Jan. 8, 1952 H. C. THOMPSON 2,581,612

ELECTRON DISCHARGE DEVICE OF THE BEAM DEFLECTION TYPE

Filed Oct. 20, 1948 3 Sheets-Sheet 1

Fig. 1.

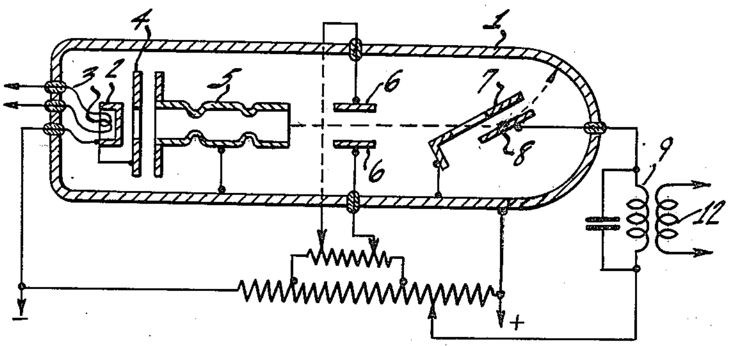


Fig. 2.

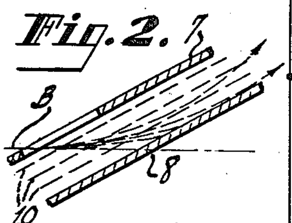
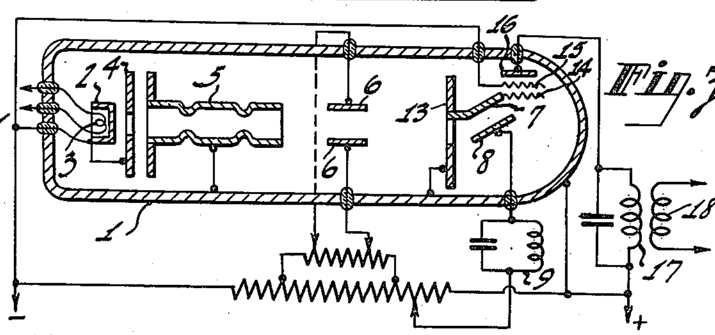


Fig. 3.



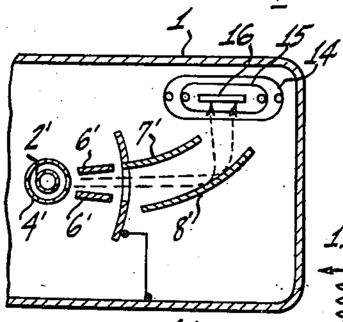


Fig. 4.

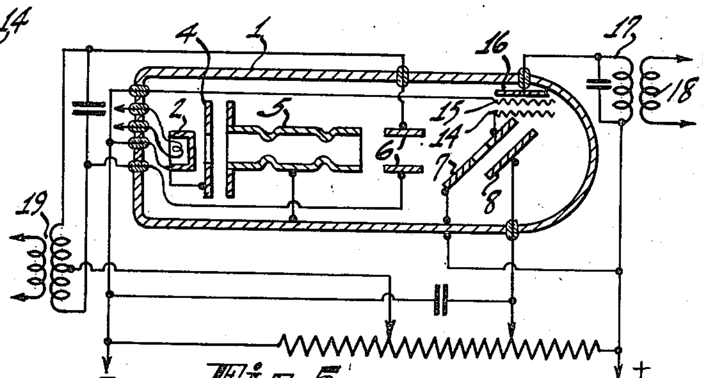
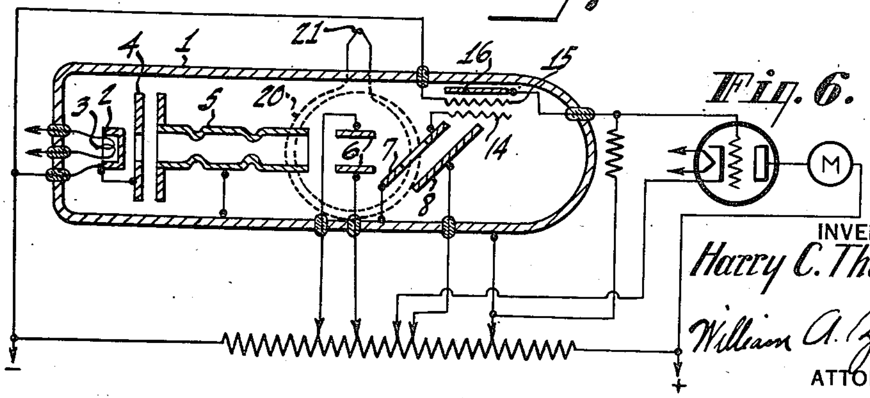


Fig. 5.

Fig. 6.



