Jan. 19, 1943.

A. M. SKELLETT

2,309,019

ELECTRON DISCHARGE DEVICE CIRCUITS

Filed Oct. 23, 1941

3 Sheets-Sheet 1

FIG. 2

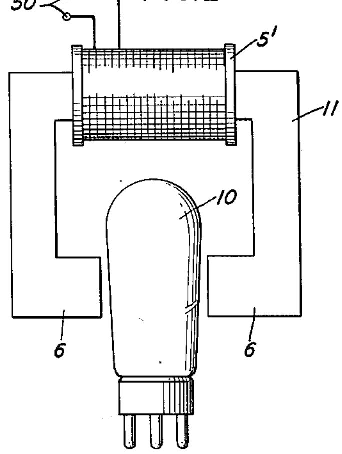


FIG. 1

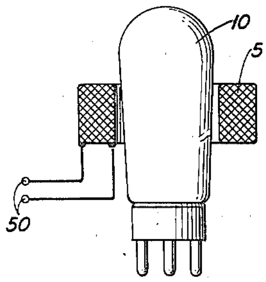


FIG. 3

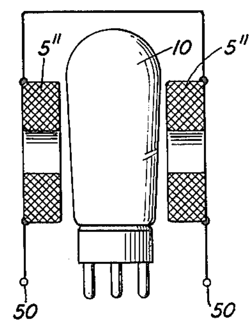


FIG. 4

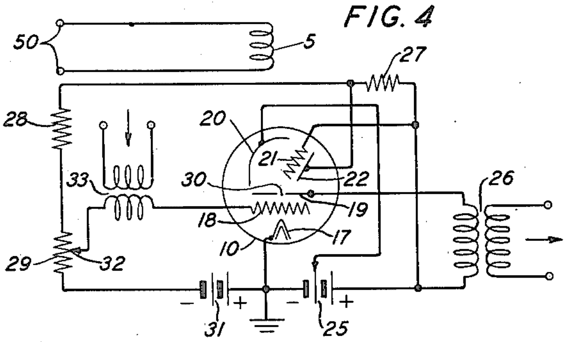
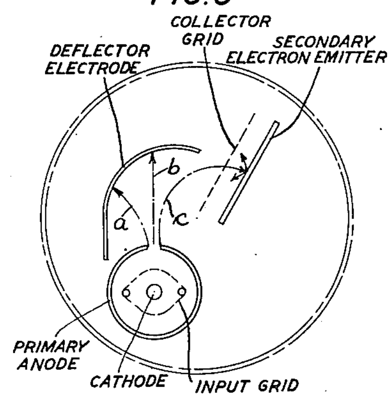


