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G. K. TEAL
ELECTRON DISCHARGE DEVICE
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2,250,283

FIG. 1

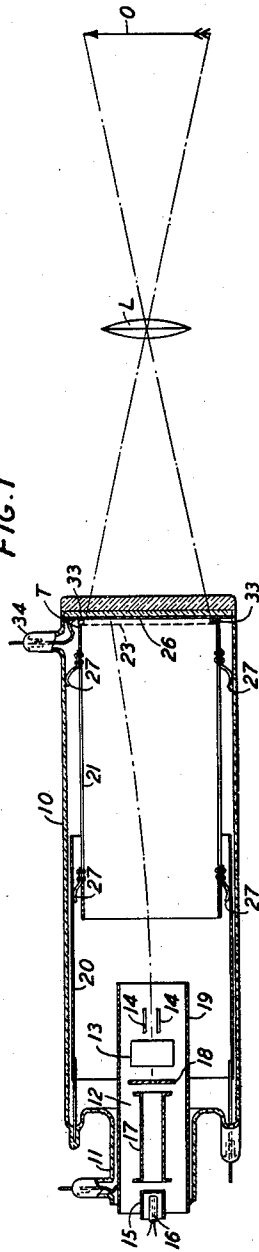


FIG. 3

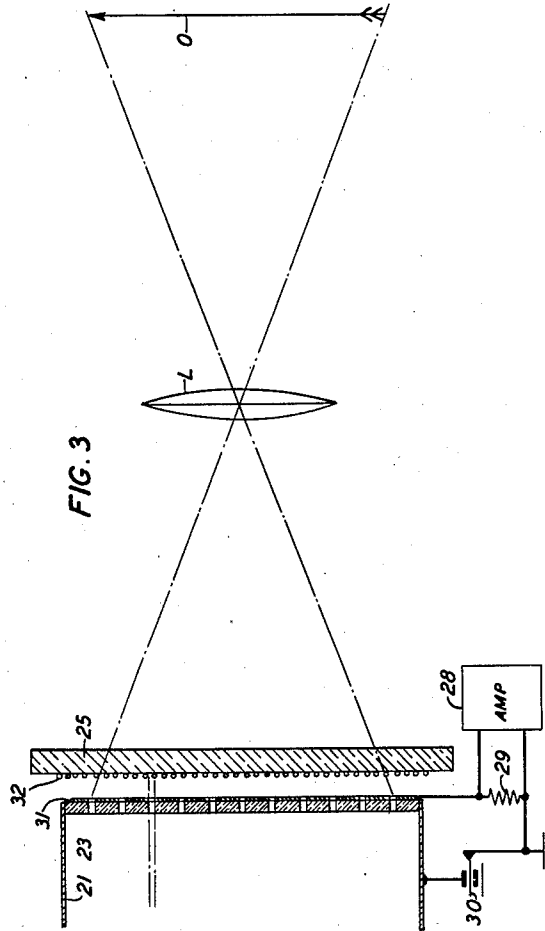
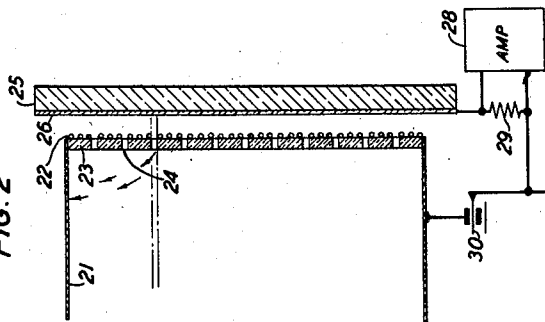


FIG. 2



INVENTOR
G. K. TEAL
BY *C. C. Sprague.*
ATTORNEY

UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

Gordon K. Teal, New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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7 Claims. (Cl. 250-150)

This application relates to electron discharge devices and more specifically to electron camera tubes suitable for television.

