

June 16, 1964

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3,137,802

SCREEN RASTER PHOTOCATHODE HAVING PHOTOEMISSIVE  
AND SECONDARY EMISSIVE PROPERTIES

Filed Nov. 23, 1960

2 Sheets-Sheet 1

Fig-1

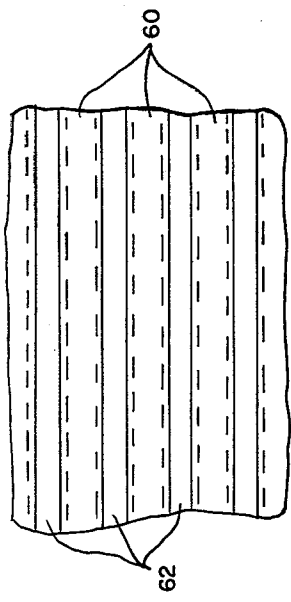
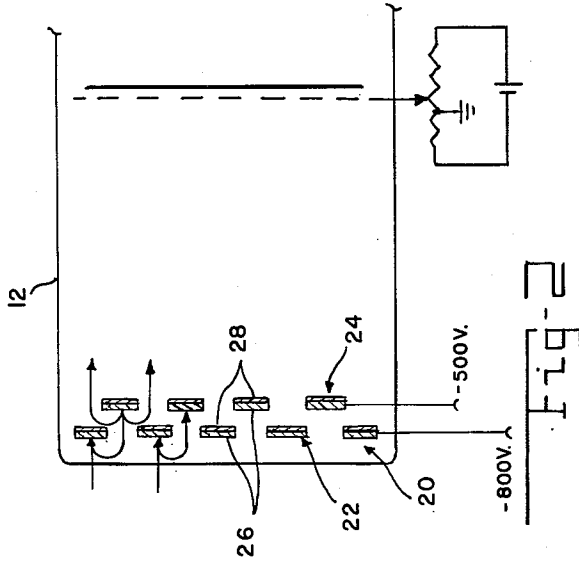
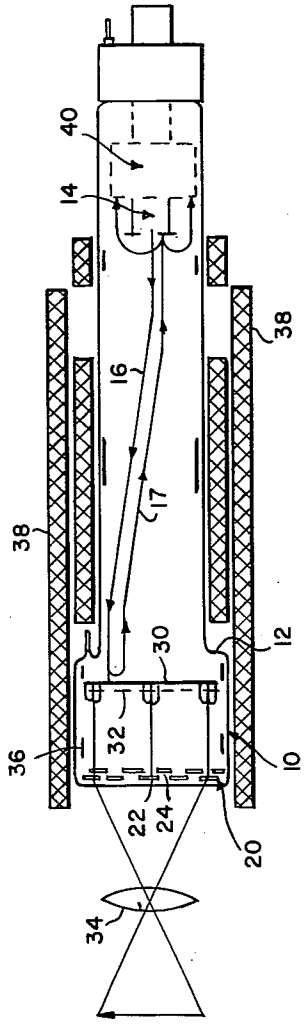