FIG. 5



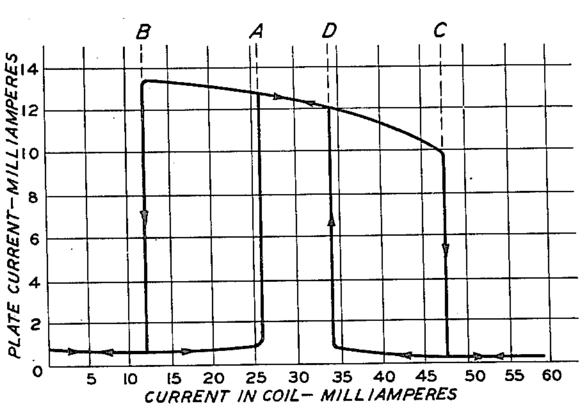


FIG. 6

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FIG. 7

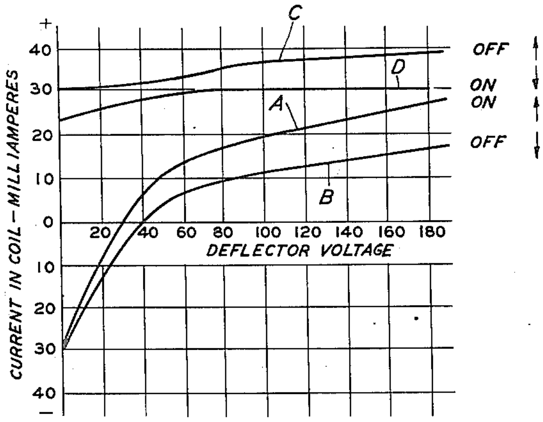

FIG. 8

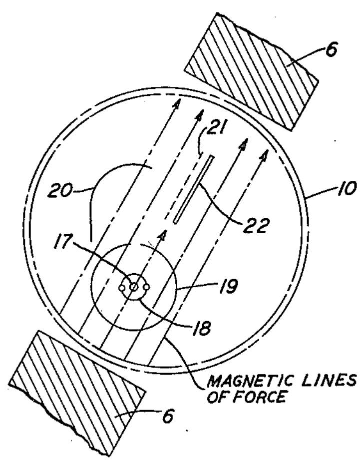

FIG. 9

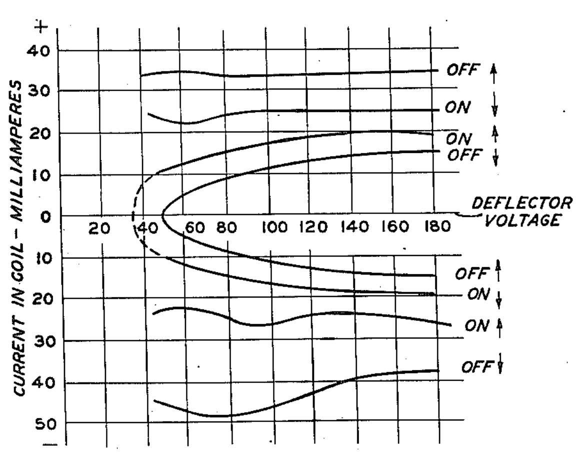

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FIG. 10

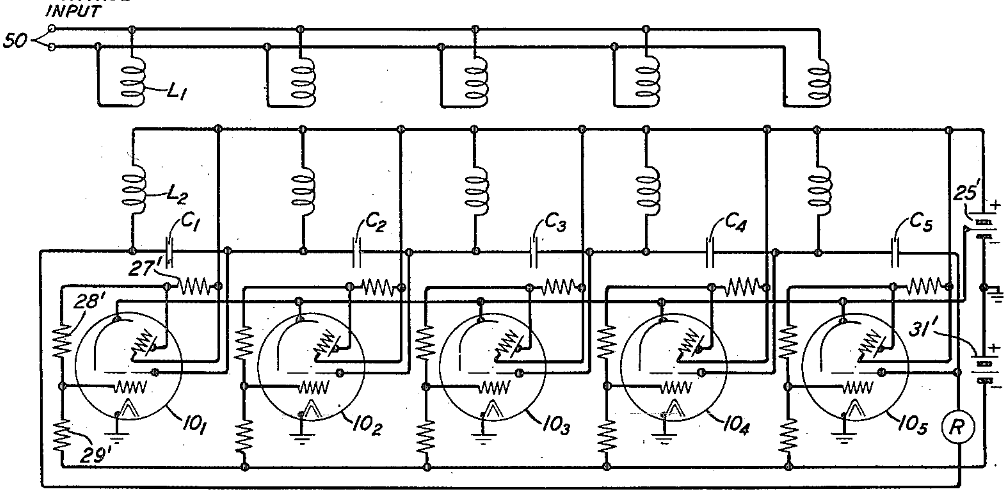


FIG. 11

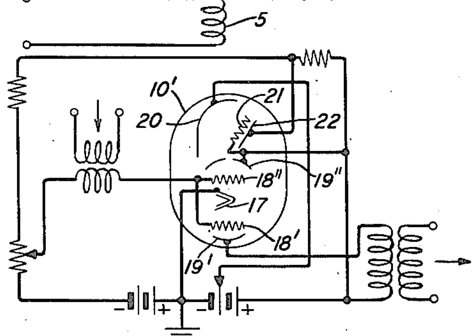


FIG. 12

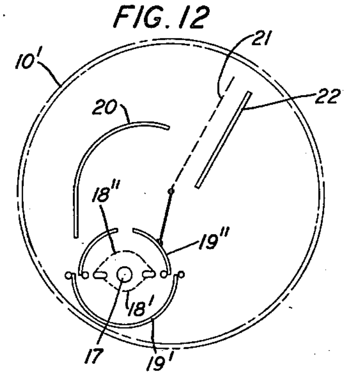
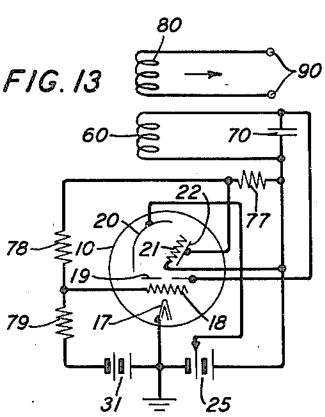


FIG. 13



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Patented Jan. 19, 1943

2,309,019

UNITED STATES PATENT OFFICE

2,309,019

ELECTRON DISCHARGE DEVICE CIRCUITS

Albert M. Skellett, Madison, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application October 23, 1941, Serial No. 416,155

13 Claims. (Cl. 250—27)

This invention relates to electron discharge devices and, more particularly, to electronic vacuum tubes of the secondary electron emission type and circuits incorporating the same. More specifically, the invention relates to modifications of the subject-matter of my United States Patent 2,293,177, of August 18, 1942, for Electron discharge device circuits.

