Oct. 31, 1939. W. HICKOK 2,178,232

CATHODE RAY TUBE

Filed March 30, 1937

Fig. 1

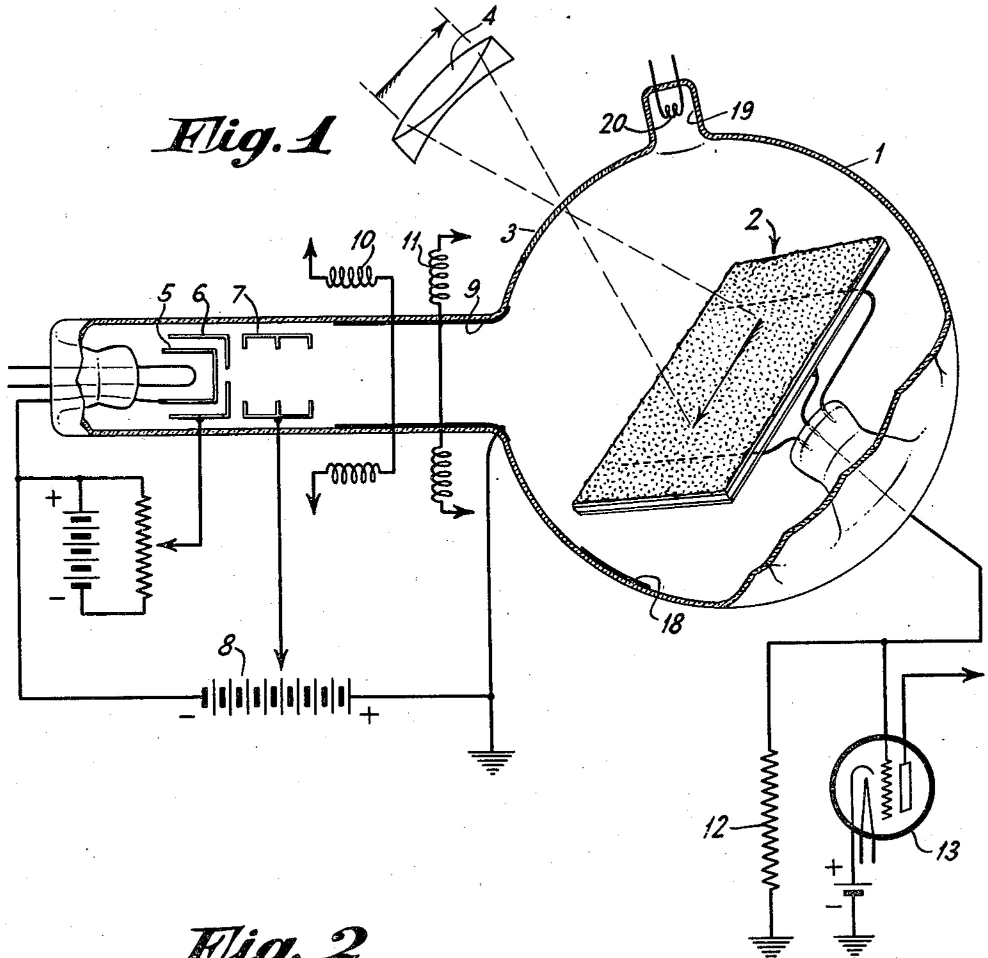
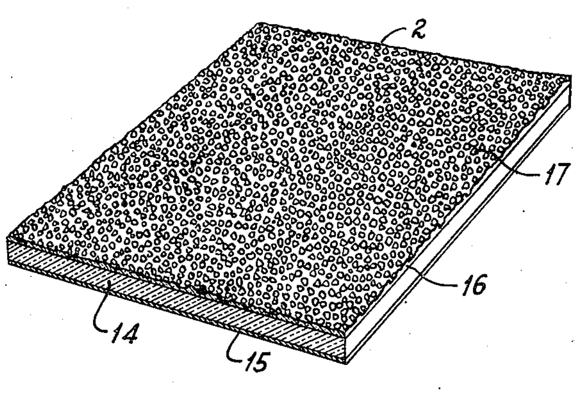


Fig. 2



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CATHODE RAY TUBE

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Application March 30, 1937, Serial No. 133,899

10 Claims. (Cl. 250—27.5)

My invention relates to improvements in cathode ray television, and particularly to an improved cathode ray device having an improved photosensitive screen or target electrode of the mosaic type in which the front or illuminated surface scanned by a cathode ray beam has on it a great number of discrete mutually insulated photoelectrically sensitive elements.

