

Feb. 20, 1940.

N. M. RUST ET AL

2,190,735

ELECTRON DISCHARGE DEVICE

Filed Feb. 2, 1938

Fig. 1

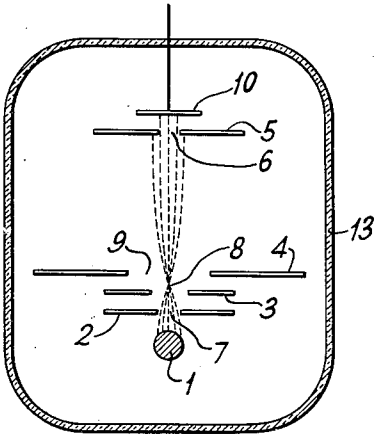


Fig. 2

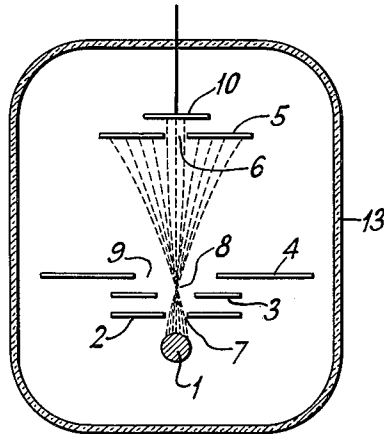


Fig. 3

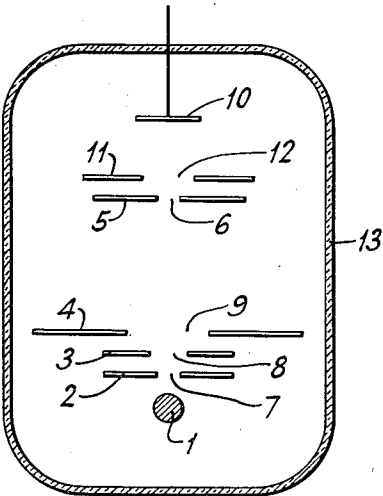
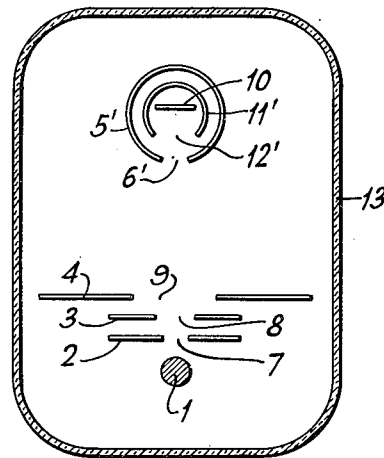


Fig. 4



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2,190,735

ELECTRON DISCHARGE DEVICE

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Application February 2, 1938, Serial No. 188,244
In Great Britain February 11, 1937

4 Claims. (Cl. 250-162)

This invention, which is for improvements in or modifications of the invention contained in our co-pending application No. 115,279 filed December 11, 1936, relates to electron discharge devices, more particularly to such devices of the so-called electron beam type, i. e., of the type wherein the electron discharge partakes more of the nature of the discharge of a cathode ray tube than of the nature of a discharge in an ordinary electron discharge tube as at present in common use.

The electron beam tube described in the co-pending application identified above is provided (in addition to the anode and the electron gun system for projecting a beam of electrons towards the anode and for controlling the intensity of the beam) with a collector electrode on the side of the anode remote from the gun and the anode is so slotted or otherwise shaped and is so positioned that the amount of cross section of the beam intercepted by the anode may be varied by deflecting the beam or by varying its cross section at the anode, any portion of the beam not intercepted by the anode falling on the collector electrode. The valve may include means for deflecting the beam transversely of the anode.

Among the important advantages obtainable from electron beam tubes as described in the co-pending application is that it is possible to obtain anode voltage-anode current characteristic curves which become substantially flat from relatively small voltages—say about 50 volts—upwards even with anode currents as high as 30-40 milliamperes.

Among the constructions described in our co-pending application are constructions whereby these characteristic curves may be caused to have negative slopes the modus operandi of these constructions depending on the obtaining of a change in the size of the cross sectional area of the electron beam at the slotted anode (behind which is the collector electrode) as the voltage on the anode is changed. Our co-pending application illustrates such a construction wherein negatively sloping characteristics are obtained with this type of focussing control action.