An object of the invention is to improve the means and method of regulating or controlling the on and off properties or conditions of a trigger device comprising a vacuum tube of the secondary electron emission type.

A feature of the invention comprises controlling the operating condition of such a trigger device by means of a magnetic field, the lines of force of which may extend either parallel to or perpendicular to the axis of the device.

A more complete understanding of the invention will be obtained from the detailed description that follows, read with reference to the appended drawings, wherein:

Figs. 1, 2 and 3 illustrate arrangements for associating a magnetic field with an electronic device or vacuum tube;

Fig. 4 shows a circuit arrangement in accordance with the invention in which a secondary electron emission type vacuum tube has an electromagnet associated with it, as in the arrangement of Fig. 1, to provide a magnetic field parallel to or along the axis of the tube;

Fig. 5 illustrates the electrode arrangement in the tube of Fig. 4 and will be referred to in describing the action of the magnetic field on the primary electrons emitted through the window or aperture in the primary anode;

Fig. 6 is a typical operating characteristic of the tube, being a plot of magnetizing current in the magnetic field producing coil of Figs. 1 and 4 versus cathode-primary anode current, evidencing two critical primary anode current "off" and two critical primary anode current "on" values of magnetizing current for a given set of potential conditions on the tube electrodes;

Fig. 7 shows a family of curves illustrating how these critical "off" and "on" magnetizing current values are affected by variation in deflector electrode potential;

Fig. 8 is a schematic of a vacuum tube such as shown in Fig. 4, but with the magnetic field producing arrangement of Fig. 2 to provide a magnetic field perpendicular to the axis of the tube;

Fig. 9 shows a family of curves illustrating how the critical "off" and "on" values of magnetizing current in the coil vary with variation in deflector electrode potential, and with the direction of flow of the magnetizing current through the coil or electromagnet of Figs. 2 and 5;

Fig. 10 shows a closed ring pulse counting circuit embodying the magnetically controlled secondary electron emitter vacuum trigger tube of this invention;

Figs. 11 and 12 show a modification of the circuit and electrode arrangements of Figs. 4 and 5; and

Fig. 13 shows an oscillation generating circuit incorporating a trigger device in accordance with this invention.

In my aforementioned Patent 2,293,177 is disclosed a vacuum tube having a trigger characteristic, i. e., it may be substantially instantaneously energized or deenergized dependent on its initial condition. For a detailed description of the construction and of circuit applications of this tube reference may be had to the aforementioned patent, but, in general, the tube comprises a cathode; an input control grid; a primary anode having an aperture or window therein for the passage or escape therethrough of primary electrons originating at the cathode; a secondary electron emitting electrode or auxiliary anode having an emission ratio greater than unity; a collector electrode or grid for collecting secondary electrons released when primary electrons bombard the auxiliary electrode; and a deflector electrode for collecting cathode particles that may be released from said cathode, and for bending or deflecting from their normal paths primary electrons that pass outwardly through the aperture in the primary anode so that they may impinge on or bombard the secondary electron emitting surface of the auxiliary electrode; all of the electrodes being supported in an evacuated envelope. The auxiliary anode has a floating characteristic, and as a result of a suitable connection to the input grid may be utilized with the latter to trigger the tube on, subsequent to which the tube may be used as a modulator, amplifier, oscillator or detector.

Instead of utilizing a signal impulse to the input grid and/or the auxiliary anode to trigger the tube on or off as in the aforementioned patent, the trigger action, in accordance with this invention, may be effected by magnetic or electromagnetic means, the presence or absence and the density of magnetic flux parallel or perpendicular to the axis of the tube determining whether the primary electron stream is incident on the auxiliary anode and whether the latter is at its flotation potential and the input grid at a potential substantially above cathode-primary anode current cut-off.

