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PICKUP TUBE HAVING A CESIATED PHOTOCATHODE AND A SUBSTANTIALLY  
LEAKAGE-FREE TARGET, AND METHOD OF  
MAKING THE SAME  
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3,179,835

*Fig. 1.*

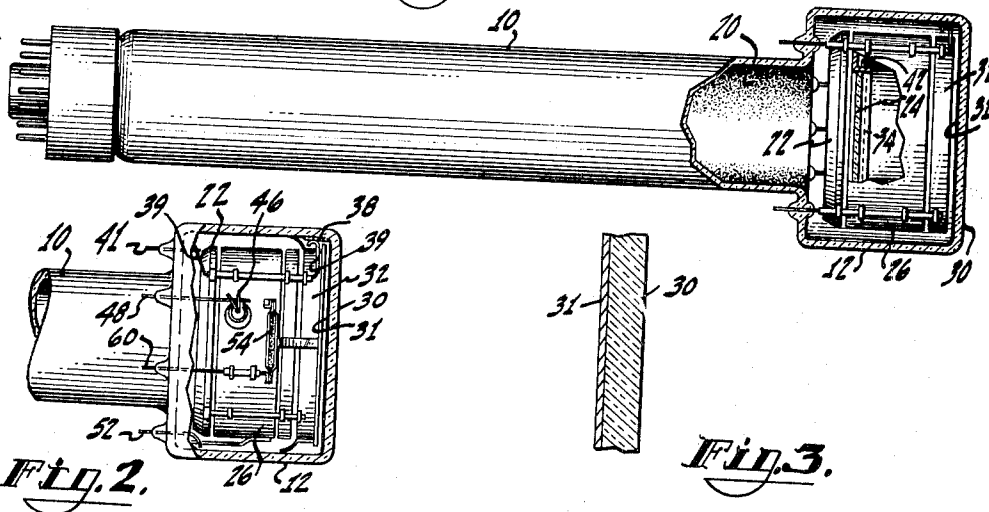
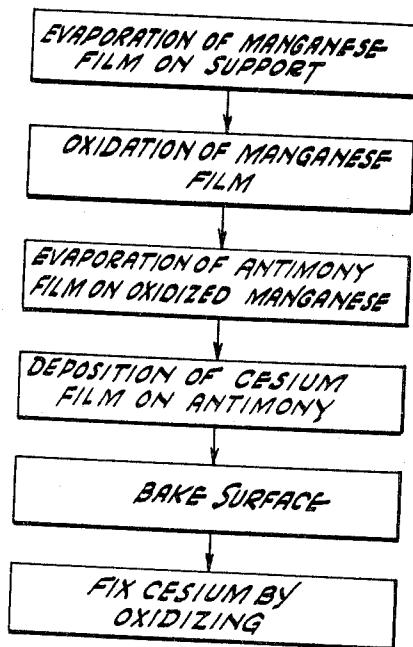


*Fig. 2.*

*Fig. 3.*

*Fig. 4.*



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## PICKUP TUBE HAVING A CESIATED PHOTO-CATHODE AND A SUBSTANTIALLY LEAKAGE-FREE TARGET, AND METHOD OF MAKING THE SAME

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This invention relates to a photosurface, and particularly to a photoemissive surface which may be especially useful for a photoemissive cathode and a method of making the same for use in a pickup or camera tube for television.

One type of television camera or pickup tube is the image orthicon tube. In the image orthicon type of television pickup tube several different photoemissive surfaces have found general application. One photosurface which has been suggested for use in this type of tube, as well as in other photosensitive devices, is a photosurface that is commercially available and is known as the S-11 photosurface. Such a photosurface includes the materials of manganese, oxygen, antimony and cesium and is described in detail in Polkosky, U.S. Patent No. 2,676,282. It has been found that, while this photosurface, which is a semi-transparent surface, is excellent for many tube types, such as photomultiplier tubes, this photosurface has certain limitations when one attempts to use this surface in an image orthicon type pickup tube.