In systems employing the well-known iconoscope or other electron camera tubes using the electron storage principle, the image produced at the receiving station from signals generated at the transmitting station by one or the other of these electron camera tubes has been diffused due to the emission of secondary electrons from one element of a mosaic target to other more positively charged elements. The present invention is directed to an electron camera tube in which this deleterious effect is substantially reduced if not entirely eliminated.

It is an object of this invention to provide an improved electron camera tube of the type utilizing the storage of electrostatic charges.

It is another object of this invention to provide an improved electron camera tube in which the intensity of secondary electrons is controlled by stored charges to produce an image current.

Other and ancillary objects will be apparent from the description below and from the appended claims.

In accordance with one embodiment of this invention, an electron camera tube is provided comprising an envelope enclosing an electron gun, a composite target comprising a perforated insulating plate having a discontinuous or globular photoemissive surface and a semitransparent metallic signal plate capable of emitting secondary electrons mounted very close to each other, a collector electrode which may comprise part of the electron gun, and two pairs of electrostatic deflecting plates. Radiations from an object or field of view pass through the semitransparent signal plate to the photosensitized perforated insulating plate to cause photoelectric emission therefrom to the signal plate. The insulating plate is scanned by a beam of electrons from the electron gun and some of these electrons pass through the perforations therein to strike the signal plate. Secondary electrons are driven from the signal plate, passing through the apertures in the insulating plate to the collector electrode, the number of secondary electrons passing through each perforation depending upon the charge on the adjacent photoemissive globule. The image current is obtained from the signal plate which is resistance coupled to a television amplifier. Due to the fact that the insulating plate and the secondary emitting signal plate are close to each other, the photoelectrons are not allowed to pass from one photoemissive element to adjacent more positively charged ones, and thus a received picture built up from the signal generated by the camera tube of this invention is not diffused as was the case in the prior art television systems mentioned above,

In a second embodiment of this invention the perforated insulating plate has a continuous photoemissive layer thereon and the plate opposite the perforated plate has a discontinuous layer of secondary emitting material thereon. Also the signal resistance may be connected to the continuous layer of photoemissive material on the perforated plate. As a modification, the perforated plate may be of metal instead of insulating material.

A feature of the present invention is that the perforated plate is mounted on a cylinder which makes slidable contact with and thus becomes electrically a part of another cylinder forming part of the electron gun system and with the interior of the tube envelope so that the perforated glass plate may be adjusted with respect to the secondary emitting plate by force exerted from without the tube.

The invention will be more readily understood from the following description taken in connection with the accompanying drawing forming a part thereof in which:

Fig. 1 shows an electronic camera tube such as is used in television transmission embodying the principles of this invention;

Fig. 2 is an enlarged view of the target assembly within the tube of Fig. 1; and

Fig. 3 shows a modified target assembly.

Referring more particularly to the drawing, Fig. 1 shows an electronic camera tube used as a pick-up device in television transmission comprising an evacuated container 10 in which is sealed a smaller container 11, the two containers enclosing an electron gun assembly indicated generally by the reference character 12 for producing a moving beam of electrons and for accelerating this beam towards a screen or target assembly T at the end of the tube remote from the electron gun, and means such as the deflecting plates 13, 13 and 14, 14 for causing the beam to scan the various elemental areas of the screen or target T in turn. Radiations from an object or field of view O without the tube are focussed by a suitable lens system indicated generally by the single lens L upon the target assembly T.

The electron gun assembly 12 comprises a cathode 15 which is heated by a heating member 16, a first anode 17 and a second anode comprising an apertured diaphragm 18, a cylinder 19, a cylinder 20 and a slidable cylinder 21. The elements 18, 19, 20 and 21 comprising the second anode member are all placed at ground potential. The cathode 15 is placed at a potential which is from 1000 to 1500 volts negative with respect to ground potential and the first anode member 17 is placed at a potential of from 600 to 800 volts above the cathode potential. These potentials are produced by any suitable means (not shown). The various elements of the electron gun sys-

tem cooperate with each other in a manner well known to those skilled in the electron optical art to produce a beam of small cross-section at the target assembly T.