Figs. 1, 2 and 3 illustrate how magnetic flux-producing means may be associated with a vacuum tube 10 of the general type disclosed in my aforementioned patent. In Fig. 1, an electromagnet 5, shown in cross section, surrounds the tube, and when energizing current flows in the electromagnet it produces magnetic flux in a direction parallel to the axis of the tube. In Fig. 2, the electromagnet 5' surrounds a yoke 11 of magnetic material between whose ends 6 the tube is located. In Fig. 3, the electromagnet comprises a pair of coils 5'', each shown in cross section, between which the tube is positioned. With the arrangements of Figs. 2 and 3, magnetic flux may be produced that is perpendicular to the axis of the tube and at an azimuthal angle dependent on the location of the yoke ends or of the coils 5'' with respect to the tube.

A circuit arrangement in accordance with the invention is shown by Fig. 4. The vacuum tube 10 comprises a primary electron source or cathode 17, which may be indirectly heated; an input grid 18; a primary anode 19 having an aperture or window 30 for the passage therethrough of some primary electrons; a deflector electrode 20; a secondary electron collector electrode or grid 21; and a secondary electron emitting electrode or auxiliary anode 22, which may be similar to the correspondingly identified elements of Figs. 1, 2 and 3 of my aforementioned patent, but with the electrode arrangement of Fig. 3A of that patent. A source 25 of potential is connected between the grounded cathode and the primary anode, in circuit with the primary winding of an output transformer 26. The collector grid is connected directly to the high potential terminal of source 25, and the auxiliary anode is connected thereto through the resistor 27. The deflector electrode 20 is maintained at a positive potential which may be of the same order as that of the collector grid and primary anode, or less. The auxiliary anode is connected to the cathode through series-connected resistors 28, 29 and the source 31 of biasing potential for the grid 18, and to the latter through the tap or slide 32 engaging with resistor 29 and the secondary winding of input transformer 33. The resistors 27, 28, 29 are proportioned so that the auxiliary anode, in the absence of primary electrons incident thereon, is at a potential above its lower zero current potential.

With appropriate positive potential on the deflector electrode and no energizing or flux-producing current flowing in the coil 5, the primary electrons that are propelled from the cathode and through the window 30 in the primary anode are caused to follow the path *b*, Fig. 5 with none having access to the auxiliary anode. With current flow in one direction through the coil 5, the electrons are deflected to the left or caused to follow the path *a*, Fig. 5; with current flow in the opposite or reverse direction through the coil 5, the primary electrons are deflected to the right or cause to follow the path *c*, Fig. 5. If it is assumed that the input grid 18 is initially biased to such a value that the cathode-primary anode current is nearcut-off, whereby the number of primary electrons reaching the primary anode is too small to provide any effective output current, and no current is being supplied to the coil 5, or only a current that produces a magnetic field that deflects to the left the electrons emitted through the window, the tube 10 is in its triggered-off condition, and signal impressed on the primary winding of the input transformer will not be transmitted through the tube. If, now, current is caused to flow in the coil in such direction as to produce a magnetic field that deflects the primary electron stream along path *c*, secondary electrons are caused to be emitted from the anode 22 and the latter rapidly rises in potential. As it increases to its stable floating potential, the bias on the grid 18 is decreased and the grid is driven sufficiently in the positive direction so that substantial flow of electrons to the primary anode results. After the tube is thus triggered on, its cathode-input grid-primary anode structure may be utilized, for example, to amplify or to detect the signal wave impressed on the cathode-input grid circuit through the transformer 33. The tube may be triggered off by removing, or reversing the direction of, the magnetic field. The described combination of coil, tube and circuit has properties the equivalent of those of a polarized relay, as well as those of a conventional vacuum tube.

The magnitude of the magnetic field strength required to make the primary electrons follow the path *c* is given by

$$H=\frac{1.414}{R}\left(\frac{Vm}{e}\right)^{1/2}$$

where m and e are the mass and the charge of an electron, V is the voltage of the primary anode and the deflector and collector electrodes, and R is the radius of the path *c*.

Fig. 6 shows the cathode-primary anode current versus current in the electromagnet 5 for a complete cycle of operation in a circuit arrangement constructed in accordance with the invention, and in which resistors 27, 28, 29 were of 4.5 megohms, 2 megohms and 1 megohm, respectively, the input grid bias was of the order of −36 volts, the deflector potential was of the order of +135 volts, and that of the primary anode and the collector grid was about +150 volts. The coil 5 consisted of 13,750 turns of No. 36 wire, and had a resistance of 3000 ohms; 10 milliamperes produced a field of 34 gauss at its center. In the "off" condition of the tube, that is, with no current in the coil 5 to produce a magnetic field of correct polarity, the anode current is a fraction of a milliampere, in the specific instance, 0.65 milliampere. Increase of the coil current causes only a slight increase in the anode current until a critical coil current A (about 26 milliamperes) is reached at which the anode current jumps to 12.8 milliamperes. Decrease in the coil current to a second critical value B (about 12 milliamperes) causes the tube to trigger off with the primary anode current restored to its low value. It will be noted that the anode current rises slightly as the coil current is thus decreased between A and B, and that the coil current to trigger off the tube is substantially less than that required to trigger it on. When the tube triggers on, the potential of the auxiliary anode rises and this helps to hold the electrons over on to it. This insures a high order of stability to the tube in its off and in its on condition.