As an example, if the S-11 photosurface is deposited in the order of antimony-cesium-oxygen, for use in an image orthicon, the sensitivity of the resultant photosurface attains only a medium level. Depositing the materials in the order of manganese-oxygen-antimony-cesium results in a photosurface that has very high sensitivity. However, when the photosurface is deposited in this order in a pickup tube, the pickup tube has target leakage, i.e., the electrical charge image tends to spread across the surface of the glass storage target. Also, when processed in the last mentioned order, the photocathode of an image orthicon tube tends to have poor stability due to the excess of free cesium which normally is used for a pickup tube photosensitive surface. The poor stability refers to the decrease in sensitivity of the target with respect to time.

It is therefore an object of this invention to provide an improved photosurface.

It is another object of this invention to provide a photosensitive camera tube having a novel photocathode of improved sensitivity.

It is a further object of this invention to provide a photosensitive image orthicon type pickup tube, and novel method of making the same, having a photocathode characterized by its substantial freedom from target leakage.

These and other objects are accomplished in accordance with the general aspects of this invention by providing an image orthicon pickup tube having a photosensitive surface of manganese, oxygen, antimony, cesium and oxygen applied in the order recited. Target leakage is prevented in the improved tube by "fixing" the cesium by the last mentioned oxygen treatment.

The invention will be more clearly understood by reference to the accompanying single sheet of drawings wherein:

FIG. 1 is a sectional view partially broken away of a television camera or pickup tube of the image orthicon type embodying the invention and having a photosurface made in accordance therewith;

FIG. 2 is a side view, partly in section, of the image portion end of the tube shown in FIG. 1;

FIG. 3 is a greatly enlarged fragmentary sectional view

of the photocathode of the tube shown in FIGS. 1 and 2; and,

FIG. 4 is a flow chart of a method of making the photosurface of the photocathode of FIG. 3.

The particular photosensitive surface which is the subject of this invention is applied to a transparent supporting surface. A specific use of the new photosurface may be in a television camera or pickup tube of the image orthicon type in which a transparent photocathode is used and the supporting surface is that of the end of the tube.

In FIG. 1 is shown a television pickup tube 10 utilizing a photoemissive surface made in accordance with this invention. In operation of the tube shown in FIG. 1, a scene which is to be televised is focused upon the end plate 30 of the tube envelope 10. Photoelectrons are released from a semi-transparent photoemissive surface 31, formed on the inner surface of the face plate 30. The photoelectrons are accelerated through an image section 12 by a ring electrode 32 so that they will strike a surface of a thin target 24, usually made of glass, with sufficient energy to cause secondary electron emission greater than unity from this surface of target 24. An electromagnetic coil (not shown) surrounding the envelope 10, provides a field coaxial with the tube envelope 10 for focusing the photoemission onto the glass target 24. A fine mesh screen 34 is closely spaced from the surface of target 24 and functions as a collector electrode for the secondary electron emission. The secondary electron emission from the surface of the glass target 24 leaves a positive charge pattern on the glass target surface corresponding to the optical image focused upon the photocathode 31. The opposite side of the glass target 24, remote from photocathode 31, is scanned by an electron beam formed by an electron gun structure (not shown in detail), positioned in the other end of the envelope 10 and including a final accelerating electrode 20. The electron beam is caused to approach the opposite side of target 24 at close to zero velocity through the use of a decelerating electrode 22. Due to the extreme thinness of the glass target 24, the electrostatic pattern on the photocathode side of the target 24 establishes the same image potential pattern on this opposite side of the target 24, i.e., the side toward the electron beam. Electrons from the cathode ray beam are scanned over the target surface and will be deposited on the positive areas of the target to neutralize the positive areas of the potential pattern on the glass target 24. The deposited beam electrons first discharge the surface of glass target 24 to cathode potential, and then the remainder of the beam is reflected back along the tube axis toward the electron gun structure. This return beam is amplified by passing it through a conventional multiplier section (not shown) in which it is finally collected to form the video or output signal of the tube.