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Jan. 8, 1952 H. C. THOMPSON 2,581,612

ELECTRON DISCHARGE DEVICE OF THE BEAM DEFLECTION TYPE

Filed Oct. 20, 1948 3 Sheets-Sheet 2

Fig. 7.

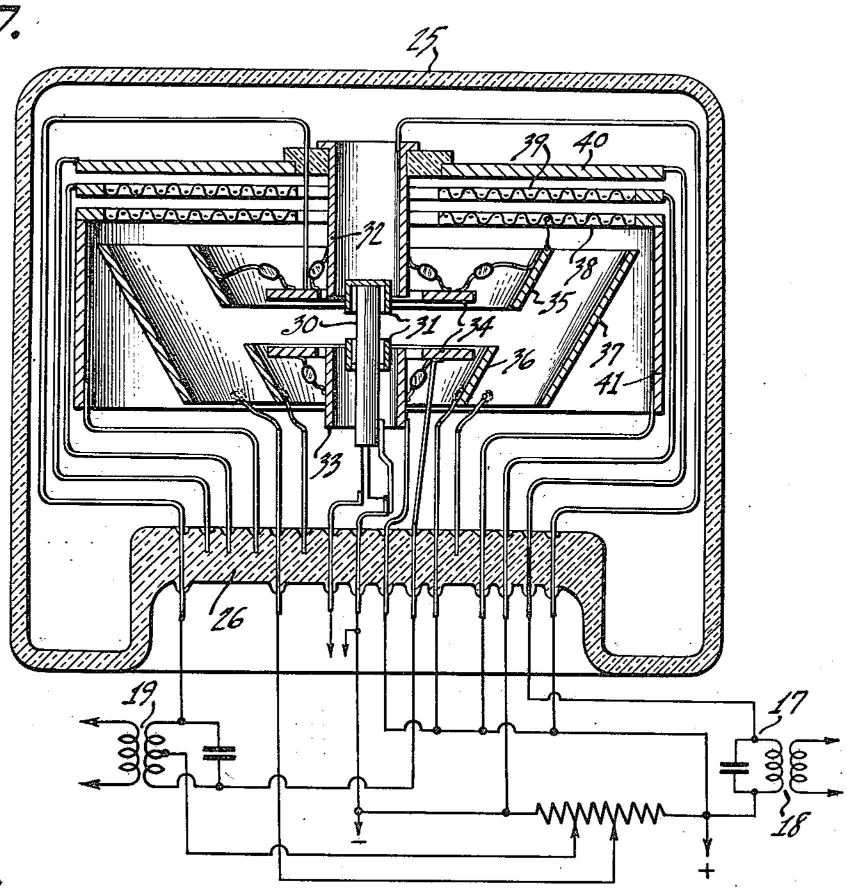

Fig. 8.

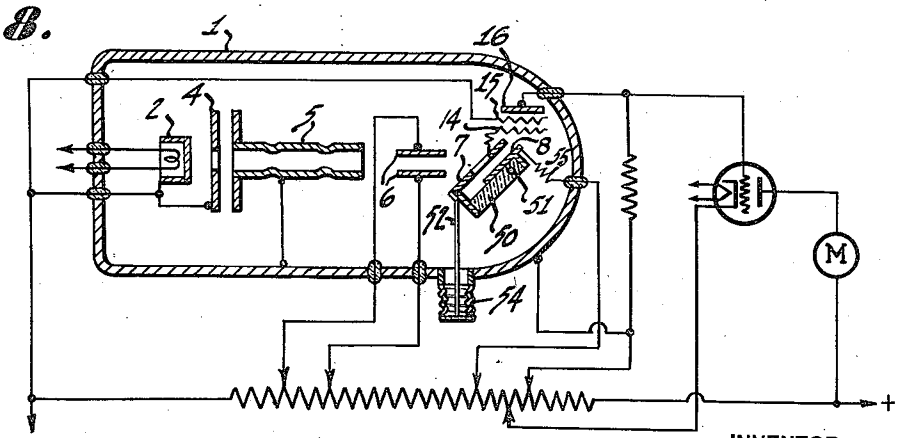

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Fig. 9.