The principal object of the present invention is to provide an electron discharge device of the beam type having negatively sloping characteristics which may be either of very slight slope or of very steep slope.

The novel features which we believe to be characteristic of our invention are set forth with particularity in the appended claims, but the invention itself will best be understood by refer-

ence to the following description taken in connection with the accompanying drawing in which Figures 1 and 2 are diagrammatic representations of one form of an electron discharge device embodying our invention under different voltage conditions, and Figures 3 and 4 are diagrammatic representations of modifications of an electron discharge device embodying our invention.

In certain circuit arrangements, for example in radio receiver circuits where high selectivity is required, it is frequently advantageous to obtain an operating anode voltage-anode current curve with a very slight negative slope over the whole curve between say 50 volts and 250 volts. For other cases very steep negative slopes may be required. The arrangements described in our co-pending application while giving negatively sloping characteristics, are not well adapted to give either very slight slopes or very steep slopes, nor is it possible to easily control the amount of slope.

Where a slight negative slope is required the tube (according to the present invention) is provided with a slotted anode in which the slot is substantially smaller in size than the slots in the other slotted electrodes of the valve. For example the slot in the slotted anode may be made of relatively short length or it may be replaced by a circular aperture. A circular aperture of about 0.5 to about 1 millimeter in diameter is approximately equivalent in results to a short slot about 1 to 2 millimeters long and about 0.5 millimeter wide. In general the use of a circular aperture placed at any point along the approximate electron beam "line focus" on the slotted anode is satisfactory. The result of using a small slot or aperture in the slotted anode is that while the change of focus which occurs as the anode voltage increases causes more and more current to miss the slotted anode and pass to the collector electrode, owing to the small size of the aperture in the slotted anode only a small amount of current will be by-passed for a relatively large change in anode voltage. In practice the collector anode should be maintained at a permanently higher voltage than the apertured or slotted anode in order to prevent the return of secondary electrons to the said apertured or slotted anode.

In Figures 1 and 2 are similar schematic views of one form of valve in accordance with this invention and adapted to give a small negative slope to the anode voltage-anode current characteristic. In these figures the electron beams

are represented in conventional manner by broken lines, Figure 1 showing the effect with a high anode voltage and Figure 2 showing the effect with a low anode voltage. In these figures the electron gun comprises a cathode 1, a control electrode 2, an accelerator anode 3, a screen suppressor electrode 4, an anode 5 whose slot 6 is, in accordance with this invention, made of substantially smaller size than the slots 7, 8, 9, in the other slotted electrodes 2, 3, 4 respectively, and final collector electrode 10. In both Figures 1 and 2 the lengths of the slots extend perpendicularly to the plane of the drawing.

Where negative sloping characteristics of large controllable negative slope are required the tubes are designed to rely for their operation more upon space charge considerations than upon beam focussing. Where a steep negative sloping characteristic is required the electron beam tube is (according to this invention) provided with a suppressor electrode which is slotted or apertured and is positioned between the slotted or apertured anode and the collector electrode.

In Figure 3 is shown a tube of this kind. Here, as before, the electrode system consists of a cathode 1, a slotted control electrode 2, with a slot 7, a slotted accelerator anode 3 with a slot 8 and a slotted screen suppressor electrode 4 with a slot 9, all of these electrodes being known per se in electron beam tubes. The electrodes are arranged in succession in the order stated close to one another with their apertures in register so that together they constitute a screened electron gun system capable of projecting an intensity controlled narrow jet or ribbon like beam of electrons. There is also provided a slotted anode 5 with a slot 6 and a collector electrode 10 behind the said slot 6. In accordance with this invention, however, there is provided between the two last mentioned electrodes 5 and 10 and adjacent the slotted anode 5, a second screen suppressor electrode 11 in the form of a plate with a slot 12 the said slot 12 being of approximately the same length as the slots in the other slotted electrodes but being wider than the slot 6 in the adjacent slotted anode 5.