As shown in FIG. 2, the photoemissive surface 31 of the tube of FIGURE 1 is connected to an external circuit through a silver stripe 38 in contact with the layer 31 and a lead 39 connected between stripe 38 and a stem pin 41.

The photosurface 31 in one example of the invention, is made in accordance with the following procedure which is summarized in the flow chart shown in FIG. 4. The oxidized manganese film of the photosurface 31 may be formed on the uncoated inner portion of the end wall 30 either before or after the electrode mount structure is sealed into the envelope. The method of formation in both cases is similar. It has been found, however, that it is an advantage to oxidize the manganese film after sealing the mount structure into the tube because the manganese oxide appears to take up water vapor, if it is exposed to the atmosphere before the tube has been sealed. Before sealing the electrode mount structure into the envelope 10, a filament or pellet 42 (FIG. 1), of pure

3  
manganese metal, is mounted within the cylindrical accelerating electrode 26 and beyond the peripheral edge of the mesh 34. One end of the filament 42 is connected to the lead 46 and to a stem pin 48 (FIG. 2). The other end of the manganese filament is connected to the inner surface of the accelerating electrode 26. The filament 42 may be commercial grade electrolytic manganese, consisting of pure manganese having a maximum of approximately 0.1% of sulfur and iron. In this manner, the filament 42 is mounted close to the face plate 30 upon which the photosurface is to be formed when the manganese is evaporated from the filament 42. Two or more filaments 42 may be arranged symmetrically about the axis of the supporting surface 30 for uniform distribution of the manganese.

The tube 10, in which the photosurface is to be formed, is first processed and evacuated, and then baked between 375°-400° C., for one hour to remove occluded gases from the envelope. The metal electrodes within the tube are then heated and degassed, as is well known in the art. Also, the thermionic cathode is activated at this point.

In order to measure the amount of material deposited on the inner surface of the face plate 30, a light source (not shown) is arranged above the tube end wall or face plate 30 and light directed through the envelope onto a photoelectric tube (not shown) to indicate the transparency of the face plate 30, and thus the amount of material deposited on the face plate may be indicated. The indicator can be adjusted to show a scale reading of 100 at full transmission of the light through the envelope face plate 30. While the envelope 10 is still being evacuated, a current is passed through the filament or pellet 42 by means of lead-in pins 48 and 52 to heat and evaporate the manganese therefrom. The evaporated manganese will condense upon the adjacent envelope wall portion and form a thin coating on the end wall 30. The manganese metal is evaporated until the light transmission or transparency has been reduced to 90% of its original value. This thickness of the manganese film is not critical and high sensitivity surfaces may be obtained with layers so thick as to afford 50% light transmission compared to the uncoated end wall or so thin as to afford 95% light transmission.

Oxygen is next introduced into the bulb through the exhaust tubulation, to a pressure of about 700 microns of mercury. The transparent manganese film is oxidized by the use of, for example, a high frequency wand (not shown) placed over the end wall 30. The high frequency potential of the wand produces within the envelope a gaseous discharge which causes the manganese to react with the oxygen in the envelope. The wand is moved over the end wall 30 for about two seconds. This method of oxidizing metal films within an envelope is well known and is fully described in Essig, U.S. Patent No. 2,020,305. The oxygen in the envelope is then removed through the exhaust tubulation. At this time, the reading of the indicator that measured transmission through the face plate is then reset to indicate 100.

