June 3, 1941. H. A. IAMS 2,244,365

ELECTRON DISCHARGE DEVICE

Filed Feb. 27, 1937

Fig. 1

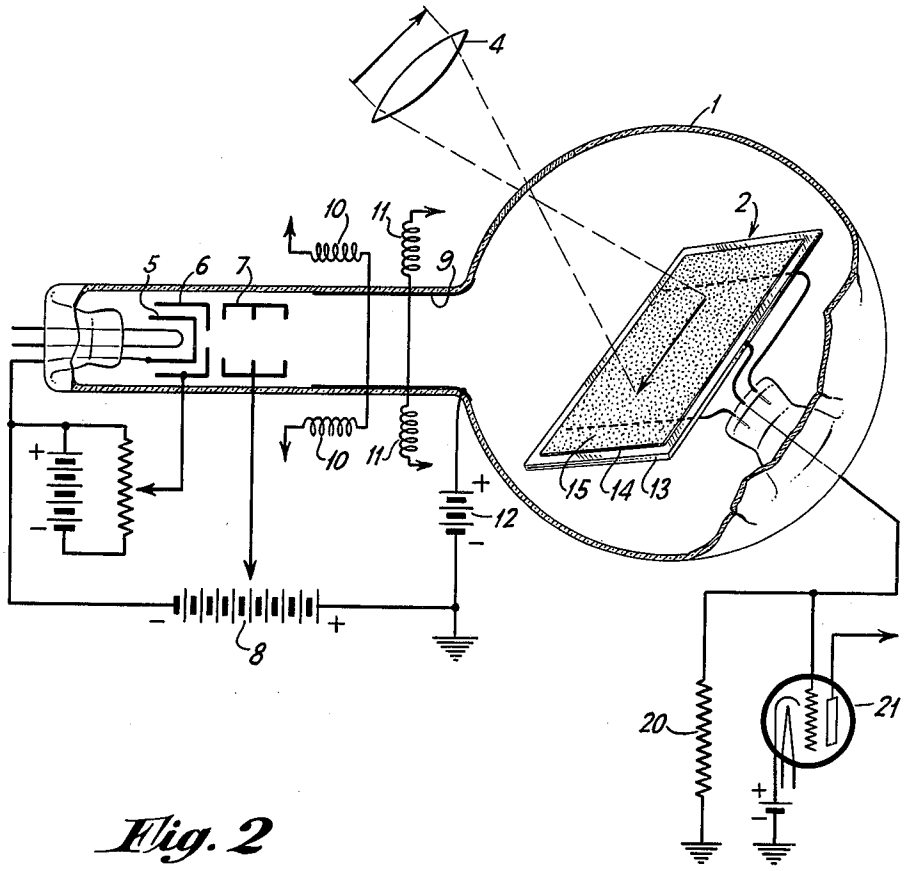


Fig. 2

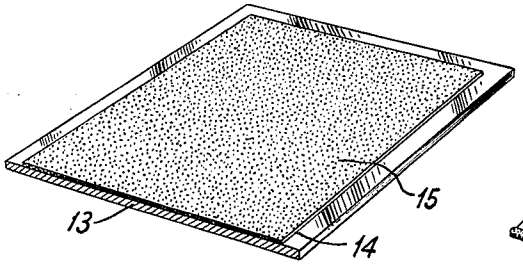


Fig. 3

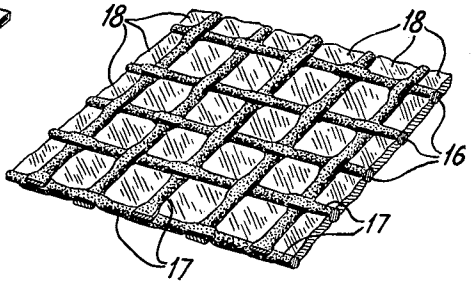
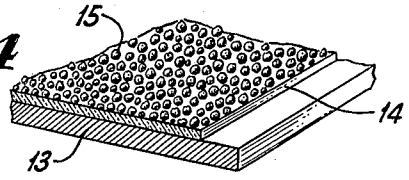


Fig. 4



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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

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Application February 27, 1937, Serial No. 128,053

6 Claims. (Cl. 178—7.2)

My invention relates to improvements in cathode ray television, and particularly to an improved device having a photosensitive electrode structure especially advantageous for use in such tubes.

