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PHOTOELECTRIC CAMERA TUBE WITH TRANSISTOR-TYPE PHOTOANODE

Filed June 21, 1960

2 Sheets-Sheet 1

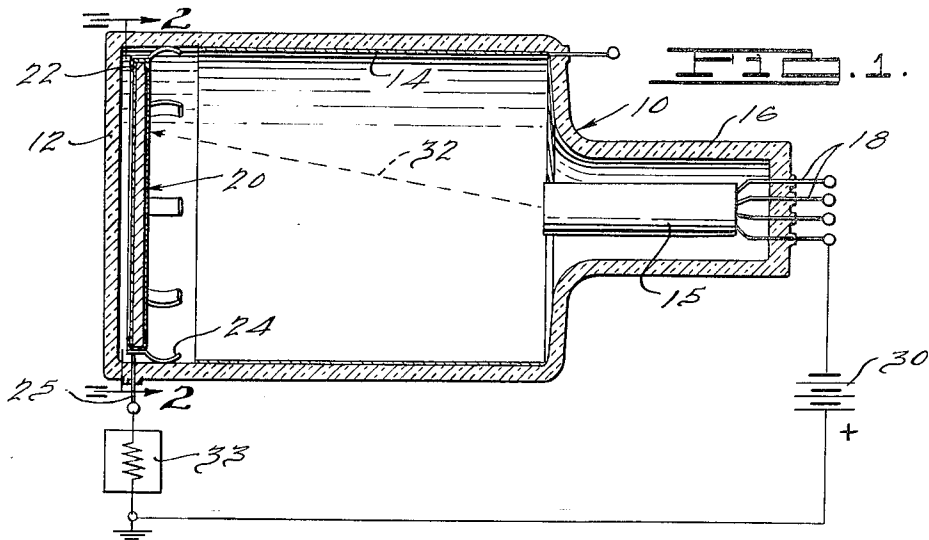
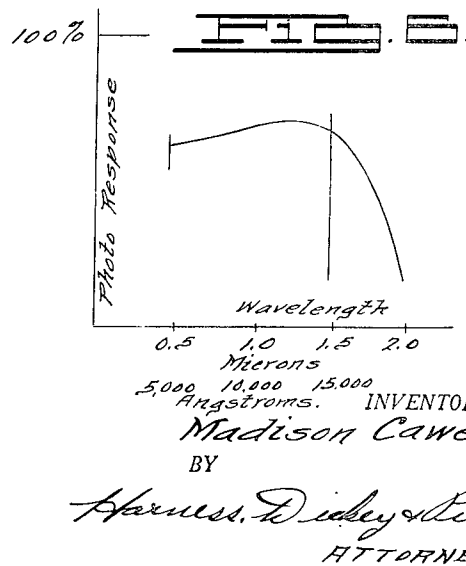
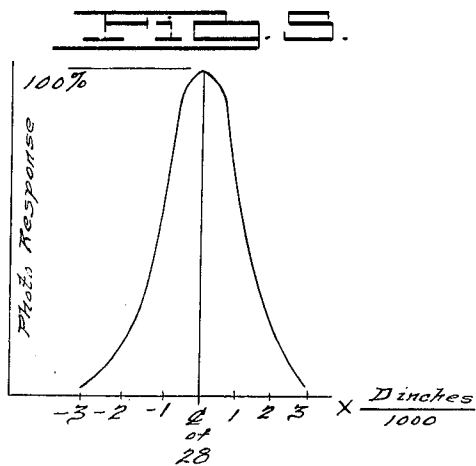
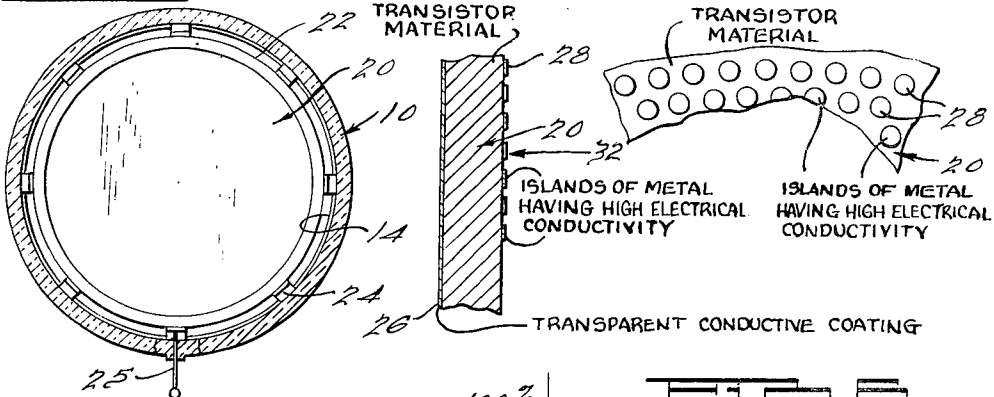


FIG. 2.

