simply charge up negatively and its potential will be brought to zero. These principles are utilized to get off and on, or operate and non-operate, or block and unblock, or "trigger" action in the vacuum tube.

The action of the device in a particular instance is shown in the circuit arrangement of Fig. 3 (corresponding to Fig. 6 of my earlier application). The floating anode 22 is connected through the resistance R and the input grid biasing battery C to the cathode. The input grid 18 is connected to one end of the secondary winding of an input transformer T_1 , the other end of the secondary winding being connected to a contact engaging the resistance R and dividing it into two portions R_1 and R_2 . The primary anode 19 is connected with the cathode through the primary winding of the transformer T_2 and the source, for example, a battery B , of anode potential. The deflector 20 is connected to the cathode and the collector grid 21 is connected to the highly positive terminal of a battery B . The values of R_1 and R_2 are such that their total adds up to a value greater than R_c , preferably considerably greater, one to five megohms being suitable.

Suppose that the cathode heater is turned on and brought to operating temperature. The floating anode and the inner grid will all be at the negative C potential and no electrons can flow through the tube. If, now, the potential of the floating anode is momentarily raised to a value greater than the first zero potential (Fig. 2) by application of the necessary potential between terminal A and ground, for example, from the pulsing source S , the potential of the grid will be raised a few volts because of the drop across R_1 and R_2 and a small electron current will flow through the tube. As soon as electrons flow to

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the floating anode, its potential will jump to the second zero voltage, carrying the grid biasing up to the operating point. The tube has then triggered-on or "fired," and can be utilized, for example, as an amplifier through the transformers shown.

It can be triggered-off by decreasing momentarily the potential of the floating anode to a value slightly less than the first zero value, or by sending a negative pulse into the input or grid circuit, that is, through the transformer T_1 , of sufficient value to momentarily cut off the electron flow. The triggering pulses to the floating anode in this figure are shown as applied through a suitable condenser C_1 . This tube when connected in the proper circuit may be used as a pulse inverting or inverter circuit. Such a circuit is shown in Fig. 4. It comprises two discharge devices 10, such as already described. The cathodes are connected together and to ground, with the deflector plates connected to the cathodes of their respective tubes. Each primary anode is connected through a load L to the positive terminal of an anode potential source B' , the negative terminal of which is connected to ground, and the primary anodes are directly connected through a condenser C_{30} . Each collector grid is connected to its respective primary anode, although it may be connected directly to the potential source B' , so that its potential does not swing with variations in the electron currents. The source C' of biasing potential for the control grids is connected between ground and the junction of resistances P_1 and P_2 , the outer ends of which are connected to the secondary anodes. The control grids are connected to adjustable or slidable contacts S_1 , S_2 engaging with resistances P_1 , P_2 . The input circuit conductors 50 terminate in an input resistance 60, one end of which is connected to ground and the other through condensers 70, 70' to the secondary anode end of the resistances P_1 , P_2 . The input terminals 40 may be connected to any suitable source of electrical pulses of positive polarity.

Let it be assumed that the tube D is "fired," that is, that its secondary anode is at upper zero current potential, and an electron stream is maintained between the cathode and primary anode; and that tube E is blocked or "extinguished." Assume, then, that a positive pulse is impressed on the terminals 40, and is of such a value that it elevates the potential of the secondary anode of tube E above its lower zero-current potential. As the secondary anode of tube D is already above that potential, the incoming impulse has little or no effect on the tube D . The control grid of tube E is driven in the positive direction, and the tube E is caused to fire in the same way as the tube of Fig. 3. As the tube E becomes operative, its primary anode swings negative, and this negative swing is transmitted by condenser C_{30} to the primary anode of tube D decreasing its potential to such an extent that primary electrons are no longer enabled to flow in tube D , and the latter is extinguished. The next positive pulse received at terminals 40 causes tube D to become operative, and causes tube E to return to its initial inoperative condition. Thus, a series of positive pulses transmitted through the terminals 40 will alternately operable the tubes D , E .

Fig. 5 shows a modification of the circuit of Fig. 4. The essential differences are as follows: The condensers 70 and 70' instead of being connected to the secondary anodes are connected directly to the control grids and the secondary

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anodes are connected to the positive terminal of the battery B' through resistances R₃. The presence of the resistances R₃ assures that the potential of the secondary anodes will never fall below a potential corresponding to the first zero crossover of Fig. 2, and the circuit as a whole is, therefore, in a condition to have the tubes D and E more readily triggered-on and off. While the circuit of Fig. 4 requires 40 or 50 volts to trigger it, the circuit of Fig. 5 will operate on pulses of only a fraction of a volt.

