Fig. 4

Fig. 5

Receiver

Matrix Unit

Square Wave Generator

Red Gate
Blue Gate
Green Gate

R-Y  B-Y  G-Y  Y
LIGHT IMAGE REPRODUCTION DEVICES

William L. Roberts, Monroeville, and Andrew P. Kruper, Pittsburgh, Pa., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application November 30, 1953, Serial No. 395,044

6 Claims. (Cl. 250—213)

This invention relates to devices capable of amplifying the intensity of a light image. It is an object of this invention to provide an improved light amplifier.

It is another object to provide an improved amplifier of images in natural color.

It is another object to provide a color television system incorporating an image intensifying device.

It is another object to provide an arrangement for reproducing in amplified intensity an image on a fluorescent screen.

These and other objects will be effected by our invention as will be apparent from the following description taken in accordance with the accompanying drawings, throughout which like references indicate like parts and in which:

Figure 1 is a schematic drawing of a monochrome image intensifier embodying our invention;

Figure 2 is a schematic drawing of a color image intensifier embodying our invention;

Figure 3 is a sectional view of a portion of an auxiliary electrode of an electron multiplier structure;

Figure 4 is a color television image reproduction system embodying our invention, and

Figure 5 is a modified color television image reproduction system embodying our invention.

Referring in detail to Fig. 1, the elements are enclosed in an evacuated envelope 10. A photo cathode 12 is positioned near one end of the envelope 10 and is substantially perpendicular to an axis 14 of the envelope 10. The photo cathode 12 consists of a photoemissive layer 20 deposited on a transparent supporting member 18 having a transparent conductive material coating, such as stannic oxide known by the trademark Nesa, by a suitable method. It may be desirable in some applications to deposit the photoemissive layer 20 directly on the face plate 16 of the envelope 10. The photoemissive layer 20 may be of any suitable material such as antimony treated with caesium which is capable of emission of electrons upon light impingement. An exterior terminal 22 is connected to the supporting member 18 for applying a voltage to the photo cathode 12 with relation to the other elements within the envelope 10. A light scene 11 is focused on the photo cathode 12 through the transparent face plate 16 and supporting member 18 by a suitable optical means such as the lens 24.

A fluorescent screen 26 is positioned near the opposite end of the envelope 10 with respect to the photo cathode 12 and is also perpendicular to the axis 14 of the envelope 10. The fluorescent screen 26 is comprised of a transparent supporting member 28, with a conductive coating such as Nesa, and is coated on the surface thereof of the photo cathode 12 with a phosphor coating 30. The phosphor coating 30 contains a phosphor as for example 32, and is capable of emission of light upon electron bombardment and will give off substantially a white light.

Positioned between the photo cathode 12 and the fluorescent screen 26 is an electron multiplication structure 13. The electron multiplication structure 13 is comprised of a plurality of similar auxiliary electrodes 29, 32, 34, and 38 of substantially the same area as the photo cathode 12 and is also perpendicular to the axis 14 of the envelope 10. Each of the auxiliary electrodes 29, 32, 34, and 38 are of similar construction. In our preferred embodiment a portion of which is shown in Fig. 3, a glass plate 31 having a plurality of parallel apertures 33 therein is utilized with the apertures inclined at an angle to the axis 14. The angle of inclination with respect to the axis 14 should be such as to allow substantially all primary electrons emitted from the photo cathode 12 will be unable to pass through the apertures 33. On the interior surface of the apertures 33 are two insulated coated portions 35 and 36. These portions 35 and 36 are deposits of material having a high ratio of secondary electron emission such as a silver magnesium alloy. The coatings 35 and 36 on the interior surface are insulated from each other and all of the coatings 35 of the apertures 33 are connected together by conductive means such as a coating 37 which is applied to one surface of the glass supporting member 31. The coatings 36 are connected together by second conductive means such as a metallic coating 39 on the opposite surface of the glass member 31. The coatings 35 are so arranged with respect to the electron emission from the photo cathode 12 that they will intercept substantially all of the electrons entering the apertures 33 while the coatings 36 are positioned and of suitable voltage so that they will intercept substantially all of the electrons emitted from the coatings 35. A terminal 49 exerts a terminal connection 10 is connected to the coatings 35 of the apertures 33 by the conductive coating 37 for the purpose of applying a voltage thereto while a terminal 42 is provided external to the envelope 10 for providing a voltage to the coatings 36 by means of coating 39.