Fig-4

Fig-2

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2 Sheets-Sheet 2

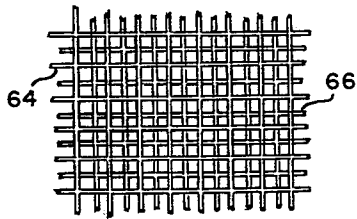


Fig 5

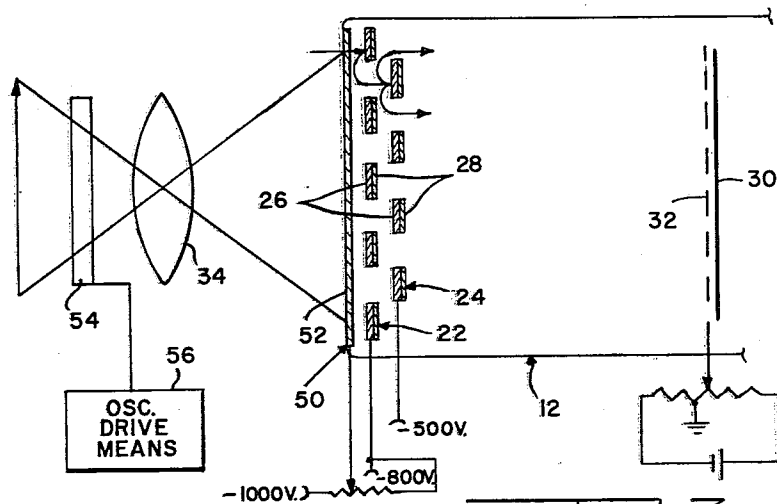


Fig 3

SENSITIVITY MILLIAMPERES/MICROWATT

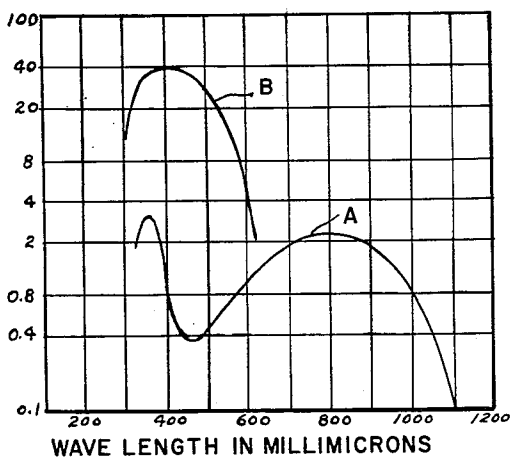


Fig 6

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1

3,137,802

**SCREEN RASTER PHOTOCATHODE HAVING PHOTOEMISSIVE AND SECONDARY EMISSION PROPERTIES**

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Filed Nov. 23, 1960, Ser. No. 71,367  
15 Claims. (Cl. 313-67)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to me of any royalty thereon.

The invention is directed to an improvement in the iconoscope, isocon, image orthicon and vidicon television pickup tubes, and more particularly to a photocathode which is a highly efficient photoelectron emitter and a secondary emission multiplier.

For most pickup devices, some other noise source within the device itself determines the limiting signal-to-noise ratio of the device and establishes a lower sensitivity than is possible with the device which is limited by the shot noise of the primary photoelectrons. In ordinary television pickup tubes, the limitation in sensitivity is determined either by the noise produced by the pickup tube load resistor in the iconoscope or by the noise in the scanning means in the case of the image orthicon. It is desirable that the noise limiting the detectivity of the tube should be the noise component of the dark current produced by the photocathode. To overcome the noise in the scanning beam or load resistor, a more highly efficient photocathode and low noise preamplification before the scanning section is desirable.

The illumination pattern on the photocathode of an imaging pickup tube consists of a flux of light photons or quanta. For presently known photocathodes, such as the silver-bismuth-cesium-oxygen surface used in image orthicons, one photoelectron is emitted for about ten photons arriving at the cathode. The photocathodes used in image iconoscope or image orthicons are semitransparent with the result that only a fraction of the light is absorbed by the semitransparent layer. The light penetrating the semitransparent photocathode will be defocused as it enters the space behind the photocathode and will produce emission of electrons from the wall of the tube and from the target plate. This emission impairs the contrast and the signal-to-noise ratio in the video signal.

It is thus an object of the invention to provide a television pickup tube which will absorb a greater fraction of light falling upon its photocathode and produce a picture under lower levels of scene illumination.

It is another object of the invention to provide a television pickup tube having an improved photocathode structure which will absorb a greater fraction of the light falling upon it and produce a picture under lower levels of scene illumination.

It is a further object of this invention to provide a substantially opaque photocathode capable of photoemission and secondary emission.

It is a still further object of this invention to provide a substantially opaque photocathode capable of emitting photoelectrons at each point on its surface in direct proportion to the intensity of the illumination in the image at that point and amplifying the number of photoelectrons by secondary emission multiplication.

It is a still further object of the invention to provide a substantially opaque photocathode capable of both photoemission and secondary emission which can be incorporated into a conventional television pickup tube structure

2

for effectively extending the spectral response of the tube to include a combination of visual and ultraviolet light or visual and infrared light.

Other objects, novel features, and advantages of this invention will become apparent upon consideration of the embodiments illustrated in the accompanying drawings and hereinafter to be described.