FIG. 3.

FIG. 4.



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2 Sheets-Sheet 2

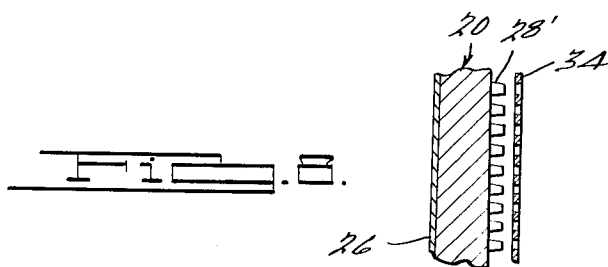
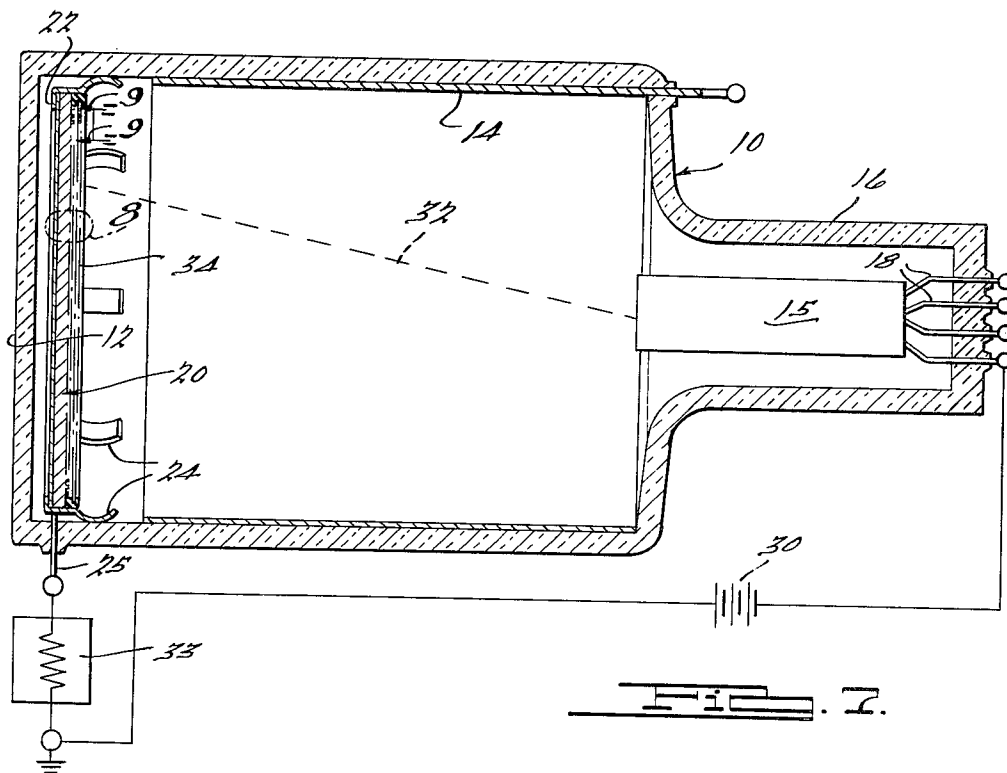
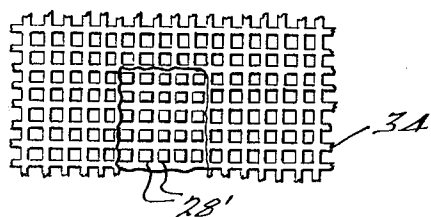


Fig. 9.



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PHOTOELECTRIC CAMERA TUBE WITH TRANSISTOR-TYPE PHOTOANODE

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13 Claims. (Cl. 313-66)

The present invention relates to photoelectrical converters and particularly to improvements in television pickup tubes.

This application is a continuation-in-part of my copending United States application, Serial No. 260,238, filed December 6, 1951, now abandoned.

An important object of the invention is to provide a pick-up tube of substantially greater sensitivity than heretofore achieved in the television art.