The auxiliary electrodes 29, 32, 34, and 38 are positioned so that they will intercept substantially all of the electrons entering the apertures 33. The front opening in the apertures 33 in the secondary auxiliary electrode 34 and those following 29 and 38 are substantially aligned with the opening of the surface of the preceding auxiliary electrode so that substantially all of the electrons leaving the preceding auxiliary electrode will pass into the apertures 33 of the following auxiliary electrode. Progressively increasing positive voltages are applied to the coatings 35 and 36 on the interior surface of the apertures 33 of the auxiliary electrodes from the source 90 by leads to the exterior of the envelope so that the electrons will be focused through the electron multiplication structure 13. It should be noted by constructing the electron multiplication structure in this manner that retention of definition in the image is obtained at each auxiliary electrode 29, 32, 34, and 38 throughout the electron multiplication structure 13.

In the operation of the device shown in Fig. 1, a black and white image is projected through the lens system 24 onto the photo cathode 12. When a light image 11 is focused on the photo cathode 12, primary electrons are emitted therefrom with a density distribution which corresponds to the distribution of illumination of the scene image. The photo cathode 12 due to the light image 11. The emitted photo electrons form a primary electron image and are accelerated to the electron multiplying structure 13 by the higher positive voltage applied thereto by means of the conductive coating. The electrons within the primary electron image strike the first auxiliary electrode and the electron multiplying structure 13 and substantially all of the electrons strike the coating 35 on the interior surface of the apertures 33 due to the large number of apertures 33 on the surface. The electrons striking the coating 35...
on the interior surface of the apertures 33 cause the coating 35 to emit secondary electrons which are collected by the second coating 36 within the apertures 33 which is at a higher positive potential than that applied to the first coating 35. The secondary electrons from the second coating 36 within the apertures 33 are accelerated to the second auxiliary electrode 34 where this process repeats depending upon the number of auxiliary electrodes within the electron multiplying structure 13. The secondary electron image, after leaving the electron multiplying structure 13, proceeds on and strikes the screen 26 thereby exciting the phosphor 30 and emitting an intensified light image representative of the object 11 focused on the photo cathode 12.

Referring in detail to Fig. 2, a device is shown similar to that in Fig. 1 and modified so that a color image may be intensified. The elements of the tube are enclosed within an envelope 10 and include in the following order a color filter structure 43, a collimating structure 44, a photo cathode 12, an electron multiplier structure 13 and a fluorescent screen 45.

The colored image 41 is focused through a suitable lens system 24 onto the color filter structure 43. The color filter structure 43 comprises a series of very thin, closely adjacent elemental areas of selected component color transmission filters. In our specific embodiment, the color filter structure 43 comprises a plurality of parallel adjacent strips R, G and B capable of transmission of selected component colors representing respectively of the colors red, green and blue. The filter strips R, G and B are arranged so that adjacent strips are of different color and in regular sequence. The strips R, G and B may be supported on a transparent member 49. The effect of the color filter structure 43 is to break the image into small elemental areas of single representative component colors. The areas are of such a size that the eye viewing three adjacent elemental areas of different colors will see a mixture of the colors.

The collimating electrode 44, which is optional, is positioned adjacent to the color filter structure 43 for the purpose of collimating the light coming through the color filter structure 43. The collimating electrode 44 is comprised of an opaque member of substantially the same area as the color filter structure 43 and having a plurality of parallel apertures 46 therein for passage of the light image.

The photo cathode 12 is positioned adjacent to the collimating electrode 44 so as to intercept the light image and form a primary electron image. The primary electron image from the photo cathode 12 is intercepted by the electron multiplication structure 13 and converted into a multiplied secondary electron image which in turn bombards the fluorescent screen 45.

The fluorescent screen 45 is comprised of a supporting structure 47 such as Ness with a plurality of elemental phosphor coatings thereon. In one specific embodiment, the phosphor coatings are in the form of strips R', G' and B' of similar dimension to said color filter strips R, G and B and in respective alignment with the filter strips R, G and B. A voltage source 90 provides progressively increasing voltages to the elemental sections of the color control electrode 57 representative of the selected component colors, an electron image is obtained after passing through the color control grid which is representative of the color image. Elemental areas of phosphor are placed in alignment and register with the areas in the color control electrode. The areas of phosphor are positioned so that they will give a color representative of the color signal applied to the elemental section on the color control electrode in registration therewith.

In our specific embodiment, the color control grid 57 is comprised of a plurality of conducting strips 60, 61 and 62 parallel to each other and insulated from each other. A plurality of apertures 59 are placed within each of the conductive strips 60, 61 and 62. The conductive strips 60, 61 and 62 are arranged in repeating sequence, that is, 60, 61 and 62 across the electrode 57. The conductive strips 60, 61 and 62 bearing the same number are connected together so as to form three insulated coplanar grids with suitable means for applying voltages thereto. The strips 60, 61 and 62 may have any orientation with respect to the light scanning spot, but in the specific embodiment shown they are shown horizontal.