In the drawings:

FIGURE 1 is a schematic illustration of the novel photocathode structure incorporated in an image orthicon tube;

FIGURE 2 is a more detailed schematic view of the image section of an image orthicon tube;

FIGURE 3 is a schematic illustration of a modification of the novel photocathode structure of the invention;

FIGURE 4 is a schematic front view of a portion of a venetian blind type of photocathode structure;

FIGURE 5 is a schematic front view of a portion of a wire mesh type of photocathode structure; and,

FIGURE 6 is a graph which indicates how a broad spectral response is possible using the FIGURE 3 modification of the invention.

Referring now more particularly to FIGURE 1, an image orthicon camera tube is shown comprising a glass envelope 10 having an enlarged portion 12 at one end for enclosing the image section of the tube. At the opposite end of the envelope 10 is an electron gun 14 having a conventional heater, cathode and control grid structure for producing an electron beam 16. A photocathode structure 20 is located within the enlarged portion 12 of the envelope at the opposite end of the tube from the electron gun 14. Spaced from the photocathode structure 20 is the glass target electrode 30. A fine mesh screen 32 is mounted closely spaced from the photocathode side of the target electrode 30.

The photocathode structure 20, as seen in detail in FIGURE 2, has two electrodes 22 and 24 having a plurality of uniformly spaced openings. The electrodes are parallelly adjacent to the front face of the envelope 10 and closely spaced from one another. The surface of each of the electrodes 22 and 24 matches the openings in the other electrode such that all light entering the face of the tube will strike either electrode 22 or electrode 24. Electrodes for the photocathode electrodes in the photocathode structure 20 must be capable of photoemission as well as secondary emission. The backing of the electrodes is composed of aluminum of a thickness which makes the surfaces of the electrodes completely opaque to light. Cesium-antimony is an example of a material that may be used as both a photoemitter as well as a secondary emitter. A photocathode electrode structure having aluminum backing of a cesium-antimony layer will produce a very efficient photoemitter and as high as 160 A./lumen has already been observed by different sources.

The light rays from the scene to be televised are focused by lens 34 onto the photocathode structure 20. Some of the light rays fall upon the surface of photocathode electrode 22 and other light rays pass through the openings in the photocathode electrode 22 to the surface of photocathode electrode 24. Photoelectrons are emitted at each point in direct proportion to the intensity of the illumination in the image at that point on the photocathode electrodes 22 and 24. The primary electrons emitted from photocathode electrode 22 are attracted by photocathode electrode 24 because of the greater positive potential of the electrode 24 and hit the photocathode electrode 24 causing the release of a number of secondary electrons for each primary electron.

The primary electrons and secondary electrons emitted from photocathode electrode 24 move to the right through

the application of a positive potential difference between the photocathode structure 20 and the mesh screen 32. The stream of electrons is magnetically focused and accelerated by an electrostatic field established by the accelerator grid 36 and the focusing coil 38. The electrons passing through the mesh strike the target 30 with sufficient energy so that several secondary electrons are emitted from the target surface for each striking electron. The bulk of these secondary electrons are collected by the mesh 32, which is normally maintained a volt or two more positive with respect to the surface of the glass target. A charge pattern corresponding to the pattern of light and shade focused on the photocathode structure 20 is thereby set up on the photocathode side of the target electrode 30.

The reverse side of the target electrode 30 is scanned by a low velocity electron beam 16. When the beam approaches target areas which are at zero potential, it is reflected back towards the electron gun 14. However, a more positive area of the target surface will cause electrons from the approaching beam to land and neutralize the positive potential charge at that area, and drive the charge area of the target to cathode potential. The remaining electrons of the beam are then reflected back to the gun end of the tube. As the electron beam 16 is scanned over the target surface, there is reflected towards the gun end of the tube a modulated return beam 17. The return beam strikes the end of the gun structure 14 which is formed as a dynode electrode and, as the first stage of the multiplier section 40. Each electron in the returning beam strikes the first dynode with sufficient energy to release several secondary electrons. These in turn are accelerated in the electron multiplier structure 40 and further electron multiplication is accomplished. The output current is closely proportional to the current in the return beam but greatly amplified.