In order to cause the electron beam generated by the electron optical apparatus described above to scan every elemental area of the field of view on the target assembly T in turn, suitable deflecting plates such as, for example, two pairs of electrostatic deflecting plates 13, 13 and 14, 14, the normals to whose surfaces are located at right-angles to each other, are provided. To the deflecting plates 13, 13 are applied deflecting voltages of line scanning frequency (5760 cycles per second, for example) and of saw-toothed wave form to produce the horizontal deflection while deflecting voltages of framing frequency (24 cycles per second, for example) and of saw-toothed wave form are applied to the deflecting plates 14, 14 to produce vertical deflection of the beam. Any appropriate sweep circuits (not shown) may be used to generate the horizontal and vertical deflection voltages. For example, reference may be made to Patent 2,178,464, issued October 31, 1939 to M. W. Baldwin, Jr. which discloses suitable balanced sweep circuits for this purpose. For a more full description of the advantages of balanced sweep circuits for use with cathode ray television tubes, reference may be made to the above-mentioned Baldwin patent and also to Patent 2,209,199, issued July 23, 1940 to Frank Gray.

The target assembly T comprises (see Fig. 2) a photoemissive mosaic 22 mounted on an insulating plate 23 (of any suitable material such as glass or mica) having a multiplicity of perforations 24 therein, adjacent the signal plate comprising a semitransparent layer 26 of a suitable metallic material which has a ratio of secondary electrons emitted therefrom to primary electrons impinging thereon of greater than one to one. The layer 26 is mounted on a glass plate 25. The glass plate 23 is by way of example 4 1/2 inches square and has in it 4225 holes per square inch. This plate is preferably prepared by coating one surface of a glass plate with a plurality of wax dots through a mesh screen, removing the screen, melting the wax so that only small spaces of the plate between the dots are left uncovered, dipping the plate in an etching solution until the acid almost etches through to the side which is not covered by the wax, etching from the other side until the acid etches through to the apertures, and then washing the plate. For a more complete description of glass plates of this character and of a method of preparing them, reference may be made to Patent 2,217,334, issued October 8, 1940 to B. A. Diggory and G. K. Teal.

A layer of silver is deposited on this glass by evaporation to insure its condensation on only one side. The conducting film thus attained is then rendered discontinuous and non-conducting by heating to a temperature above 500° C. in air or vacuum until discrete globules of silver are formed. The glass plate is then mounted on the end of the sliding cylindrical collector electrode 21 by any suitable means, such as spring clips. The cylinder 21 is held in position within the tube and in slidable contact with the cylindrical member 20 by means of the sliding contact members 27. The signal plate 26 to which an amplifier 28 is coupled through the signal resistance 29 is a semitransparent conducting film 26 of platinum, for example, deposited on the flat glass disc 25

by cathodic sputtering. Before mounting the disc in the transmitter tube, the platinum is conditioned by heating it in the air to about 550° C. This causes the electrical resistance of the film to decrease from 700 to about 30 ohms, which is less than 1 per cent of the value of the amplifier coupling resistance 29. The signal plate 26 and the glass element 23 are mounted so that the silver layer and the platinum electrode are adjacent each other and about .0015 inch apart, the distance being set by mica spacers 33 fastened to the member 23 by small clips (not shown).

