

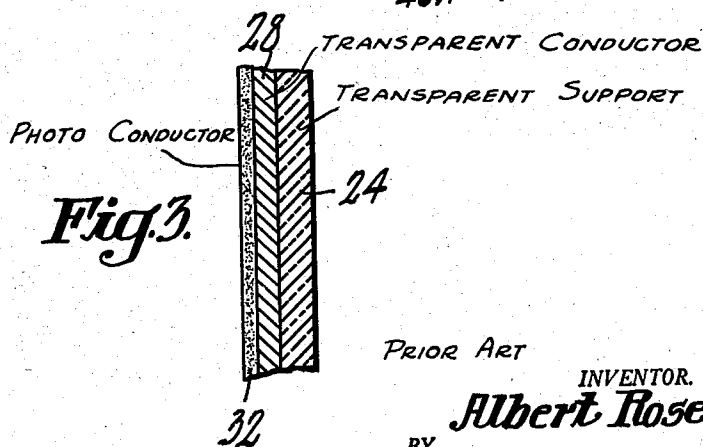
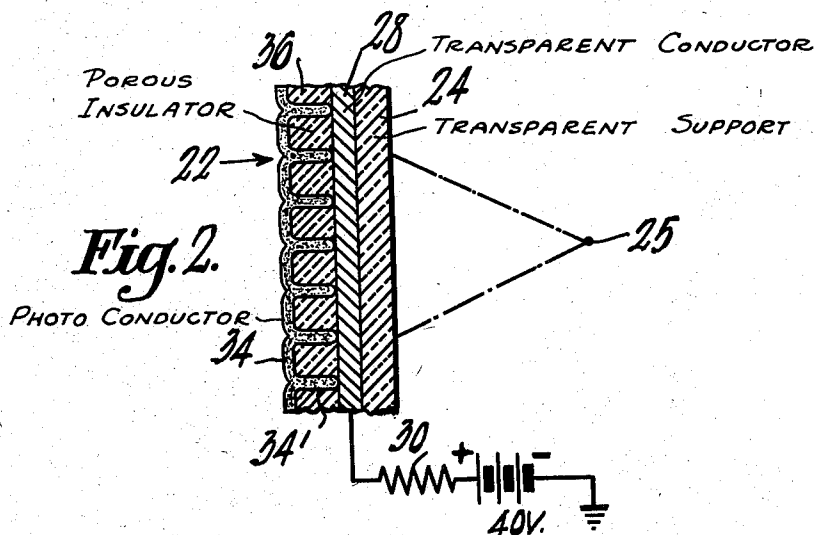
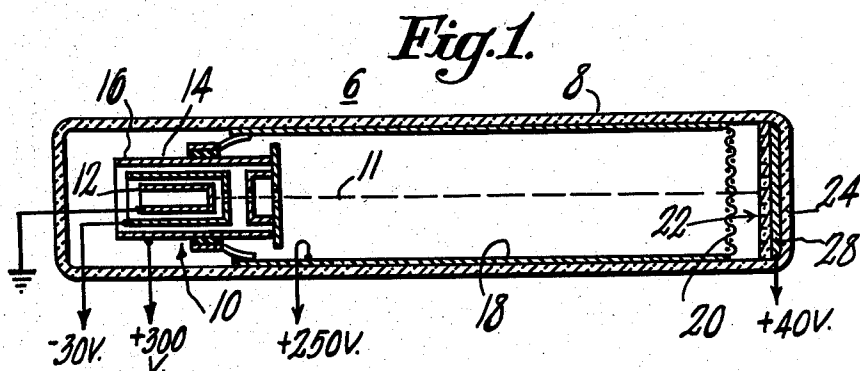
April 7, 1959

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2,881,340

PHOTOCONDUCTIVE TELEVISION PICKUP TUBE

Filed March 2, 1956



PRIOR ART

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1

2,881,340

PHOTOCONDUCTIVE TELEVISION PICKUP TUBE

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Application March 2, 1956, Serial No. 569,022

11 Claims. (Cl. 313—65)

This invention relates to electron tubes, and more especially to tubes having photo-responsive variably conductive targets.

A principal object of the invention is to provide a novel photoconductive target for a television pickup, or camera tube.

Another object is to improve the transducing characteristics of a photoconductive target such as is used in television pickup tubes and the like.

