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PICKUP TUBE TARGET STRUCTURE AND METHOD OF MANUFACTURING THE SAME

Filed Oct. 27, 1960

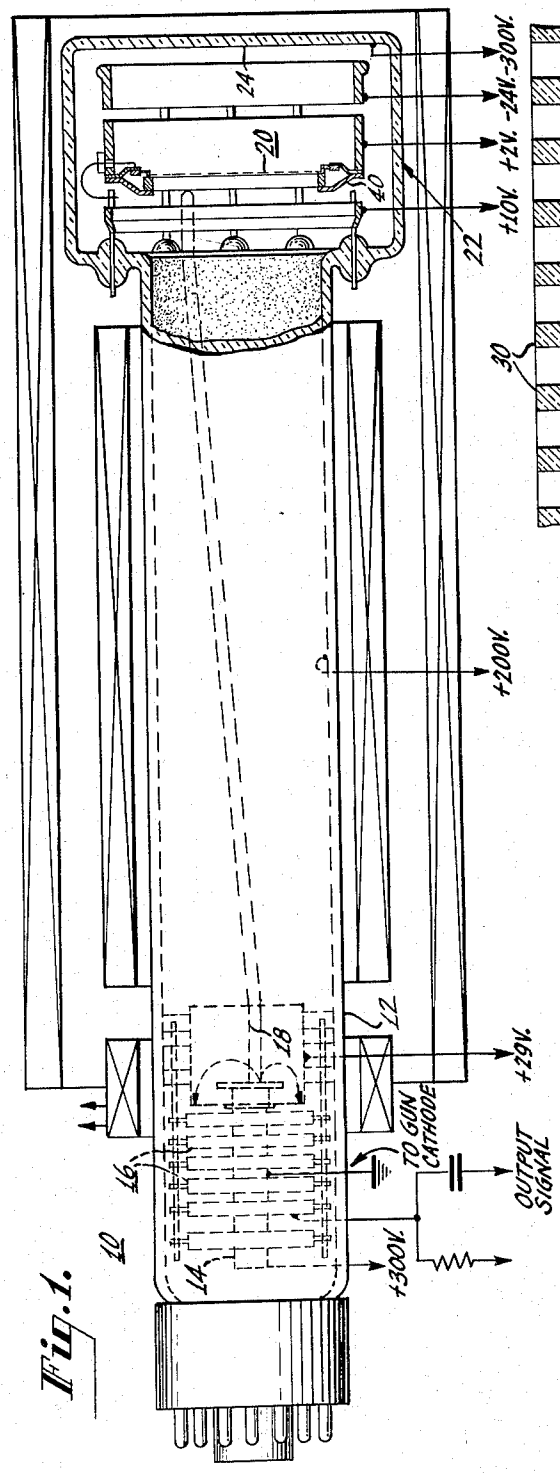


Fig. 1.

Fig. 3.

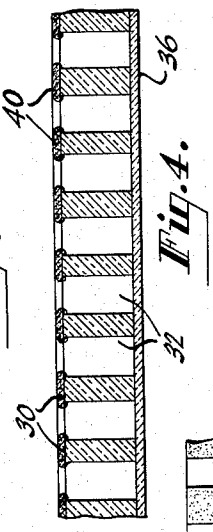


Fig. 4.

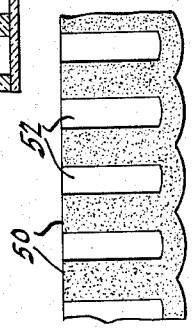


Fig. 5.

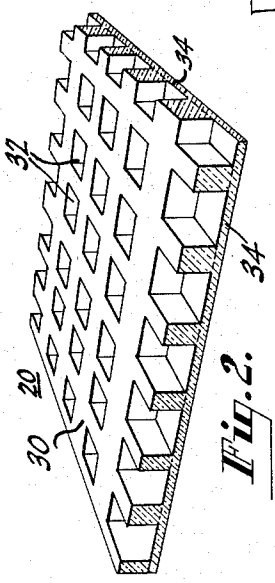


Fig. 2.

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This invention relates to target structures for use in pickup or camera tubes, and methods of making such targets. In particular, this invention relates to two-sided, image storage type, target structures for use in photoemissive type pickup tubes.

During operation of conventional image orthicon type camera tubes, a light image on a photocathode produces photoelectrons in proportion to the light from a scene to be reproduced and these photoelectrons are directed from the photocathode, as a photoelectron image, onto one side of a semi-conducting type glass target. Just prior to reaching the target, the photoelectrons pass through an apertured mesh screen or collector electrode. When the photoelectrons land on the target, these photoelectrons produce a potential variation, or stored image, on the opposite side of the target corresponding to the photoelectron image. An electron beams scans the stored image, removes the stored image, and produces an output signal in proportion to the original photoelectron image.