In the making of the tube previous to sealing it onto the vacuum station at the side tube 34, the cylindrical electrode 21 supporting the perforated glass plate 23 is moved back towards the electron gun 12. The tube is thoroughly evacuated, baked at 400° C. for two hours and cleaned up with hydrogen. On cooling to room temperature about 2 millimeters pressure of oxygen is introduced into it and oxidation of the silver particles on the face of a plate 23 to the first order blue "interference" color is then carried out by use of an "electrodeless" discharge created in the oxygen of the tube by means of a high frequency spark coil outside the tube. The oxygen is then removed by evacuation from the tube, hydrogen gas is introduced and the tube is baked to reduce the silver oxide. The oxidation-reduction cycle is carried out to insure even oxidation of the silver mosaic. The mosaic is then oxidized again. After evacuation of the oxygen, the cathode 15 of the electron gun is treated in a manner known to sensitize it with an electron emitting coating of BaO-SrO. Caesium vapour is then introduced through the side tube 34 into the space between the silver mosaic on the glass plate 23 and the signal plate 26, and the tube is baked at 200 to 225° C. for a short time after which it is sealed off from the vacuum station. The caesium photosensitizes the silver mosaic on the glass plate 23 to form photoemissive globules 22.

In the operation of the tube shown in Fig. 1 the sensitized mosaic 22 is moved up close to the platinum signal plate 26 by force exerted from outside the tube. An optical image is focussed on the photosensitized mosaic 22 by means of the lens L. The perforated plate 23 is scanned by means of the high velocity cathode ray beam generated by the gun 12, the electrons in the beam striking the back of the glass plate 23 and also going through the perforations 24 to strike the platinum signal plate 26 to cause the emission of secondary electrons which pass through the apertures 24 to the collector electrode 21. The number of secondary electrons passing through each aperture is dependent upon the charge on the adjacent photoemissive globules 22 caused by the emission of photoelectrons. The signal current due to secondary electrons passes through the coupling resistance 29 and the drop in potential across this resistance is amplified by the television amplifier 28. The amplified signal is transmitted to a suitable receiving station (not shown) where it may be used to reproduce an image of the object O.

It was found in tests of the tube described above that an optical image focussed on the mosaic 22 could be moved sideways fairly rapidly with no appearance of lag in the received image. In these tests signals were obtained with the collector electrode 22 either slightly positive or negative with respect to the signal plate 26 and also good signals were obtained when the source 30 were removed entirely.

The transmitter tube shown in Figs. 1 and 2 gives storage of charge so as to form a large image current which is larger than it would ordinarily be because of the amplification of the signal by means of the grid action of the stored charges on the photoemissive globules 22. This grid action occurs with respect to the secondary electrons emitted from the platinum layer 26 by the action of the primary electrons in the high velocity scanning beam. By the present method of operation of this device, the photosensitized silver globules 22 are charged several volts negative with respect to the signal plate 26 by the secondary electrons caused to be emitted by the action of the scanning beam from nearby points on the platinum film 26. Between times of scanning of an element of the film 26, the photoelectrons are emitted continuously from the corresponding element of the photosensitized silver mosaic 22 in proportion to the intensity of the light falling on the element during the scanning cycle. In this time interval the element of the mosaic 22 becomes less negative but on the return of the scanning beam to a point on the signal plate 26 just opposite it is quickly charged to its original negative potential. This gives a current in the coupling resistance 29 proportionate to the light energy falling on the element during the entire scanning cycle. Amplification of the image current results from the grid-like action of the stored charge on the secondary current directed through the perforations in the direction of the collector electrode. As a modification, the coupling resistance 29 may be placed between the collector 21 and ground instead of as shown in Fig. 2.

The arrangement of Fig. 1 is very efficient (theoretically more efficient than some existing well-known camera tubes) for several reasons; (1) the scanning beam charges an element of the mosaic 22 to a negative potential with respect to the signal plate 26 by means of the emission of secondary electrons from the signal plate 26, which allows immediate emission of the photoelectrons to the signal plate 26; (2) the photoelectrons are emitted under fair conditions of voltage saturation due to the nearness of the signal plate 26; (3) the photoelectrons are not emitted from one element of the mosaic 22 to adjacent ones due to the closeness of the signal plate 26; (4) the secondary electrons escaping through the apertures 24 are not likely to return to nearby or distant elements since the normal potential of the mosaic 22 is negative with respect to the platinum layer 26; (5) the excess of secondary electrons necessary to establish uniform negative equilibrium potential on the mosaic 22 is suppressed and caused to return to the platinum film 26 rather than to be emitted in all directions and return to distant less negative elements as in the case of familiar types of camera tubes; and (6) the grid action of the stored charges on the mosaic elements 22 acting on the secondary electrons escaping to the collector electrode 21 adds to the amplification of signal in the tube.