Another object is to provide such a device having improved response to dark light in the regions of the spectrum including the far infrared as well as the near infrared and visible portions of the electromagnetic spectrum.

Another object is to provide such a device of simple, rugged construction, which has a long operating life and which enables the use of simpler associated circuitry, which further may be incorporated in apparatus which is more compact, more easily serviced, and more easily maintained in proper operating adjustment than presently known tubes. A related object is to provide such a device which, by reason of its increased sensitivity, requires fewer amplifying stages in transmitting apparatus associated therewith.

Still another object is to provide such a device having improved electrooptical stability.

Another important object is to provide such a device having a photoanode formed of transistor material and which attains high quantum efficiency of electrooptical conversion in both the low energy and high energy regions of the spectrum and which utilizes the free electron conduction properties of transistor materials.

Still another object is to provide a television pick-up tube having a transistor-type photoanode and a dynamic photoconductive contact system, the effective contact being capable of spatial displacements in two dimensions for scanning by means of externally controlled electromagnetic and/or electrostatic fields which may be arranged and controlled in a manner which is essentially conventional.

A further object is to provide a pickup tube of substantially greater sensitivity than heretofore achieved in the television art having means for minimizing reduction of the picture signal due to secondary emission.

A still further object of this invention is to provide a method for depositing islands on the anode of a pickup tube through a screen in such manner as to insure that a parallax condition with reference to the electron gun, the apertures in the screen, and the islands will not result in secondary emission.

Other objects, features, and advantages of the present invention will become apparent from the subsequent description, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic longitudinal sectional representation of a photo-pick-up tube constructed in accordance with the present invention;

FIG. 2 is a sectional elevational view taken substantially on the line 2—2 of FIGURE 1 and looking in the direction of the arrows;

FIG. 3 is an enlarged diagrammatic sectional view of a fragment of the preferred photoanode construction;

FIG. 4 is an enlarged diagrammatic elevational view of a fragment of the rear face of the anode;

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FIG. 5 is a graph showing a spatial distribution of photo-conductivity with respect to one spot contact of the anode;

FIG. 6 is a graph indicating the spectral response of one of the preferred photoanode constructions;

FIG. 7 is a schematic longitudinal sectional representation of a modified photo pickup tube constructed in accordance with the present invention;

FIG. 8 is an enlarged and somewhat diagrammatic cross-sectional view of the area marked "8" in FIGURE 7; and

FIG. 9 is an enlarged and somewhat diagrammatic elevational view, partly broken away, taken substantially on the line 9—9 of FIGURE 7.

Referring now to the drawings, reference character 10 designates generally a glass envelope of generally cylindrical form having a substantially planar front window portion 12 which is optically transparent in the region 4000 to 30,000 angstroms. The cylindrical inner wall of the tube to the rear of the window carries a conductive wall-coating contact 14, while an electron gun 15 which may be essentially conventional in construction, is arranged in a coaxial neck 16 at the rear of the tube. Suitable leads as 18 for the elements of the gun are brought out through the neck, and the general methods of constructing and processing these and the other usual elements of the tube have become well known in the art.

The anode or photoanode structure is generally designated 20 and is mounted close and parallel to the window. The anode is relatively thin and planar. For example, its thickness may be of the order of .003 to .010 of an inch. The anode is formed of a transistor material. By transistor material is meant a surface comprised of a single crystal of semi-conducting material. Various transistor materials have become known in the art. The use of a transistor material of the n-type having free electron conductive properties such, for example, as a material selected from Group IV of the Periodic Table containing a contaminant selected from Group V of the Periodic Table is preferred. A suitable anode structure comprises crystalline germanium containing a small quantity of antimony, the atoms of which are distributed throughout the germanium as uniformly as possible. The anode crystal may be grown in the planar form. Such a crystal is classed as a semiconductor. It is provided with a base contact rim 22 electrically connected to the crystal. The base contact rim carries suitable supporting spring fingers 24 adapted to engage the inner wall of the envelope to support the anode. The output lead 25 is connected to the base rim as shown.