In the usual form of cathode ray transmitter the image of an object to be transmitted is focused on the front surface of a target or mosaic electrode consisting in general of a thin sheet of a good insulator, such as mica, having on the back surface a metallic coating and on the front surface a great number of discrete mutually insulated photoelectrically sensitive elements which when illuminated are charged in a positive direction with respect to an adjacent anode by reason of loss of electrons to the anode by photoelectric emission, the front or illuminated surface being scanned by a cathode ray beam to generate picture signals which are collected from the metallic coating. The metallic coating is usually connected through a load impedance to the adjacent anode, and the voltage variations across this impedance may be amplified and applied to a cathode ray type of receiving tube to produce a visible reproduction of the image.

In operation the insulated photosensitive elements of the mosaic float at a potential which is very close to the potential of the anode adjacent the mosaic. The field available for collecting the photoelectrons is limited, and charging of the elements is dependent in large measure upon the initial velocities of the photoelectrons emitted by the elements under the influence of the incident light. As a result the efficiency of the available photoelectric emission becomes less as the illumination is increased. Furthermore, when a conventional type of mosaic structure is scanned by an electron beam, the secondary electrons do not all go to the adjacent anode because certain portions of the mosaic are even more positive than the adjacent anode. The secondary electrons which return to the mosaic act to a certain extent as a high shunting resistance which short-circuits the elements, since an element which is more positive than its neighbor tends to receive a greater share of these electrons. When the illumination on the surface of the mosaic is low this effect does not cause a material loss in efficiency, but under high illumination, where considerable difference in voltage between adjacent elements may be developed, this shunting resistance may become quite low with the result that there is a large loss of signal. The return of secondary electrons to the surface of the mosaic is furthermore responsible for the generation of a spurious signal, which appears as an irregular shading over the picture. This spurious signal is the result of the variation in the instantaneous secondary emission current escaping from the mosaic to the adjacent anode. In the case of scanning such a mosaic in darkness the average secondary emission current leaving the mosaic must be equal to the cathode ray beam current since the mosaic is deposited on an insulator, but since a certain fraction of the secondary electrons from the point under bombardment by the cathode ray scanning beam returns to other parts of the mosaic surface, it is apparent that the instantaneous current leaving the mosaic may vary from point to point. This variation is due to lack of uniformity of potential and space charge over and adjacent the mosaic surface.

It is an object of my invention to provide an improved television transmitting tube incorporating a photosensitive electrode structure in which the photoelectrons may be more effectively collected. It is also an object of my invention to provide a television transmitting tube in which the electrostatic charges on the surface of a photosensitive electrode of the type described are more effectively equalized. It is a further object of my invention to provide a television transmitting tube which will produce a greater signal output.

In accordance with my invention I provide a target or photosensitive electrode, preferably of the mosaic type, and made with a thin sheet of a semi-insulator instead of with a sheet of a good insulator, such as mica, and an electrically conducting surface on the side of the semi-insulator opposite that side on which the mosaic is deposited. Further, in accordance with my invention I provide an electron collecting electrode on which I impress a positive potential higher than the potential on the conductive coating of the mosaic electrode.

These and other objects, features, and advantages of my invention will appear from the following description taken in connection with the accompanying drawing in which,

Figure 1 is a diagrammatic view illustrating one form of my television device;

Figure 2 is a view partially in section showing a portion of the electrode structure shown in Figure 1;

Figure 3 is a similar view of one modification of the electrode structure shown in Figure 2; and,

Figure 4 is a view showing an enlarged cross section of the electrode structure shown in Figure 2.