It has been found that in a cathode ray tube with the conventional mosaic electrode having on the front surface of a mica sheet discrete elements or particles of silver photosensitized by exposure to caesium vapor the best results are obtained when the tube is treated during exhaust to render the surface conductivity and resultant leakage between particles very low. Apparently this treatment is necessary to make the mica surface between the discrete particles of silver so free from caesium that the discrete particles or elements can store the electrostatic charges as a function of the illumination and retain the charges until the charged particles are swept by the scanning beam. Unfortunately this treatment makes the photosensitivity of the silver particles considerably less than the maximum obtainable.

The principal object of my invention is to provide an improved cathode ray tube having a mosaic type target electrode of greater photosensitivity than a conventional electrode having the same surface leakage. A further object is to provide an improved and highly sensitized electrode having greater photosensitivity than has heretofore been attainable.

In accordance with my invention the target electrode or screen is so made that the insulating surface between individual photosensitized elements is of considerably greater extent and the paths between them of higher resistance than in the conventional mosaic electrode. To this end an intermediate insulating coating or layer of crystals, having a flaky amorphous texture is interposed between the layer of mosaic particles and an insulating base, such as mica, thereby increasing the length and resistance of the electrical paths from particle to particle. The individual mosaic particles are formed on the intermediate insulating layer, oxidized, and photosensitized with caesium or other light sensitive materials during the evacuation of the tube. After the individual mosaic particles are formed and photosensitized excess caesium, if present, may be driven off from the areas of the intermediate coating between the particles by baking. The baking necessary to reduce surface leakage between particles to the desired extent also decreases the photosensitivity of the electrode somewhat, although not nearly as much as in the conventional electrode. In accordance with my invention, the photosensitivity of the particles may then be raised to a much greater value than heretofore obtainable by evaporating an exceedingly thin and preferably discontinuous film of metal, such as nickel, or preferably of a noble metal, such as silver, to coat the light sensitive particles with metal.

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 a television device for incorporating my invention, and

Figure 2 is an enlarged fragmentary sectional view of the photosensitive mosaic screen 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 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 or window 3 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 system 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 one or both of the deflection coils if desired. The electrode **2** is connected through the impedance **12** to ground and to the collector electrode or second anode **9**, and in operation the current flow in this circuit produces a voltage drop across the impedance **12** which may be impressed on the input of a translating device **13**, further amplified and applied to a transmitting network in a manner well known to the art.

In accordance with my invention, as best shown in Figure 2, an insulating foundation sheet or base **14** such as a sheet of mica is coated with metal or other electrically conducting material, such as a film of platinum which is coextensive with the base **14** and serves as a signal electrode from which the picture signals may be obtained. The other side of the sheet of mica has on its surface an insulating layer or film of a fluoride, such as cryolite, calcium fluoride, or sodium fluoride, on which the photosensitive mosaic surface which is scanned by the electron beam and on which the optical image to be transmitted is focused is formed. The mosaic surface is in capacitive relationship with the signal electrode. Further, in accordance with my invention I provide on the mosaic surface a coating of silver or other metal, such as the noble metals, nickel or the like, which increases the light sensitivity of the mosaic surface.

In making the mosaic electrode **2** a thin sheet of insulating material **14**, such as mica, having a plane surface and of uniform thickness is coated on one side with a thin continuous film **15** of electrically conducting material, such as platinum. The other side or front of the mica sheet **14** is then coated with a thin layer or film of insulation preferably by placing the mica sheet in a sealed glass envelope which may be evacuated.

The coating of the mica with a film of insulation may most conveniently be done by mounting within the sealed envelope a tungsten filament which may be heated to incandescence and which has been coated with the fluoride or other insulating material with which the mica sheet is to be coated. The envelope is then evacuated, and the filament heated to flash off enough of the material with which it is coated to produce the desired film. For example, I have obtained good results with a 4 by 5 inch sheet by placing a filament approximately 4 inches from the surface of the mica, and curving the mica sheet to form a cylindrical surface with the center of curvature at the filament. When using cryolite as a material with which to coat the mica, I prefer to evaporate about 1 milligram of cryolite to coat a mica surface of 20 square inches. If too much cryolite is deposited on the mica the optimum results are not obtained. By this procedure I obtain on the front surface of the mica sheet an exceedingly thin film **16** of cryolite, calcium fluoride or sodium fluoride which is believed to condense on the mica forming exceedingly minute crystals or flakes of the substance which overlap and effectively increase the distance from one elemental area to another.

To produce the photosensitive mosaic the sheet of mica is removed from the evacuated envelope, and the deposited film of cryolite is dusted with a finely divided metal compound, such as silver oxide, and the dusted sheet is rapidly heated in an oven at 800° C. until the silver oxide is reduced to silver, of which individual and minute portions are drawn up by surface tension to form a multiplicity of microscopic particles **17**, spaced from each other, the number and average size of the particles in a unit area being sufficient to satisfy the operating requirements in the way of detail of picture reproduction.