What is claimed is:

1. A pulse inverting circuit comprising a plurality of electron discharge devices, each of said devices comprising a cathode, a control grid, a primary anode, and a secondary electron emission anode, means connecting said cathodes together, means to cause said devices to operate in alternation comprising a negative reactance connecting said primary anodes, a cathode-primary anode circuit for each device including load means therein, means for biasing said control grids to preassigned potentials and for initially adjusting said secondary anodes to preassigned potentials, and means for simultaneously impressing electrical pulses on said control grids and secondary anodes to cause said devices to be alternately rendered conductive.

2. A pulse generating circuit comprising two electron discharge devices, each of said devices comprising a cathode, a control grid, a primary anode and a secondary electron emission anode, means connecting said cathodes together, a cathode-primary anode circuit for each device including load means therein, means for biasing said control grids to preassigned potentials for initially adjusting said secondary anodes to preassigned potentials, means comprising a capacitance connection between the said primary anodes, and means for simultaneously impressing electrical impulses on said control grids and secondary anodes to cause said devices to be alternately rendered conductive.

3. A high vacuum tube trigger circuit comprising two electron discharge devices, each of said devices comprising a cathode, a control grid, a primary anode and a secondary electron emission anode, means connecting said cathodes together, a capacitance connected between the two primary anodes, a cathode-primary anode circuit for each device including load means therein, means for biasing said control grids to preassigned potentials and for initially adjusting said secondary anodes to preassigned potentials, a capacitance connection between the two secondary anodes, and means for impressing electrical pulses on said control grids and secondary anodes through said capacitance so that the said devices are alternately rendered conductive.

4. A pulse generating circuit comprising two electron discharge devices, each of said devices comprising a cathode, a control grid, a primary anode and a secondary electron emission anode, means connecting said cathodes together, means comprising a negative reactance connecting said primary anodes, a cathode-primary anode circuit for each device including load means therein, means for biasing said control grids to preassigned potentials and for initially adjusting said secondary anodes to preassigned potentials, a capacitance connection between the control grids, and means for impressing electrical pulses on said control grids through the said capacitance connections.

5. A combination of claim 4 characterized by

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the fact that there is a resistance connection from each secondary anode to the primary anode voltage source.

6. A combination of claim 4 characterized by the fact that the capacitance connection between the control grids comprises two condensers in series and that the means for impressing electrical pulses on the control grids is to a point between the two condensers.

7. A combination of claim 4 characterized by the fact that the capacitance connection between the control grids comprises two condensers in series and that the means for impressing electrical pulses on the control grids is to a point between the two condensers, and that there is a resistance connection from each secondary to the primary anode voltage source.

8. In combination, a plurality of vacuum electron discharge devices, each of said devices including a pair of electrodes between which an electron stream may be established, a control electrode between said electrodes, and a secondary electron emission electrode for emitting secondary electrons when said electron stream is established; means connected to said control electrodes and to said secondary electrodes, whereby a pulse of positive polarity may be impressed on such electrodes; and means to interconnect one of said pair of electrodes in one device to a corresponding one of said pair of electrodes in the second device, whereby potential change on either of said interconnected electrodes resulting from the establishment of an electron stream between such electrode and the electrode with which it constitutes one pair of electrodes, reduces the potential on the other of the interconnected electrodes to a value precluding the maintaining of an electron stream in the device containing such other electrode.

9. The combination of the next preceding claim in which the means connected to the control electrodes and the secondary electrodes includes a reactance.

10. The combination of claim 8 in which the means connected to the control electrodes and the secondary electrodes includes a negative reactance.

11. The combination of claim 8 in which the means connected to the control electrodes and the secondary electrodes includes an individual capacitance for the control and secondary electrodes of each device.

12. The combination of claim 8 in which the means for interconnecting said corresponding electrodes of said devices comprises a reactance.

13. The combination of claim 8 in which the means for interconnecting said corresponding electrodes of said devices comprises a negative reactance.

14. In combination, a plurality of vacuum electron discharge devices, each of said devices comprising a cathode, a control grid, a primary anode containing an aperture for the escape of some of the primary electrons originating at the cathode and reaching the anode, and a secondary electron emission anode in the path of said escaped electrons for emission of secondary electrons upon bombardment by said escaped electrons; means connected to said control grids and to said secondary anodes, whereby a pulse of positive polarity may be impressed on said grids and secondary anodes; and means to interconnect said primary anodes, whereby potential change on one of said anodes resulting from establishment of electron flow between said one anode and

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its associated cathode reduces the potential on the other of said primary anodes below the value at which an electron stream could be maintained between said second primary anode and its associated cathode.

15. The combination of next preceding claim in which the means interconnecting the primary anodes includes a reactance.

16. The combination of claim 14 in which the means interconnecting the primary anodes includes a negative reactance.

17. The combination of claim 14 in which the means interconnecting the primary anodes includes a capacitance.

18. The combination of claim 14 in which the

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means connected to each control grid and a secondary anode includes a capacitance, and the means interconnecting said primary anodes includes a capacitance.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,043,242	Gebhard -----	June 9, 1936
2,093,781	Van B. Roberts -----	Sept. 21, 1937