Aug. 29, 1939. A. ROSE 2,171,224

CATHODE RAY TUBE

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Fig. 1

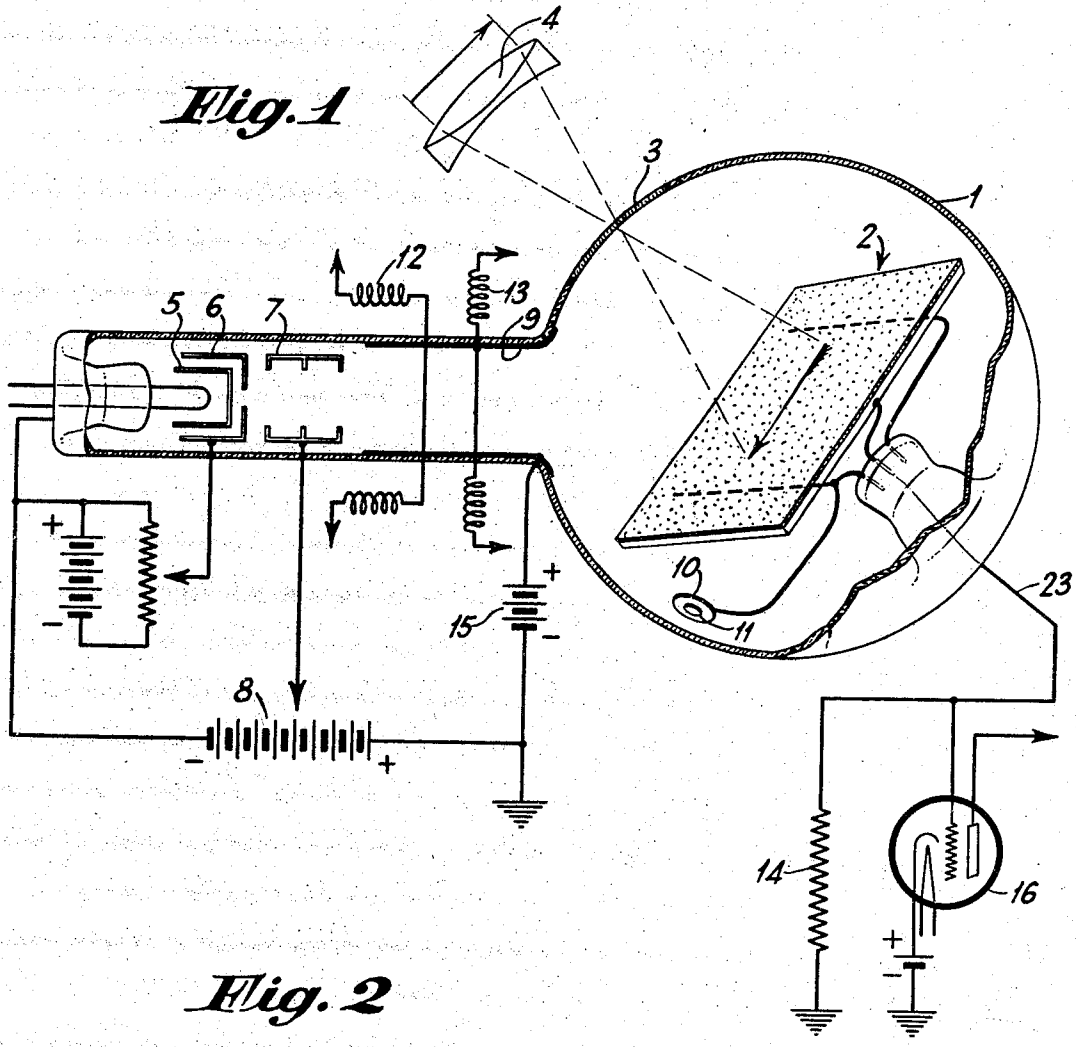
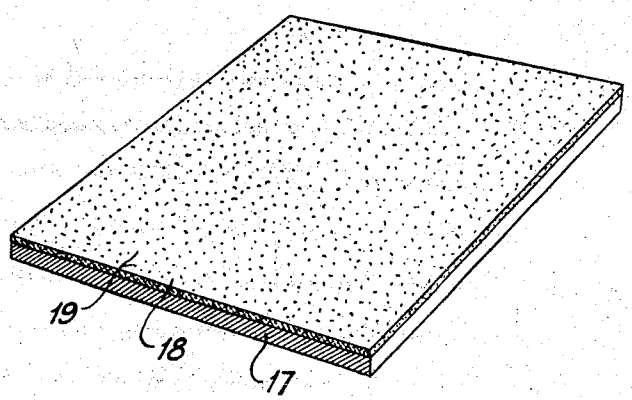