In the illustrative embodiment of my invention shown in Figure 1 the tube comprises a highly evacuated glass envelope or bulb 1 with a tubular arm or neck section enclosing a conventional type electron gun and a spherical section enclosing a flat target or mosaic electrode 2 so positioned that its front surface may be scanned by a beam of electrons from the electron gun and also may have projected upon it the optical image to be transmitted. Since the image is produced from an object situated outside the tube, that portion of the spherical section opposite the electrode 2 is made optically uniform so that the image to be transmitted may be projected upon the electrode with a minimum of distortion by the lens 4.

The electron gun assembly is of the conventional type, and comprises a cathode 5 from which an electron stream may be drawn, a control electrode 6 connected to the usual biasing battery, and a first anode 7 maintained positive with respect to the cathode 5 by a battery 8. The electron stream leaving the first anode 7 is accelerated and concentrated into an electron scanning beam focused on the front surface of the target 2 by a second anode 9, which is preferably a conductive coating on the surface of the envelope 1 near the neck of the bulb but removed from that portion through which is projected the optical image to be transmitted. Conventional deflection means such as deflection coils 10 and 11 may be used to sweep the beam in a horizontal and vertical plane, respectively, to scan the target. It is obvious that conventional electrostatic deflection plates may be substituted for the deflection coils if desired. The mosaic foundation or signal electrode 13 of the mosaic electrode 2 is connected through the impedance 20 to ground and through the battery 12 to the collector electrode or second anode 9, and in operation the current flow in this circuit produces a voltage drop across the impedance 20 which may be impressed on the input of a translating device 21, further amplified, and applied to a transmitting network in a manner well known in the art.

In accordance with my invention the photosensitive mosaic surface which is scanned by a beam of radiant energy such as an electron beam and on which the image to be transmitted is focused is, as best shown in Figures 2 and 4, formed on one side of an aluminum foundation sheet which has been treated to provide on its surface a semi-insulating layer or film of material, such as aluminum oxide. The aluminum foundation sheet, which is a metallic coating or backing for the back surface of the semi-insulating film of oxide, is in capacitive relationship with the photosensitive mosaic surface on the front surface of the film, and serves as a signal electrode from which the picture signals may be obtained. Further, in accordance with my invention I provide between the second anode and the signal electrode a potential source, such as a battery 12, which, under static conductions, maintains the second anode positive with respect to the photosensitive mosaic surface on the semi-insulating film or layer on the signal electrode.

In making the mosaic electrode 2 a sheet of aluminum 13 having a plane surface and of sufficient thickness to be rigid is first cleaned by immersing it in normal solution of sodium hydroxide. I then form on the sheet 13 a semi-insulating film 14 of hydrated aluminum oxide by electrolyzing the aluminum sheet as an anode in a sulphuric acid bath of about 1.2 specific gravity, with a lead electrode as a cathode, passing through the electrolytic cell a current of 14 to 15 amperes per square foot of anode surface for a period of approximately 1 hour. After approximately one hour of such treatment the thickness of the film reaches an equilibrium condition after which time the thickness remains substantially unchanged. I then dust the hydrated aluminum oxide film with very finely divided silver oxide, and convert the film into oxide and reduce the silver oxide to metallic silver by heating the electrode in air to a temperature of approximately 400° C. This heat treatment produces a semi-insulating film of aluminum oxide having on its surface a mosaic 15 of individually separated silver particles, which are afterward oxidized and photosensitized with caesium after the sheet has been sealed in the envelope 1. Care should be exercised that the silver oxide is not dusted on the semi-insulator in sufficient quantity to form a continuous layer of silver when reduced by the subsequent heating operation. A method of photosensitizing such particles is disclosed by S. F. Essig, U. S. Patent 2,065,570.