A further object is to improve the operating performance characteristics of light-transducing targets of the kind employing antimony tri-sulphide as the light-transducing material.

The invention finds its primary utility in television camera tubes of the type generally comprising an evacuated bulb within which is mounted an electron gun of any well known construction for developing a deflectable scanning beam of electrons. These electrons are focused and deflected in the desired scanning pattern over a photoconductive target. The target has the property of coating mutually with the scanning electron beam and with the light intensity existent on each successive elemental area of the target, so as to cause the elemental areas of the target to change their conductivity and to produce signal currents under control of the scanning beam. The target is usually supported on a light transparent glass backing, which may be constituted of the end wall or face plate of the glass bulb. Such a target usually consists of a highly conductive light transparent layer, or signal plate, which is coated or otherwise applied to the inner surface of the glass support facing the electron gun, and then a layer of photoconductive material, such for example as antimony tri-sulphide, is applied over the conducting layer.

The photoconductive layer of the target, whether it be antimony tri-sulphide or any other photoconductive material, is normally a rather good insulator when not exposed to light, and it varies its electrical conductance at each elemental area thereof in accordance with the variation of light intensity as each such area is exposed. In other words, the conductivity of the photoconductive layer is proportional to the amount of light exciting it and the conductivity variation is limited to the particular area which is so excited. Thus, when the surface of such material is subjected to light from a scene or subject to be televised, the various elemental areas change their normal non-conductance condition to correspond respectively with the light intensities from respective elemental areas of the scene or subject being televised.

One of the important characteristics that such photoconductive targets should have is a suitable time lag between the instant a given elemental area has its light excitation changed and the return of the said area to its normal non-conductivity or datum conductivity. As is well known, the photoconductive target is usually scanned in successive linear elements which together constitute a so-called frame scan, and while it is desirable that

2

there be a certain amount of lag in the target's returning to its non-conductive or datum conductance, such lag should not exceed the frame scan time. In other words, a charge storing condenser is formed by the conductive layer on one side and the scanned surface of the photoconductor on the other side having a dielectric, i.e. the photoconductor, whose charge leakage of elemental areas varies with the incident light.

It has been proposed heretofore to make the photoconductive material as a relatively smooth layer, for example of antimony tri-sulphide, usually by evaporating the antimony tri-sulphide on to the conductive layer in a vacuum and condensing it on that layer. While such targets have been found excellent in practice, it has been found that under certain conditions, the time lag of the photoconductive charge leakage effect may be protracted for more than the frame scan time. If an attempt is made to reduce this lag by using high levels of light intensity for excitation of the target, the conductivity of the target rises to such a value that its range of charge leakage variation over the operating range of light values may render the target unsatisfactory in a television pickup tube.

Accordingly, it is an important feature of the present invention to provide a photoconductive target which can be subjected to relatively high light intensities while maintaining the desired relatively wide variation of target conductivity, or charge leakage, between the variations of intensity of the exciting light.

Another feature of the invention relates to a composite photoconductive target comprising a light transparent, highly conductive stratum and a superposed composite stratum including a photoconductive material which is carried by a somewhat porous insulating material into the pores of which the photoconductive material has migrated to the required extent, the insulating material is sufficiently thin or of a selected material so as to be substantially light transparent.

Another feature of the invention relates to a photoconductive target comprising a stratum of highly conductive, light transparent material on which is superposed a composite stratum comprised of a somewhat porous, light transparent insulator into the pores of which is migrated a photoconductive material such as antimony tri-sulphide, cadmium sulphide, and the like.

A further feature relates to improvements in photoconductive targets of the type including antimony tri-sulphide.

Other features and advantages will be apparent from the ensuing descriptions and the appended claims.

In the single sheet of drawings, which show one preferred embodiment;

Fig. 1 is a sectional view of a television pickup tube embodying the invention;

Fig. 2 is an enlarged fragmentary sectional view of the target shown in Fig. 1; and

Fig. 3 is an enlarged fragmentary sectional view of a conventional photoconductive target.

