

Feb. 24, 1959

A. P. KRUPER
IMAGE INTENSIFIER

2,875,360

Filed May 25, 1953

2 Sheets-Sheet 1

Fig. 1.