An antimony film is next put down over the oxidized manganese surface, also by evaporation of the antimony in vacuum. An antimony containing filament (not shown) is also provided between one of the leads and the accelerating electrode 26 and within the electrode 26 similar to the manganese filament 42. The antimony may be high grade commercial antimony having a composition of substantially 99.88% antimony and traces of iron, sulfur, arsenic and lead. Passing a current through the antimony filament evaporates the antimony and provides a film of antimony over the oxidized manganese deposit on the end wall 30. The evaporation of the antimony is continued until the light transmission through the end wall is approximately 50 to 85 percent of its value without the evaporated antimony layer.

Cesium is then released into the evacuated envelope by heating another container 54 having cesium therein and

mounted on a lead-in pin 60. The released cesium permeates throughout the evacuated envelope and deposits over the antimony film on the end wall 30. The cesium is evaporated to provide at least enough cesium to completely react with the total amount of antimony on the oxidized manganese on the end wall 30. In order to insure that all of the antimony has been cesiated, as a practical matter, an excessive amount of cesium is preferably introduced into the envelope 10. The tube is then baked in an oven, at a temperature of approximately between 120° C. and 200° C., to promote an activating reaction between the cesium and the antimony.

After the above steps have been performed, and while the tube is still on the exhaust system, the tube is cooled to approximately room temperature. At this time sufficient oxygen is introduced into the tube to "fix" any excess cesium. Although the phenomena is not exactly understood, it is believed that the excess cesium is "fixed" by converting the free cesium into cesium-oxide. An example of a means for "fixing" the free cesium in the tube is as follows: While the tube 10 is still on the exhaust system, oxygen is introduced into the tube until the pressure is approximately  $15 \times 10^{-5}$  mm. of Hg. The oxygen is introduced in three doses, 2 or 3 seconds each, but not held so that the exhaust pump removes the oxygen shortly after its introduction.

This extra oxygen treatment "fixes" the cesium in the parts of the tube which are away from the photocathode without materially affecting the photocathode itself. Thus, the extra oxygen reacts with all of the free cesium within the envelope to form cesium oxide. Since cesium oxide does not have the migrating properties of free cesium, the cesium oxide is "fixed" in its positions within the tube. Since the excess cesium is now "fixed," target leakage in the image orthicon type pickup tube is eliminated while the photosurface still has its usual very high sensitivity. Also, the extra oxygen treatment has been found to make the tube more stable in that variations in photosurface sensitivity, with respect to time, are substantially eliminated. The extra oxygen treatment has also been found to improve the blue sensitivity of the photosurface in tubes of this type.

What is claimed is:

1. A television pickup tube having a photosensitive cathode and a target, said cathode comprising a transparent support base element, an oxidized manganese film on said base element, a deposit of antimony on said oxidized manganese film, and a deposit of cesium on said deposit of antimony, said target comprising a relatively thin structure having thereon a deposit of cesium oxide, whereby said target is substantially free from leakage.

2. In a method of making a pickup tube having an evacuated envelope enclosing a photoemissive cathode and a storage target, the steps in the order recited of depositing a layer of manganese on the face plate of said envelope, oxidizing said manganese, depositing antimony on said oxidized manganese, flashing at least enough cesium within said envelope to cesiate said antimony, whereby excess cesium is deposited on said target, and fixing said excess cesium on said target by exposing said excess cesium to oxygen, while substantially preserving said cathode from said oxygen.

3. In a method of making a camera tube having a photosurface and a storage target, the steps of depositing a photosurface of the type including a manganese oxide layer having a cesiated-antimony layer thereon, and a layer of free cesium on said target, and subsequently admitting oxygen into said tube to fix said free layer of cesium while substantially preserving said photosurface from said oxygen.

4. In a method of making a camera tube of the type having a photosurface and a storage target, the steps in the order recited of depositing manganese on a substrate, oxidizing said manganese, depositing antimony on said oxidized manganese, cesiating said antimony in such a way

5

3,179,835

that excess cesium is unavoidably deposited on said target, and introducing oxygen into said tube for fixing substantially only said excess cesium on said target, whereby said target is substantially free from charge leakage thereacross.

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6

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