Fig. 2



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CATHODE RAY TUBE

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6 Claims. (Cl. 250—27.5)

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

A common form of cathode ray transmitter tube has a target or mosaic electrode with a surface which in general consists of a great number of discrete mutually insulated photoelectrically sensitive elements and which is scanned by a cathode ray beam to generate picture signals. In such a target all of the particles should have equally responsive photosensitive surfaces, and the photosensitivity of the mosaic as a whole should be extremely good so that images of relatively low light intensity may be satisfactorily transmitted. The development of such photosensitive surfaces of the desired sensitivity is difficult and requires a great degree of skill and attention during the manufacturing process.

As the operation of such a tube depends upon secondary electrons generated when the scanning beam bombards the individual photosensitive elements, any variation from particle to particle in the ratio of primary electrons in the scanning beam to secondary electrons released by the particles under bombardment will produce a disturbance in the output circuit which in some cases may seriously modify and destroy the detail of the transmitted image. The spectral sensitivity of such electrodes, especially when sensitized with caesium, is higher in the red portion of the spectrum than is desirable.

The principal object of my invention is to provide a television transmitting device having an improved target which is easily manufactured and which does not require high photosensitivity. Another object of my invention is to provide a light responsive electrode for use in a television transmitting device which shows uniformity in operation and is not subject to wide variation in sensitivity under high electron bombardment during use. A further object of my invention is to provide a light responsive electrode having more uniform spectral response to light images in the portion of the spectrum near the blue.

In accordance with my invention I deposit a layer or film of an insulating material, such as aluminum oxide or zirconium oxide which is inherently highly refractory on a metal plate, constituting the foundation of the target, expose this film to the vapor of an active metal, such as caesium, subsequently treat the exposed film under such conditions that a considerable quantity of the metal is taken up by the film, and then drive off the active metal until the treated film shows no appreciable photosensitivity.

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 television device incorporating my invention, and

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

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 electrode 2 so positioned that its front surface may be scanned by a beam of electrons from the electron gun, and also so positioned that it 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 target 2 is made optically uniform, such as by the window 3, so that the image to be transmitted may be projected upon the electrode with a minimum of distortion by the lens system 4.

The electron gun assembly is of the conventional type and comprises a cathode 5 from which an electron stream may be drawn, 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 of the envelope through which is projected the optical image to be transmitted. A support 10 containing a quantity of a caesium bearing compound 11 is provided adjacent the target but removed from the path of the optical image projected through the window 3. Conventional deflection means, such as deflection coils 12 and 13, 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 either one or both sets of deflection coils, if desired. The target 2 is connected through the impedance 14 to ground and

through the battery 15 to the second anode 9 and in operation the current flow in this circuit produces a voltage drop across the impedance 14 which may be impressed on the input of a translating device 16, further amplified and applied to a transmitting network in a manner well known in the art.