Once the tube has been triggered on, increase of the coil current above the first trigger-on or first critical point A results in a slight decrease in the anode current until a third critical coil current C (about 46 milliamperes) is reached at which the tube triggers off. This results because the primary electron stream is deflected or bent to such an extent that the primary electrons no longer strike the auxiliary anode; the latter ceases to emit secondaries and decreases in potential to its original condition, and the effect on the grid 18 of the negative bias from source 31 is no longer compensated. After the tube has been triggered off in this manner, an appreciable reduction in the magnitude of the coil current below the upper trigger-off point C is necessary before the tube again triggers on at a fourth critical coil current D as a result of the primary electrons again bombarding the auxiliary anode. In the particular case, this occurred at about 34 milliamperes, at which the anode current rose to about 12 milliamperes. Further reduction in the coil current causes the anode current to increase slightly until coil current B is again reached at which the tube triggers off.

The sensitivity of the trigger control may be varied by changing the potential on the deflector electrode. In general, the lower the positive potential of the deflector electrode the smaller the energizing current required in the coil 5. For example, for potential conditions otherwise the same as those under which the characteristic of Fig. 6 was obtained but with the deflector electrode at +45 volts, the tube was caused to trigger on initially with a current of only 9.5 milliamperes in the coil 5. Fig. 7 shows how the critical currents A, B, C, D for the coil current vary with variation in deflector electrode potential. These characteristic curves were obtained with the primary anode and the collector grid at +180 volts, and with the input grid biased to −22.5 volts. The positive (+) and negative (−) signs on the coil current scale indicate the direction of current flow through the coil, i. e., positive currents produce a magnetic field whose tendency is to deflect the primary electron stream toward the path *c*, negative currents produce a magnetic field of reversed polarity from that of the field produced by the positive currents and whose tendency is to deflect the primary electron stream toward path *a*.

With the arrangement of Figs. 4 and 5 there is a residual primary anode current when the tube is in its off condition in order that there may be, for control purposes, sufficient primary electrons escaping through the window in the primary anode. The circuit arrangement of Fig. 11 enables maintaining the requisite primary electron flow for control purposes in the off condition of the tube and simultaneously a zero output current. The primary anode is divided into two portions 19′, 19″, and the input grid is also divided into a portion 18′ farther removed from the anode portion 19′ than another portion 18″ is from the anode portion 19″. The grid portion 18′, being nearer to the cathode than grid portion 18″, requires a lower order of negative bias to cut off electron flow to the anode portion 19′ than is required for cut-off of electron flow to the portion 19″. The greater separation between grid portion 18′ and anode portion 19′ than that between the portions 18″ and 19″ also contributes in this respect. Therefore, when grid portion 18″ is near but not quite at primary anode current cut-off potential, grid portion 18′ will be biased beyond cut-off so that, for the off condition of the tube, primary electrons do not flow to the anode portion 19′ and no output current evidences itself in the output transformer. Anode portion 19″, it will be observed, is connected within the tube to the collector grid. Fig. 12 is a plan view of a possible electrode arrangement for the tube 10′ of Fig. 11. Although in this modification of the invention both the input grid and the primary anode have been described and shown as altered in configuration, the input grid could be left the same as in Fig. 5 and only the primary anode changed, the spacings of the primary anode sections from the grid being appropriately chosen.