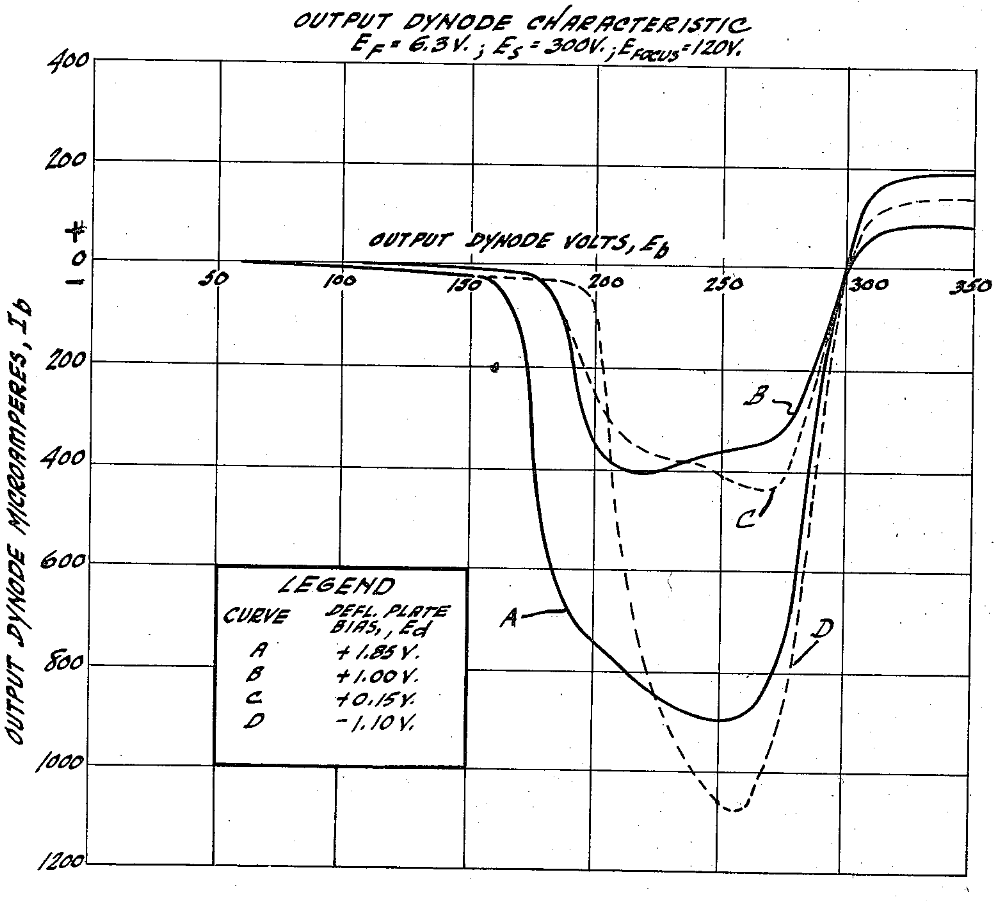
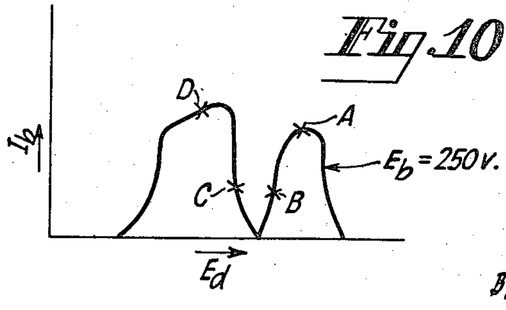


Fig. 10



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Patented Jan. 8, 1952

2,581,612

UNITED STATES PATENT OFFICE

2,581,612

ELECTRON DISCHARGE DEVICE OF THE BEAM DEFLECTION TYPE

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Application October 20, 1948, Serial No. 55,502

21 Claims. (Cl. 315—12)

1

My invention relates to electron discharge devices and associated circuits, particularly to such devices utilizing a beam of electrons directed toward an output electrode system, said beam and system having relative transverse movement with respect to each other.

In previous devices involving the transfer or switching of an electron beam from incidence on one electrode to incidence on another, the transconductance or ratio of current change to magnitude of the deflecting voltage is dependent upon the concentration of current in the beam at the target from which the beam was being deflected. Hitherto it has been necessary to focus the beam as narrowly as possible on the target and to align the edge of the target precisely with respect to the mid-plane of the beam. In one type of device of this kind a two hundred microampere beam has been focused on a five thousandths inch diameter intercepting wire from which it is deflected on to another electrode. Tubes of this kind have hitherto required high current concentrations in the beam, precise focusing thereof, and precise mechanical alignments in order to obtain high transconductance. High transconductance characteristics require a deflecting device in which precise mechanical alignments have been required.

In the present invention bringing the beam to a focus is not essential to obtain maximum possible transconductance. A parallel beam is preferred and it may have a considerable cross-section at the region of rejection instead of being extremely narrow as heretofore. The beam is not divided by an aligned edge during its transfer but is rejected as a whole from the surface of a target at a region remote from its edges. The mechanism of the rejection is entirely novel in principle since it occurs because the component of electron velocity normal to the target surface is reduced to zero at the critical target potential by the previous passage of the electron through a retarding field, thereby making it impossible for the electron to reach the target surface at or slightly below such critical potential of the target. It is known that an anode toward which electrons are normally directed cuts off or rejects the electron flow when the anode is near zero or cathode potential. In the present device a similar type of cut-off or rejection of electron flow is made to occur at an anode or target at any desired positive potential. To do this the electron beam is made to approach a target whose surface is acutely inclined to the initial beam direction through a retarding electric field whose equipotential surfaces are parallel to the target.