Inasmuch as the photoconductivity of transistor materials sometimes reaches relatively high magnitudes (of the order of several milliamperes per milliwatt of radiation), it is desirable to provide a low resistance contact to the body of the photoanode. This is preferably accomplished by a low resistance contact which engages substantially the entire area of the crystal. This may be located on the front face of the crystal and is electrically connected to the base rim, and in the preferred construction comprises a translucent electrically conductive surface 26, such as a thin evaporated coating of metal which, as is well known, may be deposited so thinly as to be transparent, or a coating of other transparent conductive material, such for example as transparent salts of tin, which are available and known in the art for use as transparent conductive coatings, being commonly sold under the trade name "Nesa." The distributed low resistance contact 26 prevents potential changes over the surface due to excessive currents through bright parts of the image. It will be appreciated that the distributed low resistance contact might be in the form of a "screen" either on the surface of or within the body of the crystal, but that in any

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event if such contact is on the illuminated surface, it must be translucent, while if it is within the body of the crystal, it must be penetrable by displaced electrons. The image may of course be focused on the anode through the window in the usual manner.

In photoconductors of the contact type formed of transistor material, an increased photoconductivity occurs when discrete regions of metallic contact are provided in the illuminated region; a plurality of metallic islands or isolated attached areas 28 of high conductivity, which may be evaporated metal surfaces, each with a small area, preferably of the order of less than one circular mil, are preferably provided upon the surface of the anode, which may be the rear surface, as shown. These small metallic islands 28 are formed by evaporating the desired metal through a fine mesh screen such as screen 34, located proximate to the anode surface. These are isolated from one another but arranged close together and are distributed in a two-dimensional array over the entire back surface of the anode, coacting with the crystal to define a plurality of photo-transistor cells. In the preferred embodiments shown in the figures and as described above, the photo-transistor cells are p-n junction diodes. The contacts for the photo-transistor cells are "formed," by passing a forming current therethrough in the manner in which contacts are formed on a transistor. This is done prior to assembly of the photoanode in the envelope. In order to apply the forming current to all of the spots 28 at once, the crystal is clamped in a suitable holder with a metal plate overlying and held against the spots.

The electron beam from the gun 15 completes the photoconductive circuit in a dynamic manner during its scanning progress across the metal islands 28 and the intervening uncovered areas of the crystal. The spatial distribution of photoconductivity with respect to each island is substantially as indicated in FIGURE 5, where D depends upon a function of the diameter of the evaporated contact spot and of the thickness of the crystal. The amplitude of the output in the region of each island will be proportional to the illumination incident upon the front face in that region, so that when an optical image is projected on the front and the tube is in operation, the circuit is completed from ground through the battery 30, the gun contacts 18, the electron gun 15, the beam 32, the metallic islands 28, crystal 20, connecting means 26, 22, 25, and the load impedance 33. A video signal of relatively large magnitude and high fidelity appears across the impedance 33 at terminal 25 to ground.

As the electron beam from the gun 15 scans the metal islands 28 and the intervening uncovered areas of the crystal, it is possible that emission of secondary electrons from the uncovered areas of the crystal will occur. The presence of secondary electrons tends to reduce the resultant useful picture signal. In order to prevent the emission of secondary electrons and the resultant reduction in picture signal from occurring, the fine mesh screen located proximate to the anode during the evaporation process previously mentioned is made an integral member with the structure comprising the anode 20, and rim 22. As can be seen in FIGURES 7, 8, and 9, with the fine mesh screen an integral part of the anode 20, and rim 22, the areas on the anode surface located between the islands 28' are substantially covered; thus the electrons from the gun 15 are prevented from striking these areas on the anode surface. In order to be certain that a parallax condition will not permit the electron beam to pass through an aperture in the screen 34 and still strike the surface on the anode located between the metallic islands 28', the metal is evaporated from a point located adjacent the aperture in the electron gun. Thus the metallic islands 28' will be formed in such a manner as to be in proper alignment with the electron beam 32 so as to eliminate the possibility of secondary emission due to a parallax condition.

While it will be apparent that the preferred embodi-

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ments of the invention disclosed are well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

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What is claimed is:

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1. In a photoelectric camera pickup device including an envelope having a window therein, a photoelectrode mounted relatively close to the window and adapted to be illuminated on its front surface through the window, said photoelectrode having a structure formed of a single crystal, a plurality of discontinuous portions on the rear surface of said photoelectrode and comprised of material more electrically conductive than the photoelectrode, and dynamic scanning means adapted to commutate said portions on the rear surface of said photoelectrode.

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2. In a photoelectric camera pickup device including an envelope having a window therein, a photoelectrode mounted relatively close to the window and adapted to be illuminated on its front surface through the window, said photoelectrode having a structure formed of a single crystal of semi-conducting material, a plurality of discontinuous portions on the rear surface of said photoelectrode and comprised of material more electrically conductive than the photoelectrode, and dynamic scanning means adapted to commutate said portions on the rear surface of said photoelectrode.