The semi-insulating layer or film 14 may, however, be formed of a vitreous material such as a vitreous enamel, which permits as a foundation the use of metals, such as nickel, which may be either of sheet or mesh form. I have used an enamel for this purpose which may be sprayed on either a nickel sheet or on a nickel mesh foundation, the constituents being in the form of oxides, the sodium oxide and potassium oxide being considered as an alkali:

	Per cent
Alkali	26
Calcium oxide	6
Boric anhydrid	18
Aluminum oxide	4
Silica	46

The enamel is prepared in accordance with the usual practice in making enamels. If finely powdered it may be sprayed from an alcohol or water suspension, as it is relatively insoluble. For spraying, a good concentration is one gram of enamel to three cubic centimeters of the suspending liquid, and for obtaining a very uniform coating the enamel should be powdered to a particle size under two microns. Referring to Figure 3, the foundation metal comprises a screen 16 preferably of fine nickel wires 16 interwoven to form a mesh having 150 wires or more per linear inch. The screen is cleaned thoroughly and I find it advantageous to oxidize the surface slightly by heating in air until it assumes a greenish color, probably due to a film of nickel monoxide, and then spray it with the enamel ground to a particle size under two microns and held in suspension in either water or alcohol to form a uniform coating of enamel 17 on the surface of the individual wires. The sprayed metal screen is then fired at about 900° C. in air in an electric furnace to fuse the enamel into a smooth glassy coating which completely covers all the metal surface and adheres firmly to it. I prefer to build the enamel coating up in a series of three to four coatings, each followed by firing until I obtain a thickness of one to two mils over the surface of the nickel wires. The enamel above referred to is relatively high in alkali content which accounts in large degree for the semi-insulating character-

istics of the material. I have found that the resistance of this enamel film after firing should be within the range of 10^8 to 10^{11} ohms/cm^3. I then provide in the interstices of the mesh and on the surface of the semi-insulating layer of enamel 17, a mosaic comprising individually separated silver plugs 18 and mount the electrode structure thus formed in the tube 1, whereupon the plugs may be photosensitized with caesium in the manner previously referred to.

In operation, I maintain the second anode more positive than the signal electrode by some means, such as a battery 12 which supplies a constant potential between the second anode and signal electrode. For maximum sensitivity, which is desirable at low light intensity, I have found that with reference to the signal electrode the second anode should be approximately 20 volts positive, but for maximum output with high light intensity the second anode should be considerably more positive, or up to approximately 150 volts. The current flow in the load impedance 20 will produce a slight voltage drop which is applied to the input of the translating device 21. This voltage drop also causes the second anode to be slightly positive with respect to the signal electrode, but the voltage difference is only a few millivolts and is, therefore, ineffectual in supplementing the constant potential of the battery 12.

In conventional cathode ray transmitting tubes having a collector electrode and utilizing a mosaic deposited on a good insulator, such as mica, backed by a signal electrode, the individual particles of the mosaic when scanned by a cathode ray beam, acquire an equilibrium potential which is, at most, about 3 to 4 volts negative with respect to the second anode or collector electrode. With any change in the potential of the collector electrode with reference to the signal electrode a corresponding change occurs in the potential of the individual particles of the mosaic, hence increasing the potential of the collector electrode with respect to the signal electrode does not increase the signal output, as after a few scansions by the cathode ray beam the particles are again at an equilibrium potential of 3 or 4 volts negative with respect to the collector electrode. However, with my new and improved device the equilibrium potential of the individual particles of the mosaic surface is controlled by the signal electrode acting through the semi-insulator on which the particles are deposited to maintain the particles at an average potential which in operation is close to the potential of the signal electrode. Therefore, while I do not desire to be restricted to any particular theory of operation, it seems probable that when the tube is in complete darkness and the electron beam is absent the individual particles constituting the surface of the mosaic take on a potential the same as that of the underlying signal electrode to which the amplifier is connected. When the scanning beam is passed over the surface, however, it tends to establish the point which is under bombardment at a potential which is positive with respect to the signal electrode and approaching that of the collector electrode or second anode 9, with the result that a leakage current begins to flow through the semi-insulator tending to establish the potential of the surface of the mosaic at a more negative voltage than that at which the beam left it. The result is that with the tube in darkness and the beam scanning the mosaic electrode, the potential of a given point on the surface of the mosaic goes through cyclic changes from near signal electrode potential to a level somewhat positive with respect to the signal electrode. The greater potential difference between the individual particles of the mosaic and the collector electrode or second anode will result in a more efficient collection of the secondary electrons released from the surface of the particles under bombardment by the cathode ray beam and for like reason, the emission of photoelectrons from the individual particles will be considerably increased.

