Feb. 6, 1962 J. F. NICHOLSON 3,020,432

PHOTOCONDUCTIVE DEVICE

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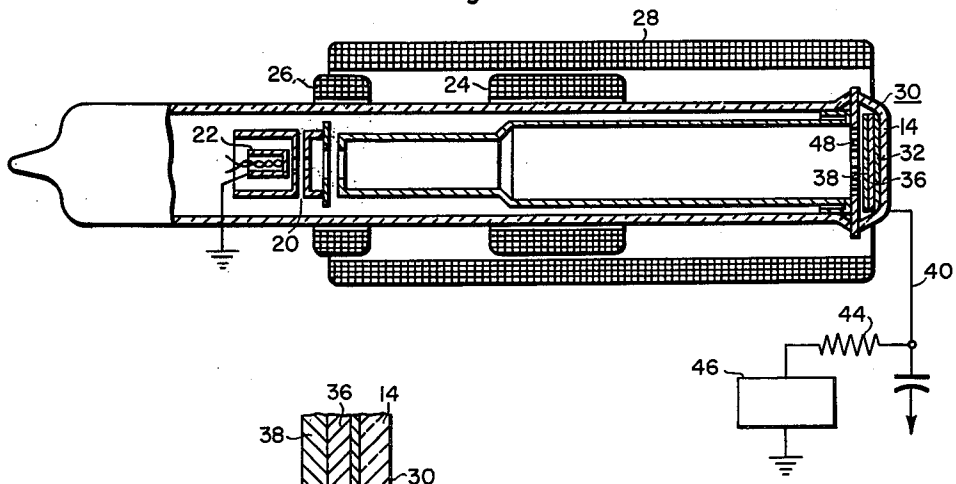
Fig. 1.



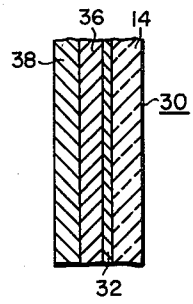
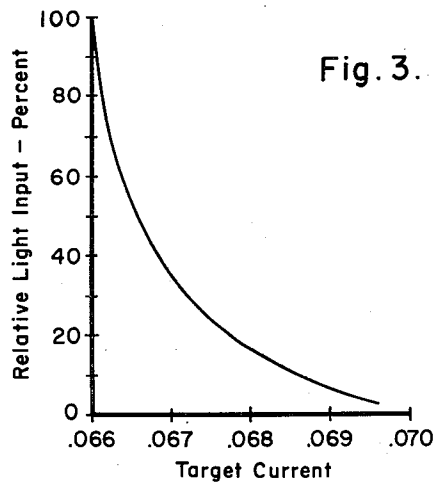


Fig. 2.

Fig. 3.



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PHOTOCONDUCTIVE DEVICE

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This invention relates to photoconductive device and more particularly to a pick-up tube.

Television pick-up tubes employing photoconductive targets and known as vidicons are well known in the art. The vidicon type pick-up tube comprises an evacuated envelope having an electron gun and a target assembly provided within the evacuated envelope. The envelope is provided with a face plate portion transmissive to light and the target structure is normally supported on this face plate member. The target member normally consists of a light transmissive electrically conductive coating on the inner surface of the face plate and a layer or layers of photoconductive material deposited on the electrically conductive coating. The conductive coating serves as the signal plate of the target and the photoconductive layer provides the light sensitive portion. An electron gun is normally provided at the opposite end of the envelope with respect to the target. The electron gun with suitable deflection and focusing means provides means of scanning the target member with an electron beam. The cathode of the electron gun is normally operated at a negative potential with respect to the signal plate of the target. The electrons within the scanning beam may be of the high energy type, that is, above first cross-over potential and below the second cross-over potential of the target member, or they may be of the low energy type, that is, below the first cross-over potential of the target. The most common type of operation is that in which the low energy electron scanning beam is utilized for scanning the target member. In the low energy type of operation, the electron scanning beam moves across the target and electrons are deposited on the exposed or scanned surface of the photoconductive layer and the surface is charged to substantially the potential of the cathode of the electron gun. When light is focused upon an area of the target, it renders the photoconductive material conductive in that particular area and causes a corresponding portion of the scanned surface of the photoconductive layer to charge in a direction toward the potential of the signal plate. The signal plate normally operates at a positive potential with respect to the scanned surface and the voltage difference between the scanned surface and the signal plate may be about 10 volts. The next time the electron beam scans this illuminated area it restores the scanned surface area to substantially the cathode potential. This return to cathode potential restores the original voltage difference across the photoconductive layer and causes an electron current to flow in the signal plate. This electron current which flows in the signal plate is coupled to an output circuit to derive an electrical signal representative of the light directed onto the area of the photoconductive layer. The signal derived from the conventional pick-up tube is such that the higher the brightness of the image directed thereon the greater will be the electrical signal derived from the output circuit. The maximum value of the electrical signal is, of course, limited by certain practical matters, such as saturation of the photoconductive material and other factors, but within a certain range of light values an increase in the amount of light will result in increased amount of current in the output circuit.