2

It is an object of my invention to provide an improved electron discharge device and associated circuits, more particularly an improved device employing a beam of electrons which is deflected relative to an output electrode system.

It is another object of my invention to provide such a device which is capable of using larger currents at low voltages than now possible with similar devices.

A still further object of my invention is to provide such a device which gives high transconductance.

A still further object of my invention is to provide such a device in which the need for precise alignment of the electrodes is obviated.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 is a schematic longitudinal section of an electron discharge device made according to my invention and its associated circuits; Fig. 2 is a schematic diagram showing the principles of my invention; Fig. 3 is a modification of the device and circuit shown in Fig. 1; Figs. 4 to 8, inclusive, are still further modifications of the electron discharge device and associated circuits shown in Fig. 1; and Figs. 9 and 10 are graphs showing the operating characteristics of the device under certain conditions.

Fig. 1 shows my invention embodied in a simple form in which the primary beam is collected in part by the metallic envelope and the output is taken from the anode (or dynode). The tube comprises an elongated metallic envelope 1 in which are mounted, in order, from left to right along the longitudinal axis, a conventional electron gun structure composed of a cathode 2 heated by a heater 3 and connected to an apertured cathode shield 4, an apertured accelerating and beam-defining electrode 5, a pair of deflecting plates 6 on opposite sides of the beam path, and an output electrode system comprising an apertured field electrode 7 and a target or collector electrode 8.

In accordance with my invention, the two parallel electrodes 7 and 8 are mounted in the envelope 1 at an acute angle to the beam path. For optimum results, this angle is approximately 30°.

In the operation of the embodiment of Fig. 1, the accelerating electrode 5 and electrode 7 are connected to a source of high potential, for example, about 300 volts, preferably by grounding the electrodes internally to the metallic envelope 1 and connecting the envelope to the potential source, and the target or collector 8 is connected through a tuned circuit 9 to a lower potential source, the cathode 2 being at zero potential, as shown. The deflecting plates 6 are connected to a biasing potential as shown, to provide means for adjusting the angle between the beam and the surfaces of electrodes 7 and 8.

The operation of the device may be better understood by reference to Fig. 2 which shows on a larger scale the parallel electrodes 7 and 8 with the parallel equipotential surfaces therebetween indicated by dash lines 10. Several paths of the electron beam B corresponding to different potentials applied to the target 8, with the field electrode 7 maintained at a constant potential, are shown by dotted lines. In its travel between the aperture of electrode 7 and the target 8 each electron has its component of velocity normal to the target 8 reduced while its component of velocity parallel to the target surface remains undiminished. When the potential of the target 8 is nearly equal to that of the electrode 7, the beam is entirely collected by the target. As the target potential is reduced, the beam is deflected more and more until a critical potential is reached, for a particular angle of inclination, electrode spacing, beam velocity and potential of electrode 7, at which the beam fails entirely to reach the target, but instead, grazes the target and continues along a new beam path to a separate collector which in Fig. 1 is the tube envelope. For one tube with electrode 7 at 300 volts this critical potential was found to be about 180 volts.

At this critical or grazing target potential the current to the target is extremely sensitive to:

1. Change of initial direction of the beam by the voltage between the deflection plates (electrodes 6 in Fig. 1);

2. Change of initial direction of the beam by a transverse magnetic field;

3. Change of target potential;

4. Change of potential of electrode 7;

5. Change of inclination of the target and its associated retarding field by mechanical means.

It will be apparent that in 5 the change is really a change of initial direction as in 1 and 2, but by mechanical means.

Two main classes of applications of the properties of my device are:

A. Applications which utilize the current changes in the target itself, as illustrated in Fig. 1; and

B. Applications which utilize the current changes of another electrode which receives the beam deflected away from the target, illustrated in Figs. 3–8, inclusive.

In class A the target must have a secondary emission ratio greater than unity since the performance is dependent upon the existence of a reversed current from the target, that is, upon a net loss of electrons therefrom. In class B the secondary emissivity of the target may have any value without altering the performance substantially.

In the embodiment shown in Fig. 1, the initial direction of the beam is adjusted by the voltage on the deflecting plates 6, the inclination of electrodes 7 and 8 and the potential of electrode 7 are fixed, and the potential of the target 8 is periodically varied by the tuned circuit 9, producing a variable target current.