The primary electron image, after passing through the color control structure 57, will pass through the electron multiplying structure 13 and, in turn, will strike an output screen 45. The output screen is similar to that described in Fig. 3 with the phosphor R', G' and B' parallel to and in alignment with the respective conductive strips 60, 61 and 62 within the color control electrode 57. The
2,821,687

In the operation of the device shown in Fig. 4, the monochrome signal received on the receiver 9 is applied to the control grid 54 of the cathode ray tube 50 while a deflection voltage is also applied to the deflection coils 53 of the cathode ray tube 50 for purposes of scanning a selected area on the screen 52. The raster scanned on the screen 52 is focused on the photo cathode 12 by means of the lens structure 55. Due to the low persistent phosphor on the screen 52, the effect is a light spot scan on the tube 56. Electrons are emitted from the photo cathode 12 with a density distribution which corresponds to the distribution of the illumination projected thereon by the cathode ray tube 50.

The electrons emitted from the photo cathode 12 form a primary electron image or beam which is representative of the intensity or brightness of the signal. The color information is added to the primary electron image or beam by the color control electrode 57. The color signals obtained from the receiver 9 are connected to the grid 57 by separate conductors indicated by the line 63. The color signals are represented by (R—Y), the red color difference signal (G—Y), the green color difference signal and (B—Y), the blue color difference signal. These color signals may be converted by known means and applied respectively to the strips 60, 61, and 62 to impress color information on the grid 57. This impresses on the primary electron image beamstriking the strips 60, the red color signal. The more negative the voltage applied to the strips 60, the less will be the number of electrons passing through the apertures 33. The electron beam image representative of the red color information is accelerated to the electron multiplication structure 13 where the electrons in the electron line are multiplied and converted to a secondary electron image which strikes the phosphor line R' giving light of a red color and the intensity depending on the number of electrons.

Due to the low persistence of the phosphor screen 52 in a cathode ray tube 50, the effect of scanning the raster on the screen 52 is similar to transmitting a light spot onto the photo cathode 12 of the image intensifier tube 56. By scanning across the color control grid 57 and phosphor strips R', G' and B' in transverse direction, it is possible to obtain a dot sequential color operation or with the electron beam scanning along the color electrode conductive strips and phosphor strips, line sequential or frame sequential may be obtained by sequential application of color signals. Since the primary electron beam spot will normally cover at least three strips of the color control electrode 57, simultaneous presentation can also in effect be obtained by simultaneous application of the color signals.

Referring in detail to Fig. 5, a possible modification of the structure shown in Fig. 3 is utilized in which the color control electrode 57 shown in Fig. 3 is removed and a color deflection electrode 67 is positioned between the electron multiplying structure 13 and the output screen 71. The color deflection electrode 67 utilized in Fig. 4 is comprised of a plurality of parallel white or plates 68 with the alternate plates connected to separate conductors 69 and 70 so that half of the plates are connected to one conductor 69 and the other half are connected to another conductor 70.

An output screen 71 is utilized of similar construction to those described in Figs. 2 and 3, but the sequence of the phosphor lines R', G', and B' is altered. A conducting plate 68 is positioned in front of every other phosphor strip R', G', or B'. In our embodiment, the phosphor strip R' is positioned between each plate 68 while the phosphor strips B' and G' alternate between the phosphor lines. In this arrangement, a plate 68 is positioned in front of each phosphor strip B' and G'. The voltage source 90 supplies progressively increasing voltages to the elements of the tube.

A conventional color receiver 9 is utilized as described in the previously cited article. The color signals R—Y, Y—B, G—Y, and Y obtained from the receiver 9 may be connected into a matrix unit 73 so as to derive color signals representative of the red, blue and green colors. The red, blue and green signals obtained from the matrix 73 are fed to the respective gaging devices 74, 75 and 76, one for each color signal, to control the grid 54 of the cathode ray tube 50. The gaging pulses fed to the gates 74, 75, and 76 must be synchronized with the color switching signal applied to the color control grid 67. The synchronizing signal is obtained from the receiver 9 for the control of a generator 77 for generating gaging pulses to the gates 74, 75 and 76 and applying signals to the color deflection grid 67.

In the operation of the device shown in Fig. 5, the color video signals from the receiver 9 are applied to the control grid 54 by the gaging devices 74, 75 and 76. Suitable deflection voltages are also derived from the receiver 9 and applied to deflection coils 53 for scanning a raster on the screen 52.

The light image raster 52 is focused on the cathode 12 by means of the lens 55. Due to the low persistence of the phosphor utilized on the screen 52, the effect is a light spot scan on the photo cathode 12. The electrons are emitted from the photo cathode 12 with a density distribution which corresponds to the light distribution projected on to the photo cathode 12 from the screen 52.