The specific description hereinabove has been with respect to a control coil that produces a magnetic field substantially parallel to the axis of the tube. The arrangements of Figs. 2 and 3 enable magnetic control of the primary electron stream by means of a magnetic field extending perpendicular to the axis of the tube. Fig. 8 illustrates the relation to the electrodes of tube 10 of the magnetic lines of force provided by the magnetic yoke and coil 5′ of Fig. 2. In a specific embodiment of the invention, the yoke was of iron, the coil consisted of 19,000 turns of No. 36 wire and had a resistance of 3,660 ohms. The gap between the faces of yoke ends 6 was about 1½ inches and 10 milliamperes of direct current in the coil 5′ produced a field of 50 gauss at the center of the gap. The direction of the magnetic field with respect to the electrodes has been determined to be somewhat critical, best results being obtained when the direction of the field in the gap was set at an angle of 4.0 degrees with respect to the plane of the collector grid, although deviations of the order of a few degrees from this condition could be tolerated. A typical cycle of on and off operation for this arrangement would be similar to that shown in Fig. 6 for the control coil arrangement of Fig. 1. With the arrangement of Fig. 2 and Fig. 8, however, the direction of current flow in the coil 5′ may be such as to produce magnetic lines of force in either direction across the gap between yoke ends 6, and yet enable substantially the same off and on cycle to be obtained. The arrangement of Fig. 2 provides the equivalent of an ordinary relay. As with the arrangement of Fig. 1, the sensitivity of the trigger control is dependent on the potential at which the deflector electrode is maintained. Fig. 9 shows a family of coil current-deflector potential curves for the arrangement of Fig. 2, in which the primary anode and collector grid of tube 10 were at +180 volts and the input grid was at a potential of −22.5 volts.

Fig. 10 shows a closed ring pulse counting circuit comprising a plurality of stages of the magnetically controlled trigger vacuum tubes of this invention. Each tube 10_1—10_5 is similar to tube 10 of Fig. 4. The magnetic field producing coil for each tube comprises two separate windings L_1, L_2, the windings L_1 being connected in parallel across the terminals 50 on which are impressed the pulses to be counted, and each winding L_2 being connected in a primary anode potential lead from the high potential terminal of source 25′, the winding L_2 of a particular tube being connected in the primary anode potential supply lead of the preceding tube in the ring. Biasing potential for the input grids of the tubes is provided by source 31′; the collector grid directly, and the auxiliary anode, through a resistor 27′ are connected to the potential source 25′, while the deflector electrodes are connected to an intermediate point on the source 25′. The resistors 27′, 28′, 29′ are proportioned so that the auxiliary anode's normal potential, i. e., when the tube is in off condition, is at least above the lower zero current potential of the auxiliary anode. The primary anodes of succeeding tubes are connected through condensers C_1—C_5. The operation of this circuit is as follows: In order to "fire" or trigger on any one tube in the ring, both windings L_1, L_2 associated with that tube must be energized. If it is assumed that tube 10_1 has already been "fired" or is in its on condition, its cathode-primary anode current flows through the L_2 winding of tube 10_2, which produces a magnetic field in tube 10_2 of a strength substantially less than that required to trigger it on. When a current pulse is impressed on the terminals 50, each winding L_1 produces a magnetic field in its associated tube that is of strength substantially less than that required to trigger on the tube, but which, in the case of tube 10_2, supplements the field already provided by its winding L_2 sufficiently to cause tube 10_2 to trigger on. This primes the succeeding tube 10_3 since the primary anode current of tube 10_2 flows through the L_2 winding of tube 10_3 and provides the initial magnetic field for the latter. Simultaneously, the preceding tube 10_1 triggers off, each L_2 winding being of sufficient resistance to cause such change in the primary anode potential of a tube as it triggers on that, acting through the coupling condenser, in the present instance C_2, it momentarily reduces the primary anode potential of the preceding tube to such a value that insufficient primary electrons reach the auxiliary anode thereof to maintain the auxiliary anode at its floating potential. The fall of the auxiliary anode potential to its normal potential causes the input grid to reduce still further the flow of primary electrons in tube 10_1 and, in the absence of energizing current in both of the windings L_1, L_2 associated with tube 10_1 the latter remains triggered off. As successive current pulses are impressed through terminals 50, the tubes "fire" in succession around the ring, the register R in the primary anode lead for tube 10_5 registering every fifth pulse received.