One type of target material that has been used for image orthicon type camera tubes prior to this invention is a thin membrane of lime glass. It has been found that, when using glass targets of this type, the resistivity of the target increases somewhat as the tube is operated. Since the conductivity of the lime glass is ionic in nature. the cause of this increase in resistivity is due, in part, to a depletion of the positive ions on the image side of the target. As the resistivity increase occurs, excessive "sticking," or picture retention, occurs which limits the useful life of the tube. Also, because of the ionic nature of the conduction in the lime glass, the temperature range throughout which the target may be operated, is limited.

Due to the thickness of the lime glass targets, which thickness is necessary to provide a self-supporting glass structure, the resistance across the target is limited. Because of this limitation, the resolution that can be obtained, when using a storage time of much more than $\frac{1}{30}$ of a second frame time, is limited. This limitation prevents the use of these targets in tubes wherein it is desirable to use relatively long frame storage times.

It has also been suggested that a target for a photoemissive pickup tube can be constructed using an insulating plate having a plurality of apertures therethrough, with a conductive material positioned in each of the apertures. One of the difficulties of this type of target structure is that the number of conductors that can be provided within a given area is low as compared to the number of elemental units that are desired for high picture definition.

It is therefore an object of this invention to provide an improved target electrode assembly for use in an image orthicon type pickup tube.

It is a further object of this invention to provide an improved pickup tube characterized in its long frame time capabilities coupled with its high picture definition.

It is a still further object of this invention to provide an improved method of manufacturing a storage target for a photoemissive type pickup tube.

These and other objects are accomplished in accordance with this invention by providing a novel pickup tube including a target assembly comprising a porous oxidized aluminum member. The pores of the aluminum oxide may be in their natural pattern or may be provided in a predetermined array. The pores may be closed with thin

films of aluminum oxide, with the films functioning as the storage area, or a thin continuous film of an effective semi-conductor, such as aluminum oxide, may be supported on the porous aluminum oxide support structure. The novel method of this invention includes an economical means for providing the aluminum oxide support member on a rigid support ring. In each embodiment of this invention of an improved camera tube, the electron image is stored on an effective semi-conducting surface which is supported by the porous aluminum oxide member.

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

FIG. 1 is a transverse sectional view of an improved image orthicon tube utilizing this invention;

FIG. 2 is an enlarged fragmentary perspective view of the target electrode shown in FIG. 1, and;

FIGS. 3 through 5 are sectional views of other embodiments of target structures made in accordance with this invention.

Referring now to the drawing in detail, and specifically to FIG. 1, an image orthicon tube **10** is shown. The image orthicon tube **10** comprises an evacuated envelope **12** having an electron gun **14** in one end thereof. Surrounding the electron gun **14** is an electron multiplier structure **16**. The electron gun **14** is designed to produce an electron beam **18** which is scanned over one side of a novel target electrode **20**.

On the opposite side of the target electrode **20**, and within an enlarged end of the envelope **12**, there is an image section **22**. The image section **22** comprises a photoemissive cathode **24** and its associated electrodes. During operation of the pickup tube **10**, the photocathode **24** produces an electron image corresponding to the light from a scene to be reproduced. The photoelectron image is directed onto the target asesmbly **20**.

The particular elements that have been described, other than the novel target assembly **20**, may be conventional and form no part of this invention except for their cooperation with the novel target **20**. If desired, a more detailed description of the other portions of an image orthicon pickup tube may be obtained by referring to one or more of many issued patents, such as Weimer Patent No. 2,537,250; Law Patent No. 2,460,093 or Weimer Patent No. 2,433,941.

As was previously pointed out, the image orthicon type pickup tubes using the prior art targets, such as lime glass, have a tendency to retain the charge image, after a certain period of tube operation. Thus, the life of these tubes is limited by picture "sticking." Two of the factors which are believed to be significant in the occurrence of excessive "sticking" are the operating temperature and the ionic conduction of the glass target.

In accordance with this invention, the target **20** comprises a porous aluminum oxide structure which is an electronic conductor. Such a target has been operated over a temperature range as great as 45° C. without undue loss of resolution. The target **20**, which is shown more clearly in FIG. 2, includes a thin aluminum support member **30** which has been oxidized, preferably by anodizing. On the support member **30** there is an oxidized aluminum storage area which is effectively a leaky electrical insulator or a resistive type semi-conductor as will be explained.