In accordance with the present invention, there is provided an electron camera tube including a target which

exhibits a decrease in output signal in response to an increase of light input.

It is accordingly an object of this invention to provide an improved pick-up tube.

It is another object to provide an improved photoconductive target for a pick-up tube.

It is another object to provide a target for a pick-up tube that provides a negative coefficient of conductivity, that is, the dark current in the target becomes a black reference and any light modulation of the target produces a negative signal or indicates a reduction in the dark current has taken place.

It is another object to provide a target structure which has the ability of responding to a wide range of light values.

It is another object to provide an improved target which provides a fast decay-time with removal of light information from the target.

These and other objects are effected by my invention as will be apparent from the following description, taken in accordance with the accompanying drawing, throughout which like reference characters indicate like parts, and in which:

FIGURE 1 is a sectional view of a pick-up tube and certain associated circuitry embodying my invention;

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

FIG. 3 is a curve illustrating the response of the target shown in FIG. 1 to light.

Referring in detail to FIGS. 1 and 2, there is illustrated a pick-up tube and associated target structure. The tube comprises an evacuated glass envelope **12** containing an electron gun assembly **20** and a target **30**. The envelope **12** includes a face plate on input window **14**. The inner surface of the window **14** is coated with a light transmissive electrically conductive film **32**. The film **32** may be of any suitable material such as tin oxide. The film or coating **32** is the signal electrode of the target **30**. The signal electrode **32** is connected by a lead **40** through a resistor **44** to a source of potential **46**.

The photoconductive material on the target **30** is deposited as a double layer **36** and **38** upon the conductive film **32**. An electrically conductive mesh or grid **48** is provided between the target **30** and the electron gun **20**. The grid **48** is adjacent the target **30** and of similar area. The cathode **22** of the electron gun **20** is connected to ground potential. The signal plate **32** is operated by means of potential source **46** at a positive potential of about 10 volts with respect to the gun cathode **22**. The electron gun **20** may be of any suitable type such as used in the conventional vidicon. A deflection-coil **24**, alignment coil **26** and focusing coil **28** are provided as in the conventional vidicon.

In the specific embodiment of the target shown in FIG. 2, the photoconductive material deposit consists of two layers **36** and **38**. The layer **36** is deposited on the conductive layer **32**. The layer **36** consists of a mixture of antimony and selenium, evaporated in a vacuum. The layer **38** which is deposited on the layer **36** is a layer of antimony trisulfide also evaporated in a vacuum.

In preparing the mixture for the layer **36**, equal weights of antimony and selenium are heated in a vacuum or in an inert atmosphere such as argon at a temperature of about 500° C. This mixture is then allowed to cool to room temperature. It was found that equal weights of antimony and selenium gave excellent results. Excess antimony is present when mixtures are prepared in this manner. Other proportions may be used such as stoichiometric proportions to give the compound Sb_2Se_3.

In depositing the layer **36**, the glass support member **14** having the conducting coating **32** thereon in a well known manner is placed in a closed container capable

of being evaporated. A small quantity of the mixture is then placed in a boat of suitable material such as nickel-chromium base alloy and sold under the trade name Nichrome. It is found that 60 mg. of the homogeneous mixture of antimony and selenium is suitable for depositing a layer of a 1" diameter target. The amount of the material utilized, of course, will depend on the area and thickness of layer desired. The boat is inserted into the container and positioned at a distance approximately 4" from the target and the system then exhausted to a pressure less than about .5 micron. The boat is then heated to approximately 400° C., the temperature is dependent on the desired speed of evaporation. This heating is carried on for approximately 3 to 4 minutes until the target thickness of about 5 microns is attained. The evaporator utilized consist of a circular disc which reflects light from the tungsten source of 11.3 watts and 2.7 amperes positioned at a distance of 10 inches from the target. The color of the light reflected from the evaporator after transmission through the target is observed during the target evaporaion process and when a slightly yellow color is attained the heat is turned off and the first layer 36 is completed.