FIGURE 3 is a modified form of the invention which advantageously can utilize the semitransparent photocathode of existing television camera tubes, the photocathode being a thin coating applied, as is known, to the inner surface of the face of the television camera tube. In this modification, the photocathode structure 50 includes the usual semitransparent photocathode electrode 52, the two opaque photo-secondary emitter electrodes 22 and 24 having a plurality of uniformly spaced openings. Photoelectrons emitted by photo cathode 52 are amplified by electrodes 22 and 24 due to secondary emission. In addition to the photoelectrons released at the photocathode, that percentage of light which passes through the photocathode unabsorbed will sensitize the photo-secondary emissive surface 26 of electrodes 22 and 24, thereby releasing for amplification an even greater number of photoelectrons. It will thus be appreciated that light from a source entering the camera tube is essentially totally converted to photoelectron energy, in accordance with the invention, the arrangement not only substantially completely eliminating the ordinarily troublesome effects of unrecovered incident light encountered in prior art orthicon-type tubes but simultaneously resulting in increased sensitivity and optimum usefulness of incident light at any given level. In addition, the presence of a greater negative voltage on electrode 52 than electrode 22 causes electrons emitted from electrode 22 to be repelled by electrode 52.

An extended spectral response for the camera tube, such as indicated by the FIGURE 6 graph, may be readily obtained using the photocathode structure illustrated in FIGURE 3. A photoemitter material such as silver-oxygen-cesium, with a response, as illustrated by curve A in FIGURE 6, in the near infrared range is deposited on the inner surface of the face of the camera tube as semitransparent photocathode electrode 52. A photo-secondary emitter such as cesium-antimony material with a response, as illustrated by curve B in FIGURE 6, in the visible range is deposited on the aluminum backing 28

at 26 forming photo-secondary emitter electrodes 22 and 24. The transmitted picture would be the near infrared picture superimposed upon the visible picture. An ultraviolet and visible picture superimposed can be obtained by utilizing a photoemitter material, such as, gold, with a response in the ultraviolet range in place of the near infrared photoemitter material.

A visible light and an ultraviolet light picture can be alternately transmitted by using a filter-shutter means 54 which includes a filter for visible light and a filter for ultraviolet light positioned in front of the camera tube. The filters are alternately moved in a predetermined time cycle before the tube by driving means 56, whereby only visible or ultraviolet light can reach the camera tube at a given time. A near infrared picture can, of course, be transmitted by using the required type of photoemitter and a near infrared filter. The shape of the vertical synchronizing pulse transmitted is formed to identify which filter is before the camera tube at the beginning of each vertical sweep. The shaped pulse received by the television receiver activates a switch which, in turn, channels the video to the proper detection circuits for the video transmitted.

The novel photocathode electrode structure of the invention must be made sufficiently fine in order to impair resolution beyond the permissible amount. Two possible electrode structures are the venetian blind structure and the wire mesh structure illustrated in FIGURES 4 and 5, respectively.

The venetian blind structure electrodes are constructed of a large number of slats 60 with a plurality of uniformly spaced slot openings 62 therebetween. The slats of the second electrode from the base of the camera tube are directly behind the openings in the first electrode as shown by the dashed lines in FIGURE 4. The slats are constructed of aluminum or similar material with a photo-secondary emitting layer, such as cesium-antimony, deposited thereon.

In FIGURE 5, the electrode structure is basically a fine aluminum or the like wire mesh. A layer of photo-secondary emitting material is deposited on the mesh. The wire mesh of the second electrode 66 from the face of the camera tube is aligned with the openings in the wire mesh of the first electrode 64.

The number of slats 60 or wires 64, 66 used in the photocathode electrode structure has to be larger than the lines of resolution required. The number and size of the slats and wires shown in FIGURES 1 through 5 are diagrammatic and a great deal more in the actual device is required.

Although the invention was described particularly with reference to the image orthicon camera tube, it is not intended to be limited thereto. On the contrary, the invention may be used in other television pickup tubes, such as, the iconoscope, the isocon or the vidicon without departing from the spirit of the invention.