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3. In a photoelectric camera pickup device including an envelope having a window therein, a photoelectrode mounted relatively close to the window and adapted to be illuminated on its front surface through the window, said photoelectrode having a planar structure formed of a single crystal of semi-conducting material, a plurality of discontinuous portions on the rear surface of said photoelectrode and comprised of material more electrically conductive than the photoelectrode, and dynamic scanning means adapted to commutate said portions on the rear surface of said photoelectrode.

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4. In a photoelectric camera pickup device including an envelope having a window therein, a photoelectrode mounted relatively close to the window and adapted to be illuminated on its front surface through the window, said photoelectrode having a structure formed of a single crystal, a plurality of discontinuous portions on the rear surface of said electrode and comprised of material more electrically conductive than the photoelectrode, dynamic scanning means adapted to commutate said portions on the rear surface of said photoelectrode, and a single output means for said portions comprising a light transmitting film of low electrical resistance carried by the front surface of said photoelectrode.

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5. In a photoelectric camera pickup device including an envelope having a window therein, a photoelectrode mounted relatively close to the window and adapted to be illuminated on its front surface through the window, said photoelectrode having a structure formed of a single crystal of semi-conducting material, a plurality of discontinuous portions on the rear surface of said electrode and comprised of material more electrically conductive than the photoelectrode, dynamic scanning means adapted to commutate said portions on the rear surface of said photoelectrode, and a single output means for said portions comprising a light transmitting film of low electrical resistance carried by the front surface of said photoelectrode.

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6. In a photoelectric camera pickup device including an envelope having a window therein, a photoelectrode mounted relatively close to the window and adapted to be illuminated on its front surface through the window, said photoelectrode having a planar structure formed of a single crystal of semi-conducting material, a plurality of discontinuous portions on the rear surface of said electrode and comprised of material more electrically conductive than the photoelectrode, dynamic scanning means adapted to commutate said portions on the rear surface of

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said photoelectrode, and a single output means for said portions comprising a light transmitting film of low electrical resistance carried by the front surface of said photoelectrode.

7. A photoelectric camera pickup device including a two-dimensional array comprising a plurality of localized phototransistor cells, a fine mesh screen disposed proximate to said phototransistor cells and electron beamtype scanning means for commutating said phototransistor cells, said screen located between said cells and said scanning means, said cells including a large number of discrete electrically conductive islands carried by and coacting with one face of a common plate formed of electrically semi-conductive material, said scanning means being directed against said island, and a single output means including a light transmitting electrically conductive layer on the opposite side of said plate providing an operative connection of substantially uniform electrical characteristics.

8. A photoelectric camera pickup device comprising means for receiving light representative of an image and for projecting the image on a light-responsive member of the photoelectric camera pickup device, said light-responsive member comprising a semi-conductor crystal of n-type material, a plurality of contacting conductive elements forming a two dimensional array on said crystal, and a layer of p-type material located between said n-type material and each of said conductive elements, electrical means for scanning said plurality of conductive elements, and means for deriving a signal from said semiconductor crystal.

9. The photoelectric camera pickup device of claim 8 in which said layer is individual to each of said conductive elements and in which said electrical means comprises means for scanning said plurality of conductive elements with an electron beam and further comprising a fine mesh screen disposed proximate to said plurality of conductive elements.

10. The photoelectric camera pickup device of claim 8 in which said light-responsive member is comprised of a single crystal of n-type material.

11. A photoelectric camera pickup device comprising means for receiving light representative of an image and for projecting the image on a light responsive member of

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the photoelectric camera pickup device, said light responsive member having n and p types semiconductor material as constituent elements and comprising a first semiconductor material of one of said n and p types, a plurality of contacting conductive elements forming a two-dimensional array on said first semi-conductor material, and a layer of a second semi-conductor material of the other of said n and p types located between said first semi-conductor material and each of said plurality of conductive elements, electrical means for scanning said plurality of conductive elements, and means for deriving a signal from said light responsive member.

12. The photoelectric camera pickup device of claim 11 in which said layer is individual to each of said conductive elements and in which said electrical means comprises means for scanning said plurality of conductive elements with an electron beam and further comprising a fine mesh screen disposed proximate to said plurality of conductive elements.

13. The photoelectric camera pickup device of claim 11 in which said light-responsive member is comprised of a single crystal of said first semi-conductor material.

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