ELECTRON DISCHARGE DEVICE

Filed Dec. 6, 1954

Fig.1.

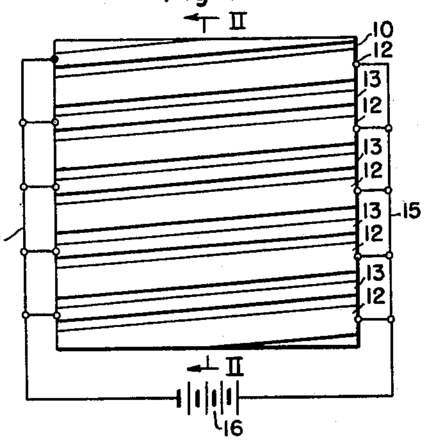


Fig.2.

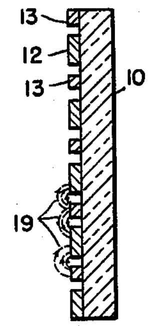


Fig.3.

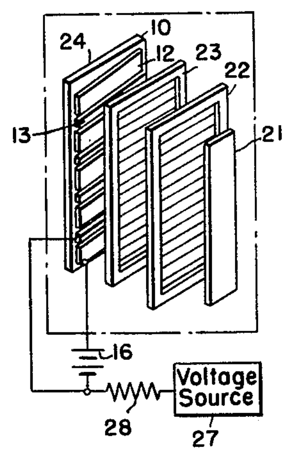


Fig.4.

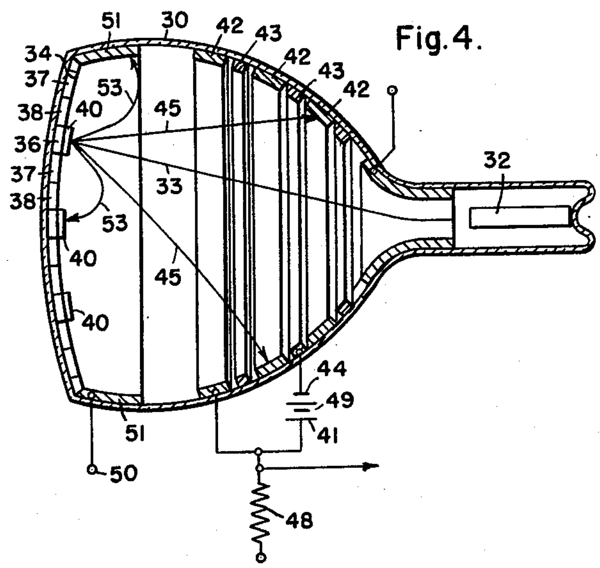
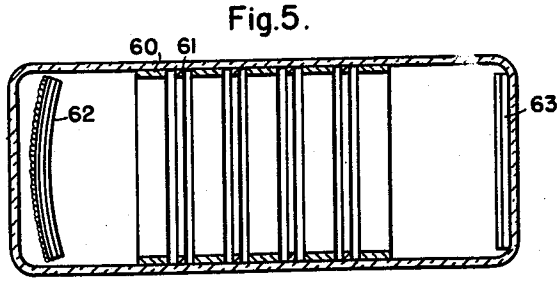


Fig.5.



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2,916,664

Patented Dec. 8, 1959

2,916,664

ELECTRON DISCHARGE DEVICE

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Application December 6, 1954, Serial No. 473,243

4 Claims. (Cl. 315—21)

This invention relates to electron discharge devices and, more particularly, to means for suppressing or controlling the emission of electrons from surfaces therein.

The emission of secondary or low energy electrons from the surfaces of the anode, collecting surface or walls of an electric discharge device on electron bombardment is disadvantageous in many cases. For example, in the tetrode type of receiving tube, there are two grids. The first or control grid which is positioned adjacent to the cathode, a second or screen grid which is positioned between the control grid and the anode of the tube. In such a tube, the electron flow for a given voltage on the control grid is largely governed by the accelerating voltage applied to the screen grid. The electrons accelerated by the screen grid in general pass on through the screen grid and are eventually received by the anode. These primary electrons, under the influence of the anode voltage upon striking the anode surface, produce emission of secondary electrons. The low velocity secondary electrons flow to the higher potential screen grid at low plate voltages. This results in decreased current in the plate circuit. This dip in the plate current characteristic results in distortion in the output. The insertion of a suppressor grid between the screen grid and the anode and held at cathode potential prevents the secondary emission effects of the tetrode. However, the suppressor grid impedes the flow of the primary electron current, especially at voltages of 100 volts or less. It is, therefore, obvious that it would be desirable to have a receiving tube which would permit the omission of a separate structure in the form of the suppressor grid and yet still reduce the secondary emission at low anode voltages with respect to the screen grid voltages.