I claim:

1. A photocathode for a television pickup tube capable of both photoemission and secondary emission, said photocathode comprising: a first photo-secondary emitter electrode having a plurality of openings, a second photo-secondary emitter electrode having a plurality of openings spaced from the said first electrode, the surface of said second electrode matching the openings in said first electrode such that all light entering the face of said pickup tube will strike said photocathode, and each of said electrodes including a backing of aluminum and a thin layer of photo-secondary emitting material.

2. A photocathode for a television pickup tube capable of both photoemission and secondary emission, said photocathode comprising: a pair of opaque photo-secondary emitter electrodes having a plurality of uniformly spaced openings, said electrodes being spaced from one another, the surface of each of said electrodes matching the openings in the other electrode such that all light entering

5

the face of said pickup tube will strike said photocathode, and each of said electrodes including a backing of aluminum and a thin layer of photo-secondary emitting material.

3. A photocathode for a television pickup tube capable of both photoemission and secondary emission, said photocathode comprising: a pair of opaque photo-secondary emitter electrodes; each of said electrodes including a fine aluminum wire mesh backing and a thin layer of photo-secondary emitting material on the side of the backing facing the face of said tube; said electrodes being spaced from one another with the wire mesh of each of said electrodes aligned with the openings in the other electrode such that substantially all light entering the face of said pickup tube will strike said photocathode.

4. A photocathode for a television pickup tube capable of both photoemission and secondary emission, said photocathode comprising: a first photo-secondary emitter electrode having a plurality of slats forming an equal number of openings between said slats, a second photo-secondary emitter electrode having a plurality of slats forming an equal number of openings between said slats spaced from the said first electrode, and the slats of said second electrode matching the openings in said first electrode such that all light entering the face of said pickup tube will strike said photocathode, and each of said slats including a backing of aluminum and a thin layer of photo-secondary emitting material on the side of the backing facing the face of said tube.

5. A photocathode for a television pickup tube capable of both photoemission and secondary emission, said photocathode comprising: a semitransparent photoemitting electrode; and a pair of opaque photo-secondary emitter electrodes having a plurality of uniformly spaced openings; said electrodes being spaced from one another; the surface of each of said opaque electrodes matching the openings in the other electrode such that all light entering the face of said pickup tube will strike said photocathode, and each of said opaque electrodes including a backing of aluminum and a thin layer of photo-secondary emitting material.

6. A photocathode in accordance with claim 5 wherein said semi-transparent photoemitting electrode is composed of an ultraviolet responsive photoemitting layer and said layer on each of said opaque electrodes is a visible responsive photoemitting layer.

7. A photocathode in accordance with claim 5 wherein said semitransparent photoemitting electrode is composed of a near infrared responsive photoemitting layer and said layer on each of said opaque electrodes is a visible responsive photoemitting layer.

8. A photocathode for a television pickup tube capable of both photoemission and secondary emission, said photocathode comprising: a semitransparent metal coating on the inner face of said tube; and a pair of opaque photo-secondary emitter electrodes having a plurality of uniformly spaced openings; said electrodes being spaced from one another; the surface of each of said opaque electrodes matching the openings in the other electrode such that all light entering the face of said pickup tube will strike said photocathode, and each of said opaque electrodes including a backing of aluminum and a thin layer of photo-secondary emitting material on the side of the backing facing the face of said tube.

9. A photocathode for a television pickup tube capable of both photoemission and secondary emission, said photocathode comprising: a semitransparent metal coating on the inner face of the said tube; a pair of opaque photo-secondary emitter electrodes; each of said electrodes including a fine aluminum wire mesh backing and a thin layer of photo-secondary emitting material on the side of the backing facing the face of said tube; said electrodes being spaced from one another, the wire mesh of each of said electrodes aligned with the openings in the other electrode such that substantially all light enter-

6

ing the face of said pickup tube will strike said photocathode.