The target 8 is a good secondary emitter, or is coated with a good secondary emitting material, whereby its voltampere characteristic has a negative resistance in the cut-off region. I have observed that the negative resistance is as low as 12,000 ohms with a 200 microampere beam and I estimate that this represents a negative conductance 40 to 50 times as great as that obtained from the same secondary emitting surface in the absence of the cut-off effect of my invention. This makes the present device capable of oscillating at much higher frequencies than the ordinary secondary emission dynatron. Electrode 7 serves as a field electrode and as a collector of secondaries from the target 8. The negative conductance property of the target at its critical potential causes circuit 9 to oscillate, which periodically varies the target potential and causes the primary beam to be deflected to and fro between the envelope and the target. Power is taken directly from the target by means of output circuit 12 coupled to circuit 9.

Fig. 3 shows a modification of the device of Fig. 1 which combines the features of classes A and B discussed above. The inclined electrode 7 is carried by an apertured plate 13 at right angles to the beam path. The inclined target 8 parallel to electrode 7 is connected to a tuned circuit 9, as in Fig. 1. In this form, however, the output is taken from a separate electrode system positioned in the path of the deflected primary beam and including a screen grid 14 connected to electrode 7, a suppressor grid 15 connected to cathode 2 and a collector electrode 16 connected to a tuned circuit 17 coupled to an output circuit 18. The other circuit connections are the same as in Fig. 1.

In the operation of the oscillator of Fig. 3, with the target at the critical potential, the oscillatory target potential deflects the beam toward and away from the output electrode system 14—16, producing a corresponding oscillatory current to the collector 16 and the output circuit. An advantage of this form over that of Fig. 1 is that the frequency of frequency-determining circuit 9 is only slightly affected by the character of the load on the output circuit 18.

Fig. 4 shows a means of utilizing a diverging electron beam from a cathode 2′ by causing it to enter a retarding field with curved equipotential surfaces between equidistant (i. e. parallel) curved electrodes 7′ and 8′. The curvature of the electrodes is such that each successive element thereof makes the same acute angle with each corresponding element of the divergent beam, so that each component of the diverging beam is retarded equally and rejected at the same potential of electrode 8′. An output electrode system is shown wherein an anode 16 is surrounded by a suppressor grid 15 and a screen grid 14.

Fig. 5 shows the tube of Fig. 3 used as an amplifier. The potential of the target 8 is maintained at its critical potential for zero deflection of the beam, and the beam is deflected laterally by means of an alternating signal voltage applied to input transformer 19 connected with deflection plates 6. Thus, the angle between the beam and the target is varied, producing a corresponding variation in the current rejected by the target and delivered to the output electrode 16.

In Fig. 6 the beam is deflected by a transverse magnetic field produced by a coil 20 mounted adjacent the tube in the region of the plates 6, which are here used only for adjusting the initial beam direction, as in Figs. 1 and 3. The magnetic field may be generated by a thermocouple voltage source 21; and this arrangement is advantageous in general for amplifying sources having low impedance, because of the inherently low impedance of the input coil.

Fig. 7 shows a modification of Fig. 5 employing a radial beam. A cylindrical vitreous envelope 25 is provided with a reentrant end portion or base 26 on which all of the electrodes are mounted. All of the electrodes have surfaces of revolution coaxial to the axis of the envelope. An elongated central cathode 30, carrying spaced cathode shields 31, is surrounded by a pair of tubular accelerating electrodes 32 and 33 spaced apart to form an annular slot to pass the radial beam from the cathode. Two apertured-disc deflecting plates 34 are located on each side of the beam outside the accelerating electrodes. The plates 34 are in turn surrounded by a pair of spaced frusto-conical rings 35 and 36 and a frusto-conical target electrode 37. The opposed curved surfaces of the frusto-conical rings 35 and 36 and the target 37 are equi-distant and parallel, as in the other forms of my invention. Adjacent the upper sides of the conical electrodes 35 and 37 are mounted a screen electrode 38, a suppressor electrode 39 and a collector anode 40, in the form of centrally apertured planar members. The screen electrode 38 is carried by a tubular member which also serves as a shield for the target 37. As shown, the electrodes 30, 33, 34 (lower), 37, 41, 39 and 40 are mounted directly on the base 26, while the electrodes 32, 34 (upper), and 35 are insulatedly mounted on the anode 40. Where necessary, the electrode supporting rods are sealed through the base 26 to serve as lead-in terminals. The circuit and method of operation in Fig. 7 is the same as that of Fig. 5.

Fig. 8 illustrates a modification of the device of Fig. 1 in which the angle between the beam and the target can be changed, to vary the cutoff characteristic, by mechanical means accessible externally of the envelope. In this tube the target 8 and apertured electrode 7 are mounted in spaced parallel relation on an insulating block 50 which is pivotally mounted in the envelope on an axis 51 at right angles to the plane of Fig. 8. To provide means for slightly rotating the movable assembly about its pivot from outside the tube, a rod or link 52 attached to the assembly is flexibly sealed through the envelope 1 by means of a tubular bellows member 54, as shown. Thus, mechanical displacements of the bellows 54 and link 52 produce corresponding changes in the current to the anode 16 which are amplified for any purpose desired. The link 52 may serve as the potential lead for electrode 7. A flexible conductor 55 is provided in the target voltage lead.