From the foregoing description it will be apparent that various other modifications may be made in my invention without departing from the spirit and scope thereof and I desire, therefore, that only such limitations shall be placed thereon as are necessitated by the prior art and set forth in the appended claims.

I claim:

1. A cathode ray device having a light sensitive mosaic, an electrode in capacitive relation with said mosaic, a semi-insulating film having an electrical resistance between 10^8 and 10^{11} ohms/cm.^{3} between said mosaic and said electrode, means for scanning said mosaic with a beam of radiant energy, an anode adjacent said mosaic for collecting electrons emitted from the surface of said mosaic, a connection between said electrode and said anode including impedance, and means in said circuit for maintaining between said electrode and said anode a constant difference of potential at least 20 volts greater than the difference of potential produced by the voltage drop in said impedance.

2. A cathode ray device with a mosaic of light sensitive elements positioned to receive an optical image, a back-plate having a load circuit containing impedance, a semi-insulating layer having an electrical resistance between 10^8 and 10^{11} ohms/cm.^{3} between said light sensitive elements and said back-plate, means to scan said elements by an electron beam, an anode adjacent said mosaic, and means for maintaining said anode at a constant potential of at least 20 volts more positive with reference to said back plate than the difference of potential produced by the voltage drop in said impedance.

3. A cathode ray device having scanning means comprising an electron gun including an anode, an electrode oppositely disposed from said electron gun, a semi-insulating layer having an electrical resistance between 10^8 and 10^{11} ohms/cm.^{3} on the surface of said electrode, a mosaic of light sensitive elements on the surface of said layer facing said electron gun, a load circuit including said electrode and said anode and having impedance and a source of voltage permanently connected to maintain said anode at a constant potential positive with reference to said electrode and at least 20 volts greater than the difference of potential produced by the voltage drop in said impedance.

4. A television transmitting device including a cathode ray tube having a source of electrons, an anode for forming a cathode ray beam, a target in the path of said beam oppositely disposed from said source and said anode, said target comprising a metal base, a layer of vitreous enamel having a resistance between 10^8 and 10^{11} ohms/cm.^{3} on the surface of said base facing said source, and a light sensitive mosaic facing said source on the surface of said semi-insulating layer, means to scan said target with

said cathode ray beam, a second anode between said first anode and said target for collecting electrons from said target, a circuit including impedance between said metal base and said second anode, and means for maintaining said metal base at a constant potential between 20 and 150 volts more negative with respect to said second anode than the negative potential impressed on the metal base by the impedance drop in said circuit.

5. A television transmitting apparatus comprising a sealed envelope containing a signal electrode, a screen consisting of a plurality of photo-electrically active elements, an anode, and a partial insulation between said element, themselves and them and said signal electrode; means for maintaining said anode at a positive potential with respect to said signal electrode; optical means for projecting an image of the object to be transmitted upon said elements causing them to emit photo-electrons; means for scanning said elements with a beam of radiant energy causing another emission of electrons, said emissions resulting in leakage currents from any of said elements through said partial insulation to said signal electrode, said leakage currents resulting from scanning being at least as great as any of said other leakage currents; an output circuit associated with said signal electrode; and means for transmitting signals generated in said output circuit.

6. A television transmitting apparatus comprising a sealed envelope containing a signal electrode, a screen consisting of a plurality of photo-electrically active elements, an anode, and a partial insulation between said elements themselves and them and said signal electrode; means for maintaining said anode at a positive potential with respect to said signal electrode; optical means for continuously projecting an image of the object to be transmitted upon said elements causing them to emit photo-electrons; means for scanning said elements with a beam of radiant energy causing another emission of electrons, said emissions resulting in leakage currents from any of said elements through said partial insulation to said signal electrode, said leakage currents resulting from scanning being at least as great as any of said other leakage currents; an output circuit associated with said signal electrode; and means for transmitting signals generated in said output circuit.

HARLEY A. IAMS.