The aluminum oxide member **30** in one example, was approximately 15 microns thick. In the aluminum oxide member **30** there is provided a large number, e.g., approximately 5×10^5 per square inch is preferred, of apertures or pores **32**. At the bottom of each of the apertures or pores **32** is a non-porous, very thin, e.g., approximately

100 Angstrom units, film, or storage area, of aluminum oxide 34.

During operation of the target shown in FIG. 2, the electrical signal is stored on the elemental units each consisting of a thin, non-porous film 34 at the bottom of each of the apertures or pores 32. Since any desired number of apertures per inch, i.e., 750 to 3,000, may be provided in the member 30, any desired picture resolution may be obtained.

The target described in FIG. 2 may be made by anodizing a sheet of aluminum, which may be approximately eight to twelve mils thick, in a suitable electrolyte, such as sulfuric or phosphoric acid, so as to form a porous aluminum oxide coating on both sides each of which is approximately 10 microns thick. At this time, a fine, for example 750 or more lines per inch, mesh screen pattern of a photoresist is applied to one side of the aluminum sheet, and a suitable masking material, e.g., masking tape, is applied to the other side of the aluminum sheet. A suitable technique for forming the photoresist mesh pattern includes applying a layer of any suitable commercially available photoresist, such as Kodak KPR photoresist material, to the one surface of the aluminum oxide. The photoresist material is then exposed to ultra violet light through a mask consisting of opaque squares and then the unexposed portions of the photoresist material are removed. The unexposed portion of the photoresist material may be removed by rinsing the target in xylol.

The aluminium oxide layer is then etched, for example with hydrochloric acid. The etching step will affect only the areas which have been exposed by the removed photoresist between the hardened photoresist material. The etching is continued until pure aluminum, i.e., the non-anodized aluminum, is reached, which may be several minutes. At this stage of manufacture, the aluminum sheet has the mesh pattern 32 of aluminum oxide on one side and a continuous sheet of aluminum oxide on the other. The exposed aluminum is then anodized in an electrolyte bath, i.e., the bottom of each pore is anodized, to form the very thin film of non-porous aluminum oxide 34 in these areas. The anodizing may be done, for example, by means of ammonium citrate or tartrate electrolyte. The preferred thickness of the film 34 is approximately 100 Angstrom units or less and corresponds to an anodizing voltage of approximately 5 volts.

At this stage, the hardened photoresist mesh is removed from the aluminum oxide 32 by a suitable solvent, such as 2-ethoxyethyl acitate, and the masking tape is removed from the other side of the aluminum sheet. Then, the continuous aluminum oxide layer is removed, for example by etching a selected area in sodium hydroxide, and the body of the aluminum sheet is removed, for example by etching in approximately 50% hydrochloric acid, which preferentially attacks the aluminum. Thus, the resulting structure which remains is the target of a porous aluminum oxide structure having each pore closed by an aluminum oxide film as shown in FIG. 2.

In the target shown in FIG. 2, the storage region is believed to be the very thin, non-porous aluminum oxide areas 34. These areas 34 are sufficiently thin and/or conducting, in the transverse direction, so that under ordinary operating conditions, there is no "sticking" of the image. Also, since the conductivity of the target is of electronic rather than ionic nature, the conductivity will not deteriorate with the age of the target. Thus, the target shown in FIG. 2 is capable of increased operating life.

The theory of operation of the target shown in FIG. 2 is not completely understood. The charge conduction transversely through the elements 34 is believed to occur either because of the relatively large voltage gradient which exists because of the extremely thin transverse dimension of the elemental units 34, or in the alternative, the charge conduction may occur because the resistivity of aluminum oxide, when processed as described, is lower

than the resistivity which would be expected from a thicker sheet of aluminum oxide.

Referring now to FIG. 3, there is shown an embodiment of this invention wherein the aluminum oxide member 30 has apertures or pores 32 etched completely therethrough. In this embodiment, after the apertures 32 have been etched, as has been described, a thin film of semi-conducting material 36 is deposited on one surface of the aluminum oxide 30. The semi-conducting material 36 may be a material such as aluminum oxide or magnesium oxide. The embodiment shown in FIG. 3 differs from FIG. 2 in that the film 36 is continuous, and extends over the lands of the aluminum oxide layer 30, rather than being positioned within the pores 32.

The continuous film 36 may be provided on the thin aluminum oxide member 30 by applying a coating of a cellulose nitrate onto the aluminum oxide in any suitable manner, such as spraying, and then evaporating a thin film of material, for example, aluminum or magnesium, onto the coating of cellulose nitrate. When this has been done, the aluminum or magnesium is oxidized and the target is baked to remove the cellulose nitrate coating.