Fig. 9 shows the output currents obtained for a particular tube, as shown in Fig. 1 having a secondary emissive target or dynode 8, as the dynode potential was varied from about 50 volts to 350 volts, with the potential of electrode 7 at 300 volts. The four curves A, B, C and D represent the results obtained at four different values of deflecting plate bias, as indicated in the legend. Each of the large loops of the curves represents the net loss of secondaries from the dynode 8. The abrupt fall of current as the potential of the dynode is decreased toward 200 volts in curve D is caused by the turning away of the primary electron beam from the dynode until it is no longer incident thereon and no longer produces secondaries therefrom. At 300 volts the primary current is about equal to the reverse secondary current, producing a zero current in the dynode lead.

Fig. 10 shows the variation in dynode current when the deflecting plate bias was varied with 250 volts on the dynode 8 and 300 volts on electrode 7. The points A, B, C and D correspond to the four curves of Fig. 9.

As stated above, the best results are produced when the angle between the surfaces of electrodes 7 and 8 and the beam axis is about 30°. This angle is not critical and may be made somewhat greater or less than 30°. However, if the angle is made more acute (smaller), the useful operating range of potentials of the target is decrease because of the effectiveness of a given change in target potential is greater. If the angle is made less acute (larger), the concentration of current at the region of impact is higher, and the emission of secondaries is smaller, in the case of a secondary emission target, and the sensitivity of the device to changes in target potential or inclination is reduced.

In my co-pending application entitled "Electron Discharge Devices of the Beam Deflection Type," Serial No. 55,501, filed concurrently herewith, now U. S. Patent No. 2,559,524, granted July 3, 1951, I have disclosed and claimed an electrode mount assembly for a beam deflection tube with an electron multiplier output system, which assembly may be used in the discharge devices illustrated schematically in Figures 1 through 6 and 8 of the instant application.

While I have indicated several specific embodiments of my invention, it will be understood that my invention is by no means limited to the exact forms illustrated or use indicated, but that many variations may be made in the particular structure used and the purposes for which it is employed without departing from the scope of the invention as set forth in the appended claims.

I claim:

1. An electron discharge device comprising electron gun means for supplying and directing a beam of electrons along a beam path, and electrode means including a first collector electrode having a surface extending across said beam path at an acute angle thereto, a field electrode positioned adjacent said first collector electrode and having a surface facing and parallel to said surface of said first collector electrode, means for applying a positive potential to said field electrode, means for applying a substantially lower positive potential to said first collector electrode, whereby during operation of said device said beam traverses a retarding electric field having parallel equipotential surfaces extending at said acute angle to the beam path and at least a part of said beam is deflected by said field away from said first collector electrode, and a second collector electrode insulated from the other electrodes and located beyond said first collector and field electrodes in position to receive electrons of said beam deflected from said first collector electrode.

2. An electron discharge device according to claim 1, including means for adjusting the potentials applied to said first collector and field electrodes to cause said beam to graze the surface of said first collector electrode.

3. An electron discharge device comprising electron gun means for supplying and directing a beam of electrons along a beam path, and electrode means including a first collector electrode

having a surface extending across said beam path at an acute angle thereto, a field electrode positioned adjacent said first collector electrode and having a surface facing and parallel to said surface of said first collector electrode, means for applying a positive potential to said field electrode, means for applying a substantially lower positive potential to said first collector electrode, whereby during operation of said device said beam traverses a retarding electric field having parallel equipotential surfaces extending at said acute angle to the beam path and at least a part of said beam is deflected by said field away from said first collector electrode, a second collector electrode insulated from the other electrodes and located beyond said first collector and field electrodes in position to receive electrons of said beam deflected from said first collector electrode, and means for periodically varying the potential of one of said first collector and field electrodes to cause said beam to be periodically shifted between said two collector electrodes.

4. An electron discharge device comprising electron gun means for supplying and directing a beam of electrons along a beam path, and electrode means including a first collector electrode having a surface extending across said beam path at an acute angle thereto, a field electrode positioned adjacent said first collector electrode and having a surface facing and parallel to said surface of said first collector electrode, means for applying a positive potential to said field electrode, means for applying a substantially lower positive potential to said first collector electrode, whereby during operation of said device said beam traverses a retarding electric field having parallel equipotential surfaces extending at said acute angle to the beam path and at least a part of said beam is deflected by said field away from said first collector electrode, a second collector electrode insulated from the other electrodes and located beyond said first collector and field electrodes in position to receive electrons of said beam deflected from said first collector electrode, and means for adjusting the acute angle between said beam path and said first collector electrode to cause said beam to graze the surface of said electrode.