It is obvious that a tube of this construction can be made to operate with other photoelectron emitters than those described above, subject to the condition that the light must not cause the emission of appreciable numbers of photoelectrons from the secondary emitter 26. It seems probable that the tube would operate even though this last condition is not fulfilled providing the

secondary emitter has a sufficiently high secondary emission.

In the embodiment shown in Fig. 3, a continuous photoemissive layer 31 is laid down by evaporation or sputtering, on the surface of the perforated glass plate 23 and a discontinuous secondary emitter mosaic 32 is laid down on the surface of the glass plate 25 by sputtering and subsequent heat treatment, the spacing between the mosaic 31 and the secondary emitting surface 32 being about the same as in Fig. 2. The signal resistance 29 is connected between the photoemitter 31 and the collecting electrode 21, a variable source 30 being used between the members 29 and 31 if desired. In a modification, the perforated screen 23 may be made of metal as all elements of the photoemitter 31 are in contact with each other. In this case the metal screen 23 must be insulated from the collector 21. Metal screens with 160,000 holes per square inch are available for this purpose.

The arrangement shown in Fig. 3 operates as follows: Radiations from the object O are projected upon the photoemitting surface 31 by means of a suitable lens system indicated generally by the lens L. Photoelectrons are given off from each elemental area proportional to the intensity of the light-tone value of the corresponding elemental area of the object and these photoelectrons are drawn to the secondary emitting surface 32 causing the various elemental globules thereof to become less positively charged in varying degrees. Once each scanning cycle the beam generated by the electron gun 12 scans the secondary emitter 32 through the perforations 24 in the plate 23 and changes the mosaic elements to an equilibrium positive potential so that they again may receive photoelectrons. During this reestablishment of an equilibrium potential on an element, secondary electron currents flow to 21 and 31. Due to the grid action of 31 on the current from an element of the mosaic, an image current is produced in the coupling resistance 29. The coupling resistance may be placed between the collector 21 and ground instead of as shown in Fig. 3. The signal in the signal resistance 29 is amplified by the amplifying device 28 and connected by suitable wire or carrier means to a television receiving station where an image is reproduced from the received signals.

Various modifications may be made in the invention as above disclosed, the scope of which is indicated by the appended claims.

What is claimed is:

1. In combination, a supporting plate having a multiplicity of apertures therethrough and a photosensitive surface thereon, a semitransparent metallic secondary emitting member closely adjacent the photosensitive surface of said supporting means, means for impressing radiations from an object or field of view upon said photosensitive surface, means for scanning said semitransparent member through the apertures in said supporting member, said supporting plate and said metallic secondary emitting member being spaced by a distance of two one-thousandths of an inch or less.

2. In combination, a supporting member having a multiplicity of apertures therethrough and a continuous photosensitive surface thereon, a semitransparent discontinuous metallic secondary emitting member closely adjacent the photosensitive surface of said supporting member, means for impressing radiations from an object

or field of view on said photosensitive surface through said metallic secondary emitting member, and means for scanning said semitransparent member with a beam of electrons through the apertures of said supporting member, said supporting plate and said metallic secondary emitting member being spaced by a distance of two one-thousandths of an inch or less.

3. In combination, an insulating plate having a multiplicity of apertures therethrough and a discontinuous photosensitive surface thereon, a semitransparent continuous metallic secondary emitting member closely adjacent the photosensitive surface of said insulating member, means for impressing radiations from an object or field of view upon said photosensitive surface through said secondary emitting member, and means for scanning said semitransparent member with a beam of electrons through the apertures in said insulating member, said insulating plate being separated from said metallic secondary emitting member by a distance of the order of two one-thousandths of an inch or less.