Referring now to FIG. 4 there is shown an embodiment of this invention wherein a collector grid 40 is provided on one surface of the porous aluminum oxide structure 30, while the continuous thin film of semi-conducting material 36 is provided on the other surface. The collector grid 40 may be provided by evaporating conductive material onto the aluminum oxide lands while the evaporator is positioned at an acute angle with respect to plane of the aluminum oxide member 30. Because of this angled evaporation, some material will be deposited down into the apertures 32.

The embodiment shown in FIG. 4 is particularly useful when the image orthicon tube shown in FIG. 1 is to be used under severe movement or motion conditions. The reason for this is that, since the collector grid 40 is fixed to the aluminum oxide support member 30, as is the semi-conducting coating 36, relative movement between the storage area 36 and the collector grid 40 is prevented.

Referring now to FIG. 5, there is shown an embodiment of this invention in which the aluminum oxide film 50 is relatively thin, for example, one to two microns and in which the natural pores of the anodized aluminum oxide are used rather than a predetermined array or pattern of pores. Because of the extreme thinness of the target, it is not known whether the charge is stored on the lands or in the material at the bottom of the pores, or both, of the oxidized aluminum film.

In this embodiment, a sheet of aluminum which may be for example approximately 10 mils thick, is anodized, for example by sulfuric or phosphoric acid, so as to yield a thin porous aluminum oxide layer on each surface of the aluminum sheet. The aluminum oxide on one side of the work member is then removed from a selected region. Normally, the region selected would have an area equal to the desired target size of the image orthicon and with a peripheral area remaining which will subsequently function as a support ring for the target. The aluminum oxide may be removed in the selected region by painting the selected region with sodium hydroxide which will remove the aluminum oxide. After this has been done, the sheet of aluminum is rinsed in water and then is dipped in hydrochloric acid to dissolve the aluminum but which will not attack the aluminum oxide region. In this manner, the aluminum oxide film 50 on the opposite side of the sheet of aluminum is isolated and forms a self-supporting porous aluminum oxide film.

As was stated, the phenomena of the operation of the targets are not clearly understood. The charge storage and conduction transversely through the targets made in accordance with this invention may occur because of the semi-conducting properties of the charge storage area. In the alternative, the charge storage area may have such

a high resistivity that picture sticking would normally occur. However, because of the extreme thinness of the charge storage area, an extremely large potential gradient, of the order of 1,000,000 volts/cm., exists in the transverse direction through the charge storage area resulting in the desired operation. Therefore, it should be understood that the term effective semi-conductor, or effective semi-conducting material as used in this application, is meant to include materials having a resistivity of approximately 10" ohm-centimeters as well as materials of higher insulating properties and which are extremely thin in the transverse direction.

In all of the embodiments of this invention, the charge storage surface is supported upon a porous anodized aluminum oxide support structure. The charge storage surface is aluminum oxide in the embodiments shown in FIGS. 2 and 5 and is aluminum oxide or other semi-conducting member in the case of the embodiments 3 and 4. Due to the fact that the targets made in accordance with this invention conduct by electron conduction, rather than ionic conduction, the problem of image sticking does not occur and extended tube life will result.

What is claimed is:

1. A target electrode for use in a tube comprising a porous aluminum oxide electrically insulating support member having a plurality of apertures therein, and a plurality of non-porous aluminum oxide elements closing adjacent ends of said apertures, each of said elements being substantially thinner than the thickness of said support member, said support member and said aluminum oxide elements being of a continuous unitary construction.

2. A target electrode as in claim 1 wherein the number of said apertures per linear inch is at least 750.

3. A target electrode for a pickup tube, comprising a continuous sheet of aluminum oxide having a multiplicity

of recesses extending from one side nearly through said sheet, the thickness of the regions of said aluminum oxide at the bottoms of said recesses being very small relative to the thickness of said sheet, whereby said regions are effectively semi-conductive in the direction transverse to said sheet.

4. A target electrode for an electron tube comprising an aluminum oxide support member having a matrix of apertures therein and a membrane consisting of aluminum oxide closing the ends of said apertures, said support and membrane having a continuous unitary construction.

5. A target electrode for an electron tube comprising a sheet made of aluminum oxide, said sheet consisting of a matrix of recesses, said recesses having side walls and bottoms, said side walls being made of aluminum oxide having pores in their natural pattern, said bottoms being made of aluminum oxide and being appreciably thinner than said sheet and defining a membrane, said side walls and membrane of said matrix having a continuous unitary structure.

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