Fig. 13 shows an oscillation generating circuit incorporating the magnetically controlled trigger tube of this invention. The control coil 60 is connected in the cathode-primary anode circuit with a frequency-determining condenser 70 in parallel with it. The resistors 77, 78, 79 are proportioned so that the auxiliary anode is at least at a potential higher than the first zero current potential of its voltage-current characteristic. The input grid is biased to near primary anode current cut-off. The deflector electrode is at a positive potential that, in the absence of, or with a minimum, current in the coil 60, permits the escaped primary electrons to deflect to and bombard the auxiliary anode whereby the latter rises to its stable floating potential and drives the input grid in a positive direction to trigger on the primary anode current. If it is assumed that the circuit has just been connected, and that the tube has triggered on, the primary anode current flow in coil 60 produces a magnetic field that, with proper polarity, deflects the escaped primary electrons away from the auxiliary anode, whereby the latter falls to the potential determined by the resistors 77, 78 and 79. The input grid potential increases negatively to near the primary current cut-off point, and the tube triggers off. The current built up in the coil 60 by the trigger-on action decreases to its original value, and the magnetic field is either no longer present or is of a value insufficient to deflect the escaped primary electrons away from the auxiliary anode. The escaped primary electrons again bombard the auxiliary anode and the tube triggers on. This cycle is repeated so long as the circuit remains connected as shown in the figure. The oscillations generated in the coil 60 may be induced in coil 80 for supply through the terminals 90 to an appropriate load. In addition to its tuning function, condenser 70 assures that the primary anode potential does not fall to too low a value when the tube triggers on. Subject-matter not specifically claimed herein is being claimed in a divisional application, Serial No. 456,875, filed September 1, 1942, for Electron dscharge device circuits.

Although this invention has been disclosed with reference to certain specific embodiments, it is to be understood that the invention is not limited thereto, but is of a scope evidenced by the appended claims.

What is claimed is:

1. In combination, an electronic device comprising a primary electron source, a primary anode containing an aperture through which some of the primary electrons originating in said source may escape, a control electrode between said source and anode, an auxiliary anode to emit secondary electrons in ratio greater than unity when bombarded with escaped primary electrons, said auxiliary anode being positioned out of the direct path of said escaped electrons, and an auxiliary electrode positioned in the path of said escaped electrons, means to maintain said auxiliary electrode at a potential positive with respect to said source such that escaped electrons are drawn to said auxiliary electrode, means for biasing said control grid negatively with respect to said cathode such that only a portion of the electrons originating in said source have access to said primary anode, means connecting said auxiliary anode and said control electrode so that increase in the auxiliary anode potential with bombardment by escaped electrons decreases the negative bias on said control electrode, and electromagnetic means to deflect the escaped electrons from their path to said auxiliary electrode and onto said auxiliary anode.

2. In combination, an electronic device comprising a primary electron source, a pair of primary electron targets, one of said targets having an aperture for the escape of some primary electrons therethrough, a control electrode between said source and said targets and having separate portions to control the electron flow between said source and each target, an auxiliary anode to emit secondary electrons in ratio greater than unity when bombarded with escaped primary electrons, and an auxiliary electrode in the normal path of said escaped electrons to attract such escaped electrons thereto, means to bias the control electrode such that some electron flow occurs between said source and said apertured target and said auxiliary electrode but none occurs between said source and the second target, means connecting said auxiliary anode and said control electrode so that change of potential on said auxiliary anode upon bombardment and cessation of bombardment thereof with primary electrons changes the potential of said control electrode in the same relative direction as that of the auxiliary anode, and means to deflect the escaped electrons from their normal path to said auxiliary electrode and onto said auxiliary anode, whereby, if the escaped electrons are so deflected, the

change in auxiliary anode potential alters the control electrode potential sufficiently to establish electron flow between said source and said second target.

3. In combination, an electronic device comprising a primary electron source, a primary anode for receiving primary electrons from said source and having an aperture through which some of the electrons may escape, an auxiliary anode to emit secondary electrons in ratio greater than unity when it is bombarded with said escaped electrons, a control electrode between said source and said primary anode, and an auxiliary electrode in the path of the escaped electrons and normally deflecting the escaped electrons onto the auxiliary anode, means to bias said control electrode so that a small number only of primary electrons flow to said primary anode and escape through the aperture therein, means connecting said auxiliary anode and said control electrode so that when primary electrons bombard the auxiliary anode and its potential rises, the bias on the control electrode is overcome sufficiently to enable a large number of primary electrons to flow to said primary anode, and means connected to said source and said primary anode to produce, when said large number of electrons flow between said source and said primary anode, a magnetic field for deflecting the escaped primary electrons away from said auxiliary anode.