Referring to Fig. 1 of the drawing, there is shown a pickup, or camera, tube 6 in accordance with this invention. The tube 6 comprises an elongated envelope 8, that is evacuated in the usual manner. In one end of envelope 8 there is provided an electron gun 10 that includes the usual cathode 12, control electrode 14 and one or more accelerating electrodes 16 for developing an electron beam 11. The final beam accelerating electrode 18 which is in the form of a tubular electrode extending along the walls of envelope 8, is closed on the other end by a mesh screen 20 that is permeable to the electron beam 11. The electron beam is deflected during tube operation in mutually coordinate directions by any well known beam deflecting system (not shown). The

beam 11 passes through screen 20 and impinges upon a target 22, which may be attached in any well known manner to a suitable light transparent backing 24 of glass. The transparent backing 24 may constitute the end wall or face plate of the pickup tube 6 as shown, or may be a separate light transparent member. The external face of the face plate 24 is arranged to be illuminated, or excited, by light from a subject or scene 25 to be televised.

The screen 20, which is located adjacent to the target 22 is, during operation of the tube, a collector of secondary electrons which can be connected to any suitable positive biasing potential, as shown. It should be understood that the various electric potential sources can be provided by any well known direct current power supply, such as is conventionally used in connection with television tubes and the like. The target 22 comprises a light transparent electrically conductive film 28 which may be constituted for example of a compound of tin, such as tin oxide or tin chloride. The conductive film 28 is covered with a photoconductive material as will be explained hereinafter. The film 28, which forms a signal plate for the tube, is provided with a suitable connector extending through the wall of the envelope so that potentials may be applied thereto. The positive potential applied to the target 22 may be of a high or low value with respect to the potential of the cathode of gun 10, depending upon whether the target is to be scanned by a high velocity electron beam or a low velocity electron beam. In the case of the high velocity beam operation, each elemental area of the photoconductor, when impinged upon by the high velocity beam, assumes a positive potential since it releases more secondary electrons than the number of electrons that land on the target as primary electrons. The secondary electrons are collected by the mesh collector electrode 20. In the case of the low velocity beam operation, the scanned surface of the photoconductor and the cathode of gun 10 are at approximately the same potential and the scanning beam releases fewer secondary electrons than there are primary electrons that land on the photoconductor, so that the scanned surface of the photoconductor is driven in a negative direction to cathode potential.

The potential of the signal plate 28 with respect to the gun cathode will depend to a certain extent upon the nature of the photoconductive material which is embodied in the target 22. If, for example, this photoconductive material is of the antimony tri-sulphide kind, and high velocity operation is used, then a positive potential of 200 volts is sufficient for the signal plate 28 with respect to the gun cathode. With low velocity operation and the same material, a 40 volt difference of potential between the signal plate 28 and the cathode 12 is sufficient.

In either type of operation, whether high velocity beam or low velocity beam, since the photoconductor, when unexposed to light is non-conductive, the photoconductor at each elemental area will assume a "cross over" floating potential determined by the beam velocity. Consequently, as long as the target 22 is unexposed to light, the output current from the target remains at a minimum or low datum level. If, however, any elemental area of the photoconductor is exposed to light, the exposed elemental area of the photoconductor becomes conductive to an extent depending upon the intensity of the light. In other words, the exposure of an elemental area of the photoconductor to light causes the area to conduct electrons between the conductive layer 28 and the scanned surface of the photoconductor. Therefore, the next time the scanning beam 11 impinges on this area, it restores the area to its datum potential. This return to datum potential restores the difference in potential between the signal plate 28 and the scanned surface of the photoconductor, resulting, due to the capacity coupling between the scanned surface of the photoconductor and the signal plate 28, in an electron current flow through a load

resistor 30. This current can be amplified in any suitable amplifier.

If, as heretofore, the photoconductive material 32 (Fig. 3), for example of antimony tri-sulphide, cadmium sulphide, and the like, were deposited directly on the conductive stratum 28, as illustrated in the magnified cross sectional view of Fig. 3, the photoconductive effect would be subject to considerable lag, which in some cases may exceed the frame scan time. This lag may become important where the exciting light is of relatively low level. While the lag tends to be reduced as the exciting light is increased in intensity, nevertheless, because of the direct application of the photoconductive material 32 on to the conductive layer 28, there is not obtained the desired range of variation in conductivity of the target. This difficulty is overcome in accordance with the present invention by making the photoconductive layer as a layer having a large plurality of photoconductive fingers or elements extending to the signal plate so that the desired conductivity range variation is obtained even with excitation lights of high intensity.