The mosaic surface may be formed however in a variety of ways in addition to the method described. Thus, for example, instead of using a metal compound which is applied to the cryolite film and subsequently reduced and drawn by surface tension into individual particles, a thin continuous film of silver may be deposited on the cryolite which is broken up into microscopic particles by suitable heat treatment.

The mica sheet carrying the particles or individual elements on the intermediate layer or film of cryolite **16** is then mounted in the tube as shown in Figure 1, the tube evacuated, and the silver particles oxidized and photosensitized by exposure to caesium vapor in the usual way. Somewhat more caesium may be used than in sensitizing the conventional mosaic, and thereby greater photosensitivity obtained without a correspondingly greater surface leakage.

During the exposure of the particles to caesium vapor some caesium condenses on the surface of the cryolite coating of the mica between the particles and thereby electrically connects the individual particles, consequently reducing the electrical resistance from particle to particle notwithstanding the long electrical path between particles provided by the cryolite coating. In photosensitization the tube is baked and simultaneously pumped until maximum photosensitivity is obtained, and during this baking and pumping most of the free caesium previously condensed on the cryolite between the particles is drawn off and taken up by a getter, such as a film **18** of stannic oxide. Caesium not drawn off appears to be so distributed over the large surface of cryolite between the particles that the electrical resistance of the path between particles is very high. The baking may be discontinued when the photosensitivity has passed the maximum and has decreased very slightly at which point the surface leakage is negligible, probably because the increased separation provided by the film of evaporated cryolite effectively isolates the particles. Following the photosensitizing process the tube is sealed off from the pump.

The tube thus constructed and treated is more sensitive than a tube with the conventional mosaic electrode, but may be made even more sensitive by further treatment in accordance with my invention. The tube is connected, as shown in Figure 1, an optical image of an object projected on the mosaic electrode **2**, and the mosaic electrode scanned with the cathode ray beam in a manner well known in the art. The picture signals derived from the signal electrode **12** are amplified by a series of amplifiers, such as the amplifier **13**, and the image projected on the mosaic **2** is recreated on a viewing tube (not shown). The resolution of the recreated image, which may be defined as the ability to distinguish two lines of an image which are close together, is noted to determine the surface condition of the photosensitive particles. A noble metal, such as silver, is then evaporated in the tube to form an exceedingly thin film on the photosensitized particles, this evaporation being continued until the resolution of the recreated image has been reduced to a fraction such as one-half of its previous value. The metal may be evaporated from a recess **19** in the wall of the tube **1** opposite the mosaic surface, but removed from the window through which the image of the object to be transmitted is projected. A tungsten filament 20 coated with silver or other metal to be evaporated is placed within this recess so that the metal projected from the filament coats the mosaic surface. Following the evaporation of silver from the filament 19 the tube is baked at 200° C. for approximately 7 to 10 minutes or until maximum photosensitivity is obtained.

Television transmitting tubes when made in accordance with my invention have shown sensitivities to light as high as three times those previously obtained.

While I do not wish to be limited by any particular theory to explain the improved sensitivity of my device, it seems probable that material such as cryolite, calcium fluoride, or sodium fluoride, when evaporated in a vacuum as described, condenses on the insulating surface in the form of overlapping crystals or flakes thereby forming a greatly increased resistance from point to point because of the greater leakage path. It is, therefore, possible to allow some excess caesium or other material used in the photosensitizing of the mosaic surface, to remain on this greatly increased surface without seriously increasing the electrical leakage from point to point. Therefore, optimum photosensitization of the mosaic may be obtained by limiting the baking of the mosaic to the time necessary for producing maximum photosensitivity rather than continuing to bake the tube to wholly remove the sensitizing material from the areas between the particles constituting the mosaic. Furthermore, the increased and overlapping surface between the various particles of the mosaic surface makes possible the subsequent evaporation of silver, or other metal, which would otherwise produce such excess electrical leakage from particle to particle of the mosaic as to make the device unsuitable for many applications. The improvement observed is attributed to the improved insulator for the mosaic elements and to the subsequent sensitizing process made possible by the use of such an insulator.

From the foregoing decription 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 television transmitting tube comprising an envelope having a transparent window for the transmission of an optical image, an electrode assembly including a non-conducting base in registry with said window, an intermediate thin lawer of overlapping crystals of an insulating material coextensive with and on one side of said base, a multiplicity of minute discrete photosensitive particles on said intermediate layer, a film of a noble metal on said particles and an electrically conducting material coextensive with and on said non-conducting base in capacitive relationship with said photosensitive particles.