4. In combination, an electronic device comprising a primary electron source, a primary anode containing an aperture through which some of the primary electrons originating in said source may escape, a control electrode between said source and anode, an auxiliary anode to emit secondary electrons in ratio greater than unity when bombarded with escaped primary electrons, said auxiliary anode being positioned out of the direct path of the escaped electrons, and an auxiliary electrode positioned in the path of said escaped electrons, means to maintain said auxiliary electrode at a potential positive with respect to said source such that escaped electrons are drawn to said auxiliary electrode, a load circuit connected to said primary anode and said primary source, a signal input circuit connected to said control electrode and said primary source, means for biasing said control electrode negatively with respect to said source such that only a portion of the electrons originating at said source have access to said primary anode whereby substantially none of the signal that may appear in said input circuit is reproduced in said load circuit, means connecting said auxiliary anode and said control electrode so that increase in the auxiliary anode potential with bombardment by escaped electrons decreases the negative bias on said control electrode such that a substantial primary electron flow to said primary anode is established whereby the signal appearing in the input circuit is reproduced in the load circuit, and electromagnetic means to deflect the escape electrons from their path to said auxiliary electrode and onto said auxiliary anode.

5. In combination, an electronic device comprising a primary electron source, a pair of primary electron targets, one of said targets having an aperture for the escape of some primary electrons therethrough, a control electrode between said source and said targets to control the electron flow between said source and each target, an auxiliary anode to emit secondary electrons in ratio greater than unity when bombarded with escaped primary electrons and an auxiliary electrode in the normal path of said escaped electrons to attract such escaped electrons thereto, means to bias the control electrode such that some electron flow occurs between said source and said apertured target and said auxiliary electrode but none occurs between said source and the second target, means connecting said auxiliary anode and said control electrode so that change of potential on said auxiliary anode upon bombardment and cessation of bombardment thereof with primary electrons changes the potential of said control electrode in the same relative direction as that of the auxiliary anode, and means to deflect the escaped electrons from their normal path to said auxiliary electrode and onto said auxiliary anode, whereby, if the escaped electrons are so deflected, the change in auxiliary anode potential alters the control electrode potential sufficiently to establish electron flow between said source and said second target.

6. The combination of claim 5 in which an electric wave input circuit is connected to said control electrode and said primary source, and a load circuit is connected to said primary source and said second target.

7. In combination, an electronic device comprising a primary electron source, a pair of primary electron targets, one of said targets having an aperture for the escape of some primary electrons therethrough, a control electrode between said source and said targets to control the electron flow between said source and each target, an auxiliary anode to emit secondary electrons in ratio greater than unity when bombarded with escaped primary electrons and an auxiliary electrode in the normal path of said escaped electrons to attract such escaped electrons thereto, means for impressing a signal wave between said control electrode and said primary source, a utilization circuit connected to said primary source and the second of said targets, means to bias the control electrode such that some electron flow occurs between said primary source and said apertured target and said auxiliary electrode but none occurs between said source and the second target, means connecting said auxiliary anode and said control electrode so that change of potential on said auxiliary anode upon bombardment and cessation of bombardment thereof with primary electrons changes the potential of said control electrode in the same relative direction as that of the auxiliary anode, and means to deflect the escaped electrons from their normal path to said auxiliary electrode and onto said auxiliary anode, whereby, if the escaped electrons are so deflected, the change in auxiliary anode potential alters the control electrode potential sufficiently to establish electron flow between said source and said second target, thereby enabling the transfer of signal wave appearing at the primary source and control electrode to the utilization circuit through the triode structure comprising the primary source, the control electrode and said second target.

8. The combination of claim 3 in which the means connected to said primary source and said primary anode to produce the magnetic field for deflecting the escaped primary electrons away from the auxiliary anode includes a coil to be traversed by electrons flowing between said source and said primary anode.

9. The combination of claim 3 in which the

means connected to said primary source and said primary anode to produce the magnetic field for deflecting the escaped primary electrons away from said auxiliary anode includes a coil to be traversed by electrons that flow between said source and said primary anode, and a frequency-determining condenser connected in parallel with said coil.

10. The combination of claim 3 in which the means connected to said source and said primary anode to produce the magnetic field for deflecting the escaped primary electrons away from said auxiliary anode includes a coil to be traversed by electrons that flow between said source and said primary anode, a frequency-determining condenser connected in parallel with said coil, and a load circuit coupled to said coil.

11. The combination of claim 1 in which a signal wave input circuit is connected to said primary source and said control electrode and a load circuit is connected to said primary source and said primary anode.

12. The combination of claim 1 in which said electromagnetic means comprises a coil which when traversed by current produces magnetic flux in a direction parallel to the axis of the device.

13. The combination of claim 1 in which said electromagnetic means comprises a coil which when traversed by current produces magnetic flux in a direction parallel to the axis of said device, current flow in one direction only through the coil being effective to produce flux deflecting the escaped electrons onto the auxiliary anode.

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