Still another example where secondary emission is undesirable is the case where it is desired to measure a small current of high energy electrons collected by an electrode when other electrodes are of a polarity and potential so as to attract secondaries emitted from the collecting electrode surface. If the secondary electrons are removed from the collecting electrode surface, they subtract from the measured current and thereby introduce an error into the measurement and also reduce the signal obtainable. This situation exists in such a device as described in my U.S. Patent No. 2,760,107, issued August 21, 1956, and assigned to the same assignee as the present invention.

Although the above two problems are directly concerned with secondary emission, this invention is not limited thereto, but may be utilized to control any electron emission.

It is accordingly an object of this invention to provide means for controlling the emission or flow of electrons from an electron emitting surface.

It is another object to dispense with a separate grid structure to control the electron emission from a planar thermionic or photoelectric cathode.

It is accordingly an object to provide a means for suppressing secondary emission from a surface within an electron discharge device.

It is another object to provide a receiving tube in which the secondary emission from the anode is reduced to a minimum by the use of a coplanar electrode.

It is another object to provide a receiving tube which adapts itself to automatic assembly.

It is another object to provide a collecting electrode within a cathode-ray tube so as to obtain the maximum signal from primary reflected electrons from the screen of the cathode-ray tube.

It is another object to prevent breakdown in high voltage type electron discharge devices due to secondary emission from the walls of the device.

These and other objects are effected by this invention as will be apparent from the following description, taken in accordance with the accompanying drawing throughout which like reference characters indicate like parts, and in which:

Figure 1 is a plan view of a secondary emission suppression structure according to my invention;

Fig. 2 is a cross sectional view, taken along line II—II of Fig. 1;

Fig. 3 is a perspective view of a receiving tube incorporating my invention;

Fig. 4 is a cathode-ray tube partly in section incorporating my invention; and

Fig. 5 is a high-voltage image intensifier incorporating my invention.

Referring in detail to Figs. 1 and 2, I have shown the basic structure of my invention to aid in the explanation of the description of embodiments thereof. The structure is comprised of an insulating member **10** having a plurality of conductive elements **12** and **13** positioned on one surface thereof. The conductive elements **12** are substantially wider than the other conductive elements **13** and are interspersed with respect to elements **13**. In the specific embodiment, the elements **13** are alternately positioned with respect to elements **12**. The elements **12** and **13** are parallel and separated from each other by a distance dependent on the voltage applied between the elements. The wider or collecting elements **12** are all connected together by means of a conductor **15** and are connected thereby to the positive terminal of a suitable voltage source, such as battery **16**. The negative terminal of the battery **16** is connected by means of a conductor **17** to the narrow or suppressor elements **13** on the insulating member **10**. The strips or conductive elements **12** or **13** may be made out of thin foils of a suitable metal or deposited by evaporation, painting, electrochemical or photochemical processes. The structure also lends itself to the printed circuit techniques.

The collecting conductive elements **12** may be of a suitable conductive material and may be of a secondary emissive material in some applications. In most applications, it will be desirable to have as small a secondary emission and back scattering of primary incident electrons as possible from the collecting elements **12**. A satisfactory material for covering the conductive elements **13** may be carbon either in the form of colloidal graphite or a coarse soot. It is found that the total yield of secondary electrons from a properly prepared soot surface will be less than .50 per primary incident electron. The suppressor elements **13** should have as low a secondary emission as possible. It is found, however, that a certain amount of secondary emission from the suppressor elements **13** cannot be eliminated. For this reason, the width of the suppressor strips **13** should be kept as low as possible relative to the collecting elements **12**.

Also, the spacing of the suppressor strips **13** from the collecting strips **12** must not be too large relative to the distance of the nearest positive potential electrode to which the secondary emitted electrons might be drawn. The effectiveness of the suppressor action by the suppressor elements 13 will be primarily a function of their spacing relative to the distance to a more positive electrode, and only to a small extent will it be influenced by the width of the suppressor strips 13. It has been found in most applications that the width of the collecting elements 12 will be of the order of four times that of the suppressor elements 13.