The electrons emitted from the photo cathode 12 form a primary electron image representative of the density or brightness of the color signals. The primary electron image is accelerated to the electron multiplier structure 13 where the electron image is converted to a secondary electron image. The secondary image is accelerated toward the image screen 71.

When no potential differences exist between the plates 68 of the color control grid 67, the electron beam will pass through the color control grid 67 and will strike the red phosphor strip. The red gaging device 74 is opened allowing the red color signal to be applied to the control grid 54 of the cathode ray tube 50 at the same time that the voltage across the plate 68 is zero. When a deflection voltage is applied to the color control grid 67 by the generator 77, the beam will be deflected to the green or blue phosphor strips G' or B' on the screen 71. When the plates 68 connected to the conductor 70 are positive with respect to the plates of the conductor 69, a green image will be reproduced. When the plates connected to the conductor 70 are positive with respect to the plates connected to the conductor 70, a blue image will be obtained.

The deflection type tube shown in Fig. 5 permits presentation of images by the frame, line or dot sequential systems. There are several possible methods of applying color information to the color deflection grids, and it is also possible to arrange the phosphor lines in different systems so as to place the blue or green strip at the center point of the deflection plates 68.

While we have shown our invention in several forms, it will be obvious to those skilled in the art that it is not so limited but is possible of other changes and modifications without departing from the spirit and scope thereof.

We claim as our invention:

5 1. A light amplifier comprising a photoemissive cathode, a fluorescent screen and means for controlling the operation of auxiliary electrodes positioned between said photoemissive cathode and said fluorescent screen, each of said electrodes having a plurality of apertures therein and inclined with respect to the axis of said light amplifier, each of said apertures having insulated portions on the inner surfaces thereof and having a coating thereon of a high secondary emissive material, means for applying operating potentials on said surfaces so as to divide the electron emission from said photoemissive cathode
into discrete electron streams and direct them on successive auxiliary electrodes whereby substantially all of the electrons leaving apertures in the succeeding auxiliary electrode will enter into apertures in the succeeding electrode.

2. A light amplifier comprising a photoemissive cathode, a fluorescent screen and one or more auxiliary electrodes having the property of high secondary electron emission, each of said auxiliary electrodes consisting of a structure extending transversely across the tube and having a plurality of apertures inclined with respect to the axis of said light amplifier.

3. A light amplifier comprising a photoemissive surface for producing an electron image in response to a light image projected thereon, means for multiplying said electron image comprising a plurality of dynode structures, each of said dynode structures comprised of a plurality of elemental secondary emissive areas inclined with respect to the axis of said light amplifier, and means for reproducing said multiplied electron image into a light image comprising a fluorescent screen.

4. A light amplifier comprising a photoemissive surface for producing an electron image in response to a light image projected thereon, filter means positioned between the photoemissive surface and said light image, said filter means comprising a plurality of selected component color strips, each of said strips passing only one selective color, a dynode structure positioned near to said photoemissive surface on the opposite side thereof with respect to said filter means so as to multiply said electron image produced by said photoemissive surface, said dynode comprised of an electrode having a plurality of apertures therein inclined to the axis of said light amplifier, each of said apertures having a coating of secondary emissive material, a fluorescent screen positioned on the opposite side of said dynode structure with respect to said photoemissive surface for reproducing said multiplied electron image into a light image, said screen comprising a plurality of phosphor strips parallel to and in alignment with said filter strips, said phosphor strips capable of emitting light of a component color upon electron bombardment of a similar color to the color passed by said filter strips which is in alignment therewith.

5. A light amplifier comprising a photoemissive cathode, a fluorescent screen, and one or more auxiliary electrodes, said auxiliary electrodes comprising a dielectric plate having a plurality of passageways inclined to the approaching incident electrons, said passageways having a first and second surface therein, said first surface positioned so as to intercept all of said incident electrons and said second surface positioned so as to collect electrons from said first surface.

6. An image reproducing device for converting color image signals into color images comprising in combination a photoemissive cathode, a luminescent screen comprised of groups of selective component color reproducing sections, a color control grid comprised of a plurality of groups of selective component color sections, and an electron multiplication structure positioned between said cathode and said luminescent screen, said electron multiplication structure comprising an electrode having apertures therein inclined to the axis of said device, each of said apertures having a coating of secondary emissive material.

References Cited in the file of this patent

UNITED STATES PATENTS

2,120,765  Orvin ------------ June 14, 1938
2,495,697  Chilowsky ------------ Jan. 31, 1950
2,594,740  De Forest et al. ----- Apr. 29, 1952
2,605,335  Greenwood et al. ----- July 29, 1952
2,634,327  Sziklai ---------------- Apr. 7, 1953