4. Electro-optical apparatus comprising an insulating grid element, a coating of photoelectric material on said grid element, said coating being adapted to receive light, an element having a surface capable of emitting electrons all portions of which are equally spaced from a face of said grid element having a photoelectric coating by a distance of the order of two one-thousandths of an inch or less, means for causing electrons to be emitted from said surface and to maintain the potential of said surface positive with respect to said coating, and an anode adjacent the side of said grid element opposite said surface for receiving the electrons emitted from said surface through the interstices of said grid, whereby when the coating of said grid element is unequally illuminated the electrons emitted from said coating as the result of said illumination pass to said electron emitting surface and are not returned to some portion of said coating.

5. In an electron discharge device comprising a container having a cylindrical insulating wall, a cylindrical conducting member within said insulating wall, an electrode supporting element in part at least within said cylindrical conducting member, spring supporting and contact elements carried by said supporting element in slidable engagement with said cylindrical conducting member under such tension that said supporting element can be moved by shaking said container, a second electrode within said container, and an insulating stop between said two electrodes to limit said movement to correctly position said supporting element with respect to said second electrode.

6. An electronic tube television camera comprising therein a plate-like element of insulating material having a multiplicity of apertures therethrough, photoemissive material on one face of said element between and around said apertures in the form of discrete separated particles, a second element on one side of said plate-like element having a face parallel to and closely adjacent said face of said plate-like element carrying said photoemissive material, said second element being capable of emitting secondary electrons under impact of a beam of electrons, the space between said faces being free of matter whereby it affords an unobstructed path for

both electrons and light, means on the opposite side of said plate-like element for generating a beam of electrons, means for causing said beam to scan said face of said second element through said apertures and release secondary electrons from said face of said second element, means for forming an image of an object upon said face carrying said photoemissive material whereby said discrete particles will emit photoelectrons and thus raise the potential of said particles in accordance with the quantity of light thereon, a collecting electrode on the same side of said plate-like element as said beam generating means for collecting secondary electrons passing through said apertures from said second element, whereby said apertured member acts as a grid to control the number of secondary electrons passing through each of said apertures in accordance with the potential of the surrounding particles of photoemissive material, and conductive means extending from said collecting electrode through the tube wall for permitting connection to be made to a translating device to be controlled by the electrons collected by said collecting electrode.

7. An electronic tube television camera comprising therein a plate-like element having a multiplicity of apertures therethrough, a continuous coating of photoemissive material on one face of said element between and around said apertures, a second element on one side of said plate-like element having a face parallel to and closely adjacent said face of said plate-like element carrying said photoemissive material, said second element being capable of emitting secondary electrons under impact of a beam of electrons and being capable of maintaining discrete electric charges on the face thereof near the face of said first member carrying the photoemissive material, the space between said faces being free of matter whereby it affords an unobstructed path for both electrons and light, means on the opposite side of said plate-like element for generating a beam of electrons, means for causing said beam to scan said face of said second element through said apertures and release secondary electrons from said face of said second element, means for forming an image of an object upon said face carrying said photoemissive material whereby photoelectrons are emitted to said face of said second element and lower the potential of various portions of said face in accordance with the quantity of light on corresponding portions of the face of said plate-like element carrying photoemissive material, a collecting electrode on the same side of said plate-like element as said beam generating means for collecting secondary electrons passing through said apertures from said second element, whereby the potential difference between each of the various portions of said face of said second member and the corresponding portion of the face of said plate-like member carrying photoemissive material acts to control the number of secondary electrons passing through the corresponding apertures, and conductive means extending from said collecting electrode through the tube wall for permitting connection to be made to a translating device to be controlled by the electrons collected by said collecting electrode.

GORDON K. TEAL,