5. An electron discharge device comprising electron gun means for supplying and directing a beam of electrons along a beam path, and electrode means including a first collector electrode having a surface extending across said beam path at an acute angle thereto, a field electrode positioned adjacent said first collector electrode and having a surface facing and parallel to said surface of said first collector electrode, means for applying a positive potential to said field electrode, means for applying a substantially lower positive potential to said first collector electrode, whereby during operation of said device said beam traverses a retarding electric field having parallel equipotential surfaces extending at said acute angle to the beam path and at least a part of said beam is deflected by said field away from said first collector electrode, a second collector electrode insulated from the other electrodes and located beyond said first collector and field electrodes in position to receive electrons of said beam deflected from said first collector electrode, and means for periodically varying the acute angle between said beam path and said first collector electrode to cause said beam to be periodically shifted between said two collector electrodes.

6. An electron discharge device having electron gun means for supplying and directing an electron beam along a beam path, a first deflector electrode having a surface extending across said beam path at an acute angle thereto, a second electrode adjacent said first electrode and having a surface facing and parallel to said surface of the first electrode, a collector electrode insulated from the other electrodes and located beyond said first and second electrodes in position to receive electrons deflected from said first electrode, and other deflecting electrodes positioned on opposite sides of the beam path and between said electron gun means and said first and second electrodes.

7. An electron discharge device including electron gun means for supplying and directing a beam of electrons along a beam path, a deflector electrode in the path of said beam and having a surface extending across said beam path at an acute angle thereto, a second electrode positioned adjacent said deflector electrode and having a surface facing and parallel to said surface of the deflector electrode and having an aperture registering with the beam path, and a collector electrode insulated from the other electrodes and located beyond said electrodes in position to receive electrons deflected from said deflector electrode.

8. An electron discharge device including electron gun means for supplying and directing a beam of electrons along a beam path, a pair of oppositely disposed electrodes on opposite sides of said beam path, a third electrode in the path of said beam of electrons and having a surface extending across said path at an acute angle thereto, and a fourth electrode positioned adjacent said third electrode and having a surface facing and parallel to said surface of the third electrode and having an aperture registering with the beam path, and a collector electrode insulated from the other electrodes and located beyond said third and fourth electrodes in position to receive electrons deflected from said third electrode.

9. An electron discharge device having electron gun means for supplying and directing an electron beam along a beam path, a first electrode in the path of said beam having a surface extending across said beam path at an acute angle thereto, a second electrode adjacent said first electrode and having a surface facing and parallel to the surface of the first electrode, and an electrode system insulated from the other electrodes and located beyond said first and second electrodes in position to receive electrons deflected from said first electrode and comprising, in order, a screen electrode, a suppressor electrode and a collector electrode.

10. An electron discharge device having electron gun means for supplying and directing an electron beam along a beam path, a first electrode in the path of said beam having a surface extending across said beam path at an acute angle thereto, a second electrode adjacent said first electrode and having an aperture through which the beam path lies, said second electrode having a surface facing and parallel to the surface of the first electrode, and an electrode system insulated from the other electrodes and located beyond said first and second electrodes in position to receive electrons deflected from said first electrode and comprising, in order, a screen electrode, a suppressor electrode and a collector electrode.

11. An electron discharge device having elec-

tron gun means for supplying and directing an electron beam along a beam path, a first electrode in the path of said beam having a plane surface extending across said beam path at an acute angle thereto, a second electrode adjacent said first electrode and having an aperture through which the beam path lies, said second electrode having a surface facing and parallel to the surface of the first electrode, and an electrode system insulated from the other electrodes and located beyond said first and second electrodes in position to receive electrons deflected from said first electrode and comprising, in order, a screen electrode, a suppressor electrode and a collector electrode, and deflecting electrodes positioned on opposite sides of the beam path and between said electron gun means and said first and second electrodes.

12. An electron discharge device including electron gun means for supplying a beam of electrons along a beam path, a first electrode in the path of said beam of electrons and having a secondary-emissive surface extending across said beam path at an acute angle thereto, a second electrode positioned between said electron gun means and said first electrode and having a surface facing and parallel to said secondary emissive surface and having an aperture registering with the beam path, a collector electrode insulated from the other electrodes and located beyond said electrodes in position to receive deflected electrons of said beam upon the application of deflecting voltages to said first and second electrodes, means including an oscillating circuit for applying alternating voltages to said first electrode, output means connected to said collector electrode, and means for applying positive voltages to said collector electrode and said second electrode and a substantially lower positive voltage to said first electrode.

13. An electron discharge device having an electron gun means for supplying, forming and directing an electron beam consisting of diverging elements, a first electrode having a curved surface extending across said beam path so that each successive element of said curved surface makes the same acute angle with each corresponding element of said diverging beam directed thereat, a second electrode adjacent said first electrode and having a curved surface facing and parallel to said curved surface of said first electrode, and a collector electrode insulated from the other electrodes and located beyond said first and second electrodes in position to receive electrons deflected from said first electrode.