As shown in Figs. 1 and 2, the photoconductive material, includes a thin surface layer 34 which is carried by a light transparent electric insulating layer 36. In accordance with the invention, the insulating layer 36 is somewhat porous so that it permits the photoconductive material 34 to be migrated through the pores thereof into contact with the surface of the conductive layer 28. In other words, the possible conductive paths between the scanned surface 34 of the photoconductor and the conductive layer 28 are confined to somewhat filamentary channels 34'. It is clear, therefore, that with this type of photoconductor, for a given signal current drawn from the target for a given light intensity, the current density must be much higher by reason of these narrow flow paths 34' to the conductive layer 28, as compared with the conventional all-over surface contact between the usual photoconductive material 32 and the conductive layer 28, as illustrated in Fig. 3.

This manner of making a target also permits other photoconductive materials to be used, which otherwise could not be used because normally they do not have enough inherent insulation properties for charge storage. For example, in the case of cadmium sulphide, which is highly sensitive in conductance variation to incident light variation, its utility has been restricted because cadmium sulphide does not have sufficiently high insulation properties to provide the requisite inhibition against leakage of the desired charge storage.

The invention is not limited to any particular composition for the porous material 36 provided it is of a transparent material or an opaque material that is sufficiently thin so as to be substantially light transparent while having high inherent electrical insulation properties. A typical example of such material is antimony oxide. While in any well known manner of applying the porous light transparent insulator to the conductive layer 28 may be employed, it is preferred to deposit it on the layer 28 by evaporation under a relatively poor vacuum, for example within the approximate range of .01 to 10 millimeters mercury. The particular pressure in this range which is most desirable is determined by the following three factors: (1) Spacing of the evaporator assembly (not shown) from the conductive layer 28; (2) Position of the evaporator shield or walls of the vacuum device (not shown); and (3) The speed of evaporation. Evaporation, as a manner of depositing the insulating material, permits accurate control over its thinness so as to make it light transparent, while evaporation in a poor vacuum imparts to it a somewhat porous structure.

After the porous light transparent insulator material 36 has been deposited on the conductor 28, the photoconductive material, such for example as antimony tri-sulphide or cadmium sulphide, is deposited, for ex-

5

ample by evaporation thereon in a high vacuum so that the evaporated photoconductive material migrates through the pores of the porous material 36, forming relatively narrow or filamentary paths 34', and covers the surface of the material 36. In order to control the extent of migration of the photoconductive material into the transparent insulator 36, it may be necessary to subject the composite target to a controlled baking heat. It will be understood, of course, that the magnified illustration in Fig. 2 is essentially schematic, and while the filamentary or narrow conductive paths 34' are shown as substantially linear, that is not necessarily so. The important feature is that the photoconductive material is migrated through the transparent insulator material 36, after the latter has been deposited, so as to limit the conductive contact between the photoconductive material and the conductor 28 to substantially discontinuous areas, as distinguished from a continuous contact area as is used in the conventional target illustrated in Fig. 3.

While reference has been made herein to antimony trisulphide as one of the preferred photoconductive materials, either the black or red variety thereof may be used, but the red variety is preferred. In addition to antimony trisulphide and cadmium sulphide, other photoconductive materials such as cadmium selenide and selenium may be utilized. Furthermore, while the transparent insulator is referred to as antimony oxide, any other equivalent insulator, such as zinc sulphide and silicon dioxide may be employed, but it is preferred to employ antimony trioxide for that purpose. Furthermore, the invention is not limited to any particular method of migrating or permeating the photoconductive material into and through the pores of the transparent insulator, providing the latter insulator is first deposited in a discrete layer in porous form and thereafter the photoconductive material is deposited thereon. Depending upon the selection of the porous insulating material, the photoconductive material, and the method for applying the material it may be desirable, to effect the necessary migration or permeation of the photoconductor into the insulator, to bake the target. Any temperatures below that which would harm the properties of the porous insulator or the photoconductor may be used for the baking step. For example, when cadmium sulphide is used, a baking temperature up to 600° C. is satisfactory.

Various changes and modifications may be made in the disclosure without departing from the spirit and scope of the invention.