In use the second suppressor electrode 11 is maintained at or near cathode potential and normal operating potentials are applied to all the other electrodes. The action of the second suppressor electrode 11 is to prevent electrons which have passed through the slot 6 in the slotted anode 5 to the collector electrode 10 returning to said slotted anode 5. In other words, the second suppressor electrode permits of quite low potentials being applied to the collector electrode 10 without any risk of secondary electrons returning to the slotted anode 5 which may be at an operating potential say between 50 and 250 volts. Nevertheless not all the current reaching the aperture 6 in the slotted anode 5 necessarily passes on to the collector electrode 10 because of space charge limitations in the space between these two electrodes. These space charge limitations depend on—

- (a) The beam current at the slot in the slotted anode 5.
- (b) The potential of the slotted anode 5.
- (c) The potential of the collector electrode 10.
- (d) The separation between the slotted anode 5 and the collector electrode 10, and
- (e) The potential on the second suppressor electrode 11.

In practice, with the second suppressor electrode 11 at cathode potential, the collector elec-

trode 10 at 5 to 100 volts, and the separation between these two electrodes at 2 to 5 millimeters, it is found that large currents will pass to the collector electrode 10 only when high potentials are applied to the slotted anode 5. At low values of slotted anode potential, the space charge causes much of the current to pass to the said slotted anode 5 and hence the current to this anode 5 falls as its potential rises and vice versa.

It is found that by varying the potential on the collector electrode 10 the steepness of the negative slope of the anode voltage-anode current characteristic can be varied over a wide range. At its steepest the slope may be equivalent to a negative resistance of only a few thousand ohms.

Obviously any negative slope arising from a focussing action in the tubes described in our co-pending application will be additive to that arising from space charge effects in the slotted anode collector electrode region and by using these two actions in conjunction, quite steep negative slopes can be obtained without (it will be observed) depending in any way upon unreliable or irregular secondary emission effects.

The various slotted electrodes employed in valves in accordance with this invention need not be, as they are in Figures 1, 2 and 3 all in the form of slotted flat plates, for other forms of slotted electrodes may be used, either in the gun or elsewhere. For example, the accompanying Figure 4 shows a valve which is like that of Figure 3 except that the collector electrode 10 is within a cylindrical second screen suppressor electrode 11' having a slot 12', this electrode being in turn within on anode 5' which is also of cylindrical form and has a slot 6'. In each case the electrodes are enclosed by an envelope 13.

While we have indicated the preferred embodiments of our invention of which we are now aware and have also indicated only one specific application for which our invention may be employed, it will be apparent that our invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of our invention as set forth in the appended claims.

What we claim as new is—

1. An electron discharge device having a cathode for emitting electrons and an apertured anode for receiving said electrons, and a collector electrode on the side of the anode opposite from said cathode, and a plurality of apertured electrodes including a control grid, an accelerating grid, and a screen grid positioned between the cathode and the apertured anode, all of said electrodes being positioned with the apertures in alignment, and an apertured suppressor electrode positioned between the apertured anode and the collector electrode.

2. An electron discharge device having a cathode for emitting electrons and an apertured anode for receiving said electrons, and a collector electrode on the side of the anode opposite from said cathode, and a plurality of apertured electrodes including a control grid, an accelerating grid and a screen grid positioned between the cathode and the apertured anode, all of said electrodes being positioned with the apertures in alignment, and an apertured suppressor electrode positioned between the apertured anode and the collector electrode, the suppressor electrode being closer to the apertured anode than to said collector electrode.

3. An electron discharge device having a cathode for emitting electrons and an apertured anode for receiving said electrons, and a collector electrode on the side of the anode opposite from said cathode, and a plurality of apertured electrodes including a control grid, an accelerating grid and a screen grid positioned between the cathode and the apertured anode, all of said electrodes being positioned with the apertures in alignment, and an apertured suppressor electrode positioned between the apertured anode and the collector electrode, said apertured anode and said suppressor electrode being slotted cylinders surrounding said collector electrode.
4. An electron discharge device comprising a

cathode for emitting electrons, and an anode electrode comprising a flat apertured plate and a collector electrode on the side of the anode opposite the cathode and in registry with the aperture in the anode, a flat control electrode, a flat accelerating electrode and a flat screen electrode mounted in succession from the cathode to the anode and provided with apertures aligned with the aperture in the slotted anode, and a suppressor electrode comprising a flat electrode having an aperture of larger size than the aperture in the anode and aligned with the aperture in the anode.

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