The system is then opened to the atmosphere and a boat is inserted containing about 60 milligrams of antimony trisulfide. This boat may also be provided with a 400 line woven steel mesh to provide proper evaporation of the material. The system is again exhausted to a pressure of about .5 micron and the antimony trisulfide is heated to approximately 450° C. and the material is deposited onto the antimony and selenium layer until a deep yellow color is attained. This second layer of antimony trisulfide on the target is of about 5 microns in thickness. Again the proper thickness is determined by the light reflection as in the case of the first layer. The second evaporation step should be accomplished as soon as possible after the container is opened so that the first layer is not exposed to atmosphere for more than 2 minutes. The target consisting of the antimony and selenium layer and the antimony trisulfide layer is then complete and is ready to be sealed into the envelope.

It is found that when this target is positioned within the tube, an unexpected and significant change is attained over the conventional vidicon type tube. With the target capped so that no light is directed onto the target member 30, the output current from the signal plate is at a maximum value as is indicated in FIG. 3. The curve shown in FIG. 3 also illustrates that as the illumination increases on the target the signal goes down in value. This is in the opposite direction to that expected in he conventional vidicon. This provides a tube having a negative coefficient of conductivity. It is also found that this tube is not saturated by high lights such as the light from a 1500 watt lamp. In the case of a conventional vidicon that is illuminated with a 1500 watt lamp the target would be saturated and no intelligence would be derived from the output signal.

This characteristic provides a pick-up tube for viewing objects in direct sun light.

In the above device, the low energy electron scanning beam was utilized and the signal derived from the signal plate as in conventional vidicon operation.

Another possible application of the invention is one in which the signal is derived from the return beam such as in the well known image orthicon pick-up tube. The smaller the signal on the target the greater number of electrons in the return beam. By utilizing the target disclosed herein the number of electrons in the return beam would be relatively small where there was no illumination and therefore the signal to noise would be considerably improved. One of the problems with the image orthicon is that the major portion of the electron beam is returned which results in high noise background. By using the target disclosed herein, the major portion of the scanning beam would land on the target in the unilluminated parts and in the illuminated parts of the target the return beam would be of the larger value. In this manner the noise from the image orthicon type tube or a return beam type tube would be substantially reduced.

While I have shown my invention in only a single form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible to various changes and modifications without departing from the spirit and scope thereof.

I claim as my invention:

1. The method of making a light sensitive target for an electron discharge device which comprises depositing a film of a light transmissive electrically conductive material on a support member, depositing a layer of a mixture of antimony and selenium onto said conductive film in a vacuum and then depositing on said antimony selenium film a layer of a antimony trisulfide in a vacuum to provide a negative coefficient of conductivity target.

2. The method of making a light sensitive target for an electron discharge device which comprises coating a light transparent support member with a transparent electrically conductive coating, evaporating a quantity of antimony and selenium onto said electrically conductive coating in a vacuum and evaporating a quantity of antimony trisulfide onto said antimony and selenium layer in a vacuum.

3. A photoconductive target electrode for a pick-up tube, said electrode comprising, a transparent support, a thin electrically conductive film on one surface of said support plate, a thin vacuum deposited coating of a mixture of selenium and antimony of a thickness of 5 microns on the exposed face of said conductive film and a thin vacuum deposited coating of antimony trisulfide of a thickness of about 5 microns on said film of antimony and selenium.

4. An electron camera tube comprising an electron gun means including a source of electrons for providing an electron beam on a path, a target electrode spaced from said gun means and arranged transversely to said beam path, said target electrode comprising a transparent support plate, a thin conductive film on one surface of said support plate and a photosensitive means on said conductive film which has the property of a negative coefficient of conductivity, said means comprised of a vacuum deposited first layer of a mixture of antimony and selenium on said conductive film and a vacuum deposited second layer of antimony trisulfide on said first layer.

5. An apparatus for converting a radiation image into an electrical signal, the magnitude of which decreases with increasing radiation intensity, which comprises; an evacuated envelope, a target electrode of material positioned at one end of said envelope which exhibits a decrease in conductivity with an increase of radiation adapted to receive said radiation image, an electrically conductive layer positioned on one side of said target material and an electron gun within said envelope for directing a stream of electrons onto said target material.

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