What is claimed is:

1. A light sensitive variably conductive target for an electron discharge device comprising, a support member, a coating of conductive material on said support, a coating of porous insulation on said conductive material, and a coating of photoconductive material on said insulation material, said coating of photoconductive material substantially covering the exposed surface of said insulation material.

2. A light sensitive variably conductive target for an electron discharge device comprising, a support member, a coating of transparent conductive material on said support, a coating of light transparent porous insulating material on said conductive material, and a substantially continuous coating of photoconductive material on said insulating material, said photoconductive material substantially filling the pores of said insulating material and providing a discontinuous contact with said conductive material.

3. A light sensitive variably conductive target for an electron discharge device comprising, a support, a coating of transparent conductive material on said support, a coating of porous insulation material on said conductive coating, and a coating of photoconductive material deposited on the insulation material, said photoconductive material covering the exposed surface of said insulating material and permeating the pores of said insulating material to provide a multiplicity of discrete contact paths to said conductive material.

6

4. A light sensitive variably conductive target for an electron discharge device comprising, a support member, a layer of transparent conductive material on said support member, a porous layer of transparent insulating material on said layer of conductive material, a photoconductor on said insulating material, said photoconductor covering the exposed surface of said insulating material and extending into the pores of said insulating material to contact said conductive material, said photoconductive material being chosen from the group consisting of antimony trisulphide, cadmium sulphide, cadmium selenide, and selenium.

5. A light sensitive variably conductive target for an electron discharge device comprising, a support member, a layer of transparent conductive material on said support member, a porous layer of transparent insulating material on said layer of conductive material, a photoconductor on said insulating material and covering the surface thereof and extending into the pores of said insulating material to contact said conductive material, and said porous insulating material being chosen from the group consisting of antimony oxide, zinc sulphide and silicon dioxide.

6. A light sensitive target for an electron discharge device comprising, a light transparent glass support, a conductive film on said support, and a composite charge-leaking and light responsive coating on said conductive coating, said composite coating comprising a light transparent layer of a porous insulation chosen from the group consisting of antimony oxide, zinc sulphide, and silicon dioxide, and a coating of photoconductive material chosen from the group consisting of antimony trisulphide, cadmium sulphide, cadmium selenide and selenium, with the photoconductive material covering the surface of said insulation material and penetrating the pores thereof to provide a discontinuous conductive interface to said conductive coating.

7. A light transducing tube comprising, an evacuated envelope containing means to develop a scanning electron beam, a light sensitive target assembly within said envelope to be scanned by said beam and cooperating with said beam to produce output signal currents corresponding to the light excitation on elemental areas of said target assembly, said target assembly comprising a conductive film provided with a lead-in conductor to apply a biasing potential thereto, a layer of light transparent porous insulation on said conductive film, and a coating of photoconductive material on said insulation material and covering the surface thereof and permeating the pores of said insulation material to decrease the time lag of said target assembly while enabling said target assembly to be excited by high intensity light and while maintaining a predetermined wide range of conductivity variation in the target.

8. The method of making a light sensitive target for an electron discharge device which comprises, attaching a film of transparent conductive material to a support, depositing on said film a layer of porous insulation material, and then depositing on said porous insulation material a layer of photoconductive material and causing said photoconductive material to permeate the pores of said insulation material.

9. The method of making a light sensitive transducing target for an electron discharge device which comprises, coating a light transparent support with a transparent electrically conductive film, evaporating a quantity of an insulating material to form a porous light transparent insulating coating on said film, and then evaporating a photoconductive material in a high vacuum on to said insulating material to form a photoconductive surface and to impregnate the pores of said insulation material with said photoconductive material.

10. The method of making a light sensitive target for

an electron discharge device, said method comprising, coating a light transparent support with a light transparent electrically conductive film, evaporating a quantity of an insulating material in a poor vacuum within the approximate range of .01 to 10 millimeters of mercury to form a porous light transparent insulating coating on said film, and then evaporating a photoconductive material in a high vacuum of approximately 10^{-5} millimeters of mercury to form a photoconductive surface on said insulating coating and to penetrate the pores of said insulating coating.

11. The method according to claim 10 in which the target after having the photoconductive material evaporated thereon is subjected to a heat baking operation to migrate the photoconductive material into the pores of the insulation material for the purposes described.

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