10. A photocathode for a television pickup tube capable of both photoemission and secondary emission, said photocathode comprising: a semitransparent metal coating on the inner face of the said tube; a first photo-secondary emitter opaque electrode having a plurality of slats forming an equal number of openings between said slats; a second photo-secondary emitter opaque electrode having a plurality of slats forming an equal number of openings between said slats spaced from the said first electrode; the slats of said second electrode matching the openings in said first electrode such that all light entering the face of said pickup tube will strike said photocathode; and each of said slats including a backing of aluminum and a thin layer of photo-secondary emitting material on the side of the backing facing the face of said tube.

11. A photocathode-electron multiplier assembly for a television pickup tube comprising a first intersticed electrode arranged to be bombarded on one surface by light entering the tube, a second intersticed electrode closely spaced from the opposite surface of said first electrode and having its interstices masked by said first electrode, a layer of photo-secondary emissive material on the surfaces of said electrodes confronting the face of the tube whereby primary electrons are emitted by said electrodes upon incidence of light, and the opposite sides of said electrodes being coated with material which is opaque to visible light.

12. A photocathode-electron multiplier assembly for a television pickup tube comprising a first grid-like electrode perpendicularly arranged to the axis of the tube to be bombarded on one surface by light entering the tube, a second grid-like electrode mounted adjacent the opposite surface of said first electrode in parallel relation thereto, the interstices of said second electrode being masked by the grid structure of said first electrode so that substantially all incident light is intercepted by said electrodes, a layer having secondary-emissive and photo-emissive properties on those surfaces of said electrodes receiving incident light so that said electrodes emit primary electrons in accordance with the optical image and additionally said second electrode emits secondary electrons upon incidence of primary electrons from said first electrode, and the opposite surfaces of said electrodes being provided with a material which is opaque to visible light.

13. A photocathode-electron multiplier assembly for a television pickup tube comprising a photocathode for emitting photoelectrons, a first intersticed electrode adjacent said photocathode and arranged perpendicular to the axis of the tube to receive on one surface thereof photoelectrons from said photocathode, a second intersticed electrode closely spaced from the opposite surface of said first electrode in parallel relation thereto, the interstices of said second electrode being coplanar with the solid portion of said first electrode to form a continuous electrode screen substantially overlapping said photocathode, each of said electrodes having the surface thereof directed toward said photocathode rendered photo- and secondary-emissive so that light passing through said photocathode unabsorbed bombards said surfaces in proportion determined by the optical image, thereby effecting substantially total recovery of the incident light and evoking additional photoelectron release due to the photoemissive property of said electrodes, and a coating opaque to visible light applied to the opposite surface of said electrodes.

14. A photocathode-electron multiplier arrangement for a television pickup tube comprising a photocathode having a spectral response extending over a predetermined portion of the electromagnetic spectrum, a first intersticed electrode adjacent said photocathode arranged perpendicular to the axis of the tube to receive on one sur-

7

face thereof photoelectrons emitted by said photocathode, a second intersticed electrode closely spaced from the opposite surface of said first electrode in parallel relation thereto, said second electrode being vertically offset from said first electrode to mask substantially completely the interstices of said first electrode, each of said electrodes having its surface facing said photocathode rendered compositely photo- and secondary-emissive so that substantially all light passing through said photocathode unabsorbed falls on said electrodes, the photo-emissive property of said electrodes producing a special response over the visible portion of the spectrum thereby extending the overall spectral response of the tube, and means for rendering the opposite surfaces of said electrodes opaque to light in the visible portion of the spectrum.

15. A photocathode-electron multiplier arrangement for a television pickup tube comprising a photocathode having a spectral response extending over a portion of the electromagnetic spectrum adjacent the visible portion of the spectrum, a first intersticed electrode adjacent said photocathode to receive on one surface thereof photo-

8

electrons emitted by said photocathode, a second intersticed electrode spaced from the opposite surface of said first electrode, said second electrode having its interstices vertically offset from the interstices of said first electrode in such manner that the interstices of said first electrode are substantially completely masked, each of said electrodes having the surface facing said photocathode rendered compositely photo- and secondary-emissive whereby substantially all light passing through said photocathode unabsorbed falls on said electrodes and evokes increased photoemission, the photoemissivity of said electrodes being such as to provide a spectral sensitivity in the portion occupied by the visible spectrum, and means on the opposite surfaces of said electrodes for rendering said electrodes opaque to light in the visible portion.

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