In the operation of the device shown in Figs. 1 and 2, a negative potential is applied to the suppressor strips 13 with respect to the collecting strips 12 by means of the battery 16. A retarding field indicated on the drawing by dotted lines 19 is, therefore, applied between surfaces of the collecting elements 12 and the suppressor elements 13 and thereby the number of slow secondary electrons leaving the region of collecting elements 12 is reduced to a minimum number. The direction of the field is indicated by the arrows on the lines 19. By adjusting the voltage difference between the suppressor elements 13 and the collector elements 12, the relative number of electrons escaping from the collecting surfaces 12 can be controlled readily just as in the case of a conventional pentode utilizing a separate suppressor grid.

In Fig. 3, there is shown a receiving tube in which a secondary electron suppressor structure, such as described in Figs. 1 and 2, is employed as the anode 24. The electrode assembly is contained in an envelope, not shown, and may be of any suitable structure. I have shown only the basic elements necessary to explain my invention. The electrode assembly comprises a cathode 21 which may be of any suitable type such as the indirectly heated type as shown in the embodiment. A control grid 22 and a screen grid 23 are positioned in the order enumerated adjacent to the cathode 21. The anode 24 of the electrode assembly is positioned adjacent to the screen electrode 23 so as to collect the electrons emitted from the cathode after passing through the control grid 22 and the screen grid 23. In the structure shown, the electrodes 21, 22, 23 and 24 are of a planar type configuration; however, any suitable type configuration may be utilized such as a tubular or elliptical member.

The structure of the anode 24 is of similar type and construction as that described with reference to Figs. 1 and 2. The collecting strips 12 serve as the anode portion or electron collector of the type shown, while the suppressor strips 13 act in a manner previously described. In addition to the voltage difference supplied between the suppressor strips 13 and the collecting strips 12 by the battery 16, a plate voltage is supplied to both the collecting strips 12 and the suppressor strips 13 by means of a suitable plate supply voltage source 27 through a resistor 28. The operation of the receiving tube shown in Fig. 3 is similar to that of a pentode type receiving tube and the operating characteristics of the tube are also similar to that of a pentode. At those voltages where the anode 24 is at a potential more negative than the screen electrode 23, the secondary electrons emitted from the collecting strips 12 would normally be collected by the screen grid electrode 23 as in a typical tetrode. By applying the voltage by battery 16 between the collecting strips 12 and the suppressor elements 13, the secondary emission from the collecting strips 12 may be controlled in a manner previously described with reference to Fig. 1.

In Fig. 4 there is shown another embodiment of my invention incorporated into a color television reproduction tube. The tube comprises a glass envelope 30 of conventional design in which an electron gun 32 is mounted in one end thereof for producing a scanning electron beam 33. The electron beam 33 scans a raster on a phosphor screen 34 positioned on the opposite end of the envelope 30 with respect to the electron gun 32. The phosphor screen 34 is comprised of a plurality of phosphor strips 36, 37 and 38 capable of emission of selected primary colors. One of the selected color phosphors 36 may be covered by a thin layer 40 of material such as gold having a high electron back-scattering power. A more complete description of the tube structure described above with respect to Fig. 4 is given in my beforementioned U.S. Patent 2,760,107, entitled, "Color Television." Positioned on the bulb wall of the envelope 30 adjacent to the phosphor screen are a plurality of parallel conducting ring strips 42 and 43. I have shown only a few strips 42 and 43 in enlarged proportion to aid in illustrating the invention. Each of the conducting rings 42 and 43 is disposed on the wall so that it is continuous and substantially equally spaced at all points from the phosphor screen. The rings 42 and 43 serve not only to form a field-free region as in the conventional coating in a cathode ray tube for the electron beam 33, but also to detect a sensing signal from the screen 34 in the form of primary reflected or high energy back scattered electrons indicated by the lines 45. The elements 42 which serve as the collecting elements are insulated from the elements 43 which serve as the suppressor elements. The elements 42 alternate with the elements 43 along the wall of the tube. The suppressor elements 43 are connected together and brought out to the exterior of the envelope 30 to the negative terminal 44 of a battery 49. The collector elements 42 are also connected together and brought out to the exterior of the envelope 30 to the positive terminal 41 of a battery 49. The battery 49 places a negative bias on the suppressor elements 42 with respect to the collecting elements 43. The voltage of the battery 49 may be of the order of 200 volts, while a 10 kilovolt source (not shown) is connected through a resistor 48 to the terminal 41 to provide necessary focusing voltage for the electron beam 33. The spacing and width of these suppressor and collecting elements 42 and 43 and the material used therein may be of similar type to that described with reference to Figs. 1 and 2. A particularly simple method of depositing the strips 42 and 43 on the wall is the process of painting a double spiral of coarse graphite in a suitable solution onto the walls through the neck of the tube.