14. An electron discharge device having electron gun means for supplying and directing an electron beam along a beam path, a first electrode in the path of said beam having a plane surface extending across said beam path at an acute angle thereto, a second electrode adjacent said first electrode and having an aperture through which the beam path lies, said second electrode having a surface parallel to the surface of the first electrode, and an electrode system insulated from the other electrodes and located beyond said first and second electrodes in position to receive electrons deflected from said first electrode and comprising, in order, a screen electrode, a suppressor electrode and a collector electrode, and means for deflecting said beam including means for generating a magnetic field transverse to the beam path.

15. An electron discharge device having electron gun means for supplying and directing an

electron beam along a beam path, a first electrode in the path of said beam having a plane surface extending across said beam path at an acute angle thereto, a second electrode adjacent said first electrode and having an aperture through which the beam path lies, said second electrode having a surface facing and parallel to the surface of the first electrode, and an electrode system insulated from the other electrodes and located beyond said first and second electrodes in position to receive electrons deflected from said first electrode and comprising, in order, a screen electrode, a suppressor electrode and a collector electrode, deflecting electrodes positioned on opposite sides of the beam path and between said electron gun means and said first and second electrodes, and means responsive to temperature conditions for deflecting said beam including means for generating a magnetic field transverse to the beam path in the region of said deflecting electrodes.

16. An electron discharge device including a cathode, a first electrode surrounding said cathode and having an annular aperture extending therethrough, oppositely disposed ring-like members lying in parallel planes extending transversely through said cathode adjacent the edges of said annular aperture, a cone-shaped second electrode surrounding said first electrode and having an annular aperture registering with the annular aperture in said first electrode, another cone-shaped electrode surrounding said second electrode, a flat plate-like collector electrode extending transversely of said cathode and adjacent said cone-shaped electrodes, and plate-like screen and suppressor electrodes positioned between said plate-like collector electrode and said cone-shaped electrodes and disposed parallel to said collector electrode.

17. An electron discharge device having electron gun means for supplying and directing an electron beam along a beam path, a first electrode in the path of said beam having a plane surface extending across said beam path at an acute angle thereto, a second electrode closely adjacent said first electrode and having an aperture through which the beam path lies, said second electrode having a surface facing and parallel to the surface of the first electrode, and an electrode system insulated from the other electrodes and located beyond said first and second electrodes in position to receive electrons deflected from said first electrode and comprising, in order, a screen electrode, a suppressor electrode and a collector, said first and second electrodes being pivotally mounted, and means for rotating said first and second electrodes about said pivot to vary said acute angle.

18. An electron discharge device having an envelope containing electron gun means for supplying and directing an electron beam along a beam path, a first electrode in the path of said beam having a plane surface extending across said beam path at an acute angle thereto, a second electrode closely adjacent said first electrode and having an aperture through which the beam path lies, said second electrode having a surface facing and parallel to the surface of the first electrode, and an electrode system insulated from the other electrodes and located beyond said first and second electrodes and comprising, in order, a screen electrode in position to receive electrons deflected from said first electrode, a suppressor electrode and a collector, said first and second electrodes being pivotally mounted as a unit in

said envelope, and externally-operable means for rotating said unit about its pivot to vary said acute angle comprising a flexible member forming a portion of said envelope and a mechanical link within said envelope connecting said unit to said flexible portion.

19. An electron discharge device comprising electron gun means for supplying and directing a beam of electrons along a beam path, and electrode means including a first collector electrode having a surface extending across said beam path at an acute angle thereto, a field electrode positioned adjacent said first collector electrode and having a surface facing and parallel to said surface of said first collector electrode, means for applying a positive potential to said field electrode, means for applying a substantially lower positive potential to said first collector electrode, whereby during operation of said device said beam traverses a retarding electric field having parallel equipotential surfaces extending at said acute angle to the beam path and at least a part of said beam is deflected by said field away from said first collector electrode, a second collector electrode insulated from the other electrodes and located beyond said first collector and field electrodes in position to receive electrons of said beam deflected from said first collector electrode, and means for changing the acute angle between said beam path and said first collector electrode to change the proportion of said beam which is deflected away from said first collector electrode.

20. An electron discharge device including electron gun means for supplying and directing a beam of electrons along a beam path, a deflector electrode in the path of said beam and having a surface extending across said beam path at an acute angle thereto, a second electrode positioned adjacent said deflector electrode and having a surface facing and parallel to said surface of the deflector electrode, and a collector electrode insulated from the other electrodes and located beyond said electrodes in position to receive electrons deflected from said deflector electrode.

21. An electron discharge device according to claim 20, further including means located between said electron gun means and said deflector electrode for deflecting the beam relative to said deflector electrode.

HARRY C. THOMPSON.

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