In accordance with my invention the target, as best shown in Figure 2, comprises a metal foundation sheet 17 which serves as a signal electrode from which the picture signals may be obtained. This foundation sheet is coated on one side with a thin porous layer or film 18 of material such as aluminum oxide or zirconium oxide which in operation is semi-conducting under the influence of light. The surface of this layer, on which the image to be transmitted is focused, is scanned by the electron beam. The oxide composing the layer is in itself a good insulator but the layer is rendered semi-conducting by the incorporation in it of an active metal, such as caesium distributed throughout the layer of oxide as indicated at 19. The layer 18 has negligible photosensitivity but has about the same secondary electron emissivity as the conventional target of the mosaic type.

In operation the second anode 9 should be maintained more positive than the electrode foundation plate or signal electrode 17 by some means such as a battery 15. 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, up to approximately 160 volts.

In conventional cathode ray transmitting tubes having a collector electrode and utilizing a mosaic of discrete photosensitive particles deposited on an insulator, such as a sheet of mica backed by a signal electrode, the individual particles of the mosaic when under the influence of a light image to be transmitted acquire potentials which are proportional to the light intensity thereon. The particles being in capacitive relationship with the back-plate may be likened to individual condensers which are discharged in a predetermined sequence when scanned by the cathode ray beam. However, with my new and improved device I do not utilize the principles of storing a charge on particles or elemental areas of the scanned target, but instead utilize the change in conductivity of the oxide film 18 in accordance with the intensity of light on the elemental areas thereof. 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 various elemental areas constituting the surface of the target electrode take on a potential the same as that of the underlying signal electrode to which the amplifier is connected. When the electron 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 foundation plate or signal electrode 17 and approaching that of the second anode 9. When an optical image of the object to be transmitted is projected upon the surface of the target electrode, the elemental areas of the film 18 become electrically conductive to an extent dependent upon the intensity of light on the elemental areas. Therefore the potential of the respective areas changes in accordance with the degree of light and shade on the respective areas, with the result that the areas under greater illumination are more negative than the areas subjected to a lesser degree of illumination. This change in potential on the respective areas occurs during the intervals between scannings of the electron beam. When the target electrode is scanned by the electron beam a larger proportion of the secondary electron emission from the areas under greater illumination is collected by the second anode than is collected from those areas subjected to illumination of a lesser degree. The variable secondary emission is either collected by the second anode 9 or distributed over the surface of the layer 18, any variation in the instantaneous value of the electrons reaching the second anode producing a corresponding potential variation in the output impedance 14, which potential variation is amplified and applied to a transmission network in a manner well known in the art.

One method of making a target assembly is as follows: A sheet of metal 17, such as aluminum or nickel having a plane surface and of sufficient thickness to be rigid, is first cleaned by immersing it in a normal solution of sodium hydroxide, following which it is rinsed in distilled water and dried in warm air. I then deposit on the sheet 17 a film or layer 18 of aluminum oxide or zirconium oxide by coating one surface of the sheet with a suspension of the finely divided oxide in a binder, such as a solution of nitrocellulose in methanol, preferably by spraying the suspension on the foundation metal 17 by a fine orifice air brush. The particle size of the oxide preferably should be about one ten thousandth of an inch, although a particle size somewhat larger than this may be tolerated.

The coated metal plate is then baked in vacuum for a period of approximately one hour at 450° C. to volatilize the binder and form a thin adherent film of oxide on the plate. The thickness of the film of oxide 18 affects the operating characteristics of the device, and I have found that such a film having a thickness of one to three thousandths of an inch is most satisfactory for the purpose. The metal plate with the film of oxide on one surface is mounted in the tube 1 in a position to have the film side scanned by the electron beam from the gun structure, and also to have projected on the surface of the film 18 a light image from the lens system 4. The tube is then baked and exhausted to a very good vacuum at a temperature of 450° C. for approximately 2 hours, the metal parts of the gun structure being degassed at intervals by raising the temperature of these parts to a dull red heat by subjecting them to a high frequency field. The highly evacuated tube is disconnected from the pump and is allowed to cool to room temperature, and then caesium vapor is evolved from a caesium bearing compound 11 in the retainer 10 by heating the retainer 10 with a high frequency induction coil. The caesium vapor condenses on the walls of the tube and on the surface of the oxide film 18. For this purpose I have used as a source of caesium 100 milligrams of the mixture of caesium chromate, zirconium and aluminum described by P. S. Lester in his co-pending application Ser. No. 103,514, filed October 1, 1936, where the surface of the film 18 to be sensitized has an area of approximately 18 square inches.