2. A cathode ray television transmitting tube comprising an envelope having a transparent window for the transmission of an optical image, an electrode assembly including a non-conducting base in registry with said window, an intermediate thin layer of a material selected from the group consisting of cryolite, calcium fluoride, and sodium fluoride coextensive with, and on one side of said base, a multiplicity of discrete photosensitive particles each of minute size on said intermediate layer, and an electrically conducting material coextensive with and on said non-conducting base and in capacitive relationship with said photosensitive particles.

3. A cathode ray television transmitting tube comprising an envelope having a transparent window for the transmission of an optical image, an electrode assembly including a non-conducting base in registry with said window, an intermediate thin layer of a material selected from the group consisting of cryolite, calcium fluoride, and sodium fluoride coextensive with and on one side of said base, a multiplicity of discrete photosensitive particles each of minute size on said intermediate layer, a film of a noble metal on said particles and an electrically conductive coating coextensive with and on the opposite side of said non-conducting base.

4. A light sensitive mosaic electrode comprising a sheet of mica, an intermediate layer of a material selected from the group consisting of cryolite, calcium fluoride, and sodium fluoride coextensive with and on one side of said mica, a mosaic of minute discrete photosensitive particles on said intermediate layer and an electrical conductor coextensive with said mosaic and in capacitive relationship with said photosensitive particles.

5. A light sensitive mosaic electrode comprising a sheet of mica, an intermediate thin layer of cryolite coextensive with and on one side of said mica, a mosaic of minute discrete photosensitive particles on said intermediate layer, a film of silver on said particles and an electrical conductor coextensive with said mosaic and on the opposite side of said mica sheet.

6. A light sensitive mosaic electrode comprising an electrically non-conducting base, an intermediate thin insulating layer with a roughened surface coextensive with and supported by said base, a mosaic of minute discrete photosensitive particles on said intermediate layer, a film of silver on said particles and an electrical conductor co-extensive with and in capacitive relationship with said photosensitive particles.

7. The method of producing a cathode ray tube having a mosaic electrode of mutually separated photosensitive particles in an envelope which includes the steps of depositing a noble metal on the photosensitive particles after evacuation and sealing of the envelope, projecting an optical image on said mosaic electrode, scanning the electrode to produce picture signals representative of the optical image on said electrode, creating a picture replica of the optical image with the produced picture signals, determining the resolution of the picture replica, and limiting the deposit of the noble metal in accordance with the resolution of the picture replica.

8. The method of preparing a photosensitive mosaic surface upon an insulating target electrode for use in a cathode ray tube having means for producing a cathode ray beam for scanning said electrode which comprises the steps of forming a multiplicity of discrete metallic particles on said electrode, oxidizing the particles, photoelectrically sensitizing said particles by depositing alkali metal thereon, removing the excess alkali metal from areas intermediate the particles, tracing the developed cathode ray beam across the photosensitive particles to determine the resolution produced by the particles, depositing conducting material upon the photosensitive

particles simultaneously with the scanning operation until the resolution has been reduced to a fraction of its previous value thereby limiting the period of deposition of the conducting material in accordance with observations of the signals resulting from scanning and subsequently heating the electrode to further photosensitize said particles.

9. The method of preparing a photosensitive mosaic surface on an insulating target electrode for use within a cathode ray tube incorporating means for developing and scanning a cathode ray beam, which comprises the steps of depositing a continuous film of conductive material upon the target electrode, heating the film to form a multiplicity of electrically isolated particles, oxidizing the formed particles, photoelectrically sensitizing the formed particles by depositing an alkali metal thereon, removing excess alkali metal from areas intermediate the formed particles, projecting an optical image on said particles, tracing the developed cathode ray beam over the formed particles to produce electrical signals representative of the optical image, producing a replica of the optical image with said electrical signals, determining the resolution of said optical image replica, depositing additional conducting material upon the formed particles simultaneously with the scanning operation until the resolution of the optical image replica has been reduced to a fraction of its previous value thereby effectively limiting the period of deposition of the additional conducting material in accordance with observations of the signals resulting from scanning and subsequently heating the target electrode to further photosensitize said particles.

10. The method of improving the sensitivity of a mosaic electrode structure formed from photoelectrically sensitized discrete particles of conducting material supported on an insulating base within a cathode ray tube wherein a cathode ray beam for scanning is developed, which comprises the steps of tracing the developed cathode ray beam across said metallic particles, determining the resolution of which the electrode structure, is capable, depositing additional conducting material upon the photosensitive particles simultaneously with the scanning operation until the resolution has been reduced to one-half of its previous value thereby effectively limiting the period of deposition of the additional conducting material in accordance with observations of the signals resulting from scanning and subsequently heating the base to a temperature range of the order of 200° C.

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