In the operation of the device shown in Fig. 4, a portion of the primary electrons within the electron beam 33 will be reflected back as the electron beam 33 scans a raster on the phosphor screen 34. The number of reflected primary electrons from the sensing elements 40 will be much greater than that from the uncoated phosphor strips 37 and 38. The strips 37 and 38 may be coated with a material that reflects only a small number of incident electrons. Since the phosphor screen 34 is held at a potential of approximately 25 kilovolts applied to terminal 50, while the collecting elements 42 and suppressor elements 43 are of the order of 10 kilovolts, the secondary electrons which are of low energy will be returned to the screen 34 or to a coating 51 adjacent to the screen 34, as indicated by the lines 53. The reflected primary electrons which are of higher energy will be reflected back from the screen 34 as indicated by lines 45 and overcome the opposing potential field and strike the collecting strips 42 on the wall of the tube. The voltage supplied by the battery 49 between the collecting strips 42 and the suppressor strips 43 will prevent secondary emission from the collecting strips 42. Since the secondary electron emission from the collecting strips 42 is suppressed thereby, the signal received from the phosphor screen 34 due to the reflected electrons will be greatly enhanced, and the signal obtained across the load resistor 48 will be of a greater value than that normally obtained.

In Fig. 5 I have shown another possible embodiment of my invention in an image intensifier device in which two parallel spiral continuous low resistance strips 60 and 61 are painted from one end of the tube to the other end. By the application of a suitable voltage across both ends of the strips and a suitable voltage difference signal between the two strips, a voltage gradient due to resistance of strips 60 and 61 may be obtained along the tube so as to focus the electrons from a photocathode 62 onto a target 63. The operation of the strips 60 and 61 would act to suppress emission from the strips 60 and the exposed envelope. This structure could be utilized in an image intensifier where the envelope walls are tapered to reduce the electron image from the photo-cathode to a small target.

Another possible embodiment of my invention is the utilization of parallel conductive strips painted on the interior walls of high voltage tubes, such as X-ray tubes and rectifiers, and then applying a voltage difference between the two parallel strips so as to reduce the possibility of breakdown to the glass wall of the envelope, which is primarily caused by secondary emission from the glass wall.

It is found that electrons, ions or photons striking the glass wall or other elements within a high voltage tube cause undesirable emission of electrons from the surface. The emission of electrons causes the surfaces to charge up to high positive potentials. The undesirable high voltages may cause breakdown of the insulation such as the glass walls or between surfaces within the tube.

Although I have described my invention primarily with respect to the utilization of a secondary electron suppressor on the collecting surface of a tube or the wall thereof, my device may also be utilized to control the secondary emission or photoelectric emission from emitting surfaces.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited but is susceptible of various other changes and modifications without departing from the spirit and scope thereof.

I claim as my invention:

1. A cathode-ray tube comprising an envelope and having therein an electron gun for generating a beam of electrons, a screen positioned at the opposite end of said envelope on which a raster is scanned by said electron beam, said screen comprising a plurality of elements capable under electron bombardment of producing light representative of selective component colors, a portion of said light producing elements also capable of producing a large number of reflected primary electrons in comparison to the remainder of said light pro-

ducing elements, means for collecting said primary reflected electrons comprising a plurality of parallel electrically conductive elements positioned on the wall of said envelope, said electrically conductive elements operating at a negative potential with respect to said screen and means for impressing a voltage difference between adjacent conductive elements so as to collect only the primary reflected electron from said screen and suppress any secondary emission from said conductive elements due to bombardment by said primary reflected electrons.

2. A high-voltage electron discharge device comprising an envelope of an insulating material, said envelope having on the interior surface thereof a plurality of electrically conductive parallel strips, alternate elements connected together so as to provide a first and second group of strips, the strips in said first group of less width than the strips in said second group, and means for applying a negative bias to said first group of strips with respect to said second group of strips.

3. An electron discharge device comprising a cathode and an image screen and means for focusing electrons emitted from said cathode on to said screen, said means comprising a first and a second continuous parallel spiral coating of resistive material positioned on the interior surface of the envelope between said cathode and said screen, said first coating of less width than said second coating and means for applying a negative bias to said first coating with respect to said second coating.

4. An electron discharge device comprising an envelope and having therein an electron emissive structure, said structure comprising a first and second group of parallel coplanar elements, said first group of elements of said structure capable of emission of electrons, said second group of elements insulated from said first group and alternating in position with the elements of said first group, said second group of elements of smaller area than said first group, and means for applying a negative bias to said second group of elements with respect to said first group.

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