In accordance with my invention the tube is again put on the pump, and while on the pump is baked at 225° C. for a period of time sufficient

to impregnate the film 18 with caesium. The period of baking is dependent upon the thickness of the film 18, and which for a film one thousandth to three thousandth of an inch thick has been found to be approximately 15 minutes. The end point of the baking may be determined more accurately by testing the photoelectric emission from the surface of the film 18 during the baking. To make this test the electrodes 9 and 17 are connected through a microammeter to a source of positive and negative potential, respectively, and the photo-emission noted from time to time during the baking. During the first few minutes of baking the photoelectric current as indicated on the microammeter will reach a maximum value. This maximum value of photoelectric emission is only a small fraction of that obtained with respect to that of a conventional photosensitive mosaic electrode but the baking should be continued until the photoelectric emission is still lower, and is to advantage approximately one half of the maximum value, or for all practical purposes is negligible. The tube is then sealed off and is ready for use.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my 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 my invention as set forth in the appended claims.

I claim:

1. The process of forming a photoconductive surface on an electrically conductive base which comprises depositing on said base a layer of refractory oxide, exposing the layer to vapor of an alkali metal, depositing alkali metal on the exposed surface of said layer, heating said base and said layer to photosensitize said layer and impregnating said layer with the alkali metal deposited on the surface of said layer by baking said base until said layer shows negligible photoelectric emission and negligible electrostatic storage.

2. The process of forming a photoconductive surface on a metal base which comprises depositing on said metal base a layer of refractory oxide, exposing said layer to caesium vapor to deposit caesium thereon, impregnating the layer of refractory oxide with the deposited caesium and baking said base and said layer to provide said layer with a surface having negligible photoelectric emission and negligible electrostatic storage.

3. A non-electrostatic storage target electrode for cathode ray transmitting tubes comprising an electrically conductive plate and a photoconductive substantially nonphotoelectrically emissive coating on one surface of said plate, said coating consisting of a highly refractory oxide of high electrical resistance and electrically conductive particles of alkali metal distributed throughout said coating to render said coating electrically conductive to an extent sufficient to eliminate electrostatic storage between the exposed surface of said coating and said conductive plate.

4. A non-electrostatic storage type target electrode for cathode ray transmitting tubes comprising an electrically conductive plate having on one surface thereof a nonphotoelectrically emissive layer consisting of a highly refractory oxide of high electrical resistance impregnated throughout the thickness of the layer with a sufficient quantity of alkali metal to render the impregnated layer sufficiently electrically conductive to prevent the formation of electrostatic charges on the exposed surface of said layer with respect to said plate.

5. A non-electrostatic storage type target electrode for cathode ray transmitting tubes comprising a metal plate, a coating consisting of a thin adherent layer of finely divided refractory oxide deposited on and in contact with one surface of said plate, the thickness of said layer being substantially from $\frac{1}{1000}$ to $\frac{3}{1000}$ of an inch, and an alkali metal disseminated throughout said layer leaving substantially no alkali metal on the exposed surface of said layer, the photoelectric emission of said layer being negligible.

6. A non-electrostatic storage type target electrode for cathode ray transmitting tubes comprising a metal plate, a coating consisting of an adherent layer from $\frac{1}{1000}$ to $\frac{3}{1000}$ of an inch thick of finely divided oxide selected from the group consisting of aluminum oxide and zirconium oxide in contact with one surface of said plate, and photoactive electrically conductive particles containing caesium distributed throughout the layer of oxide in a sufficient amount to render said layer electrically conductive when illuminated with light, said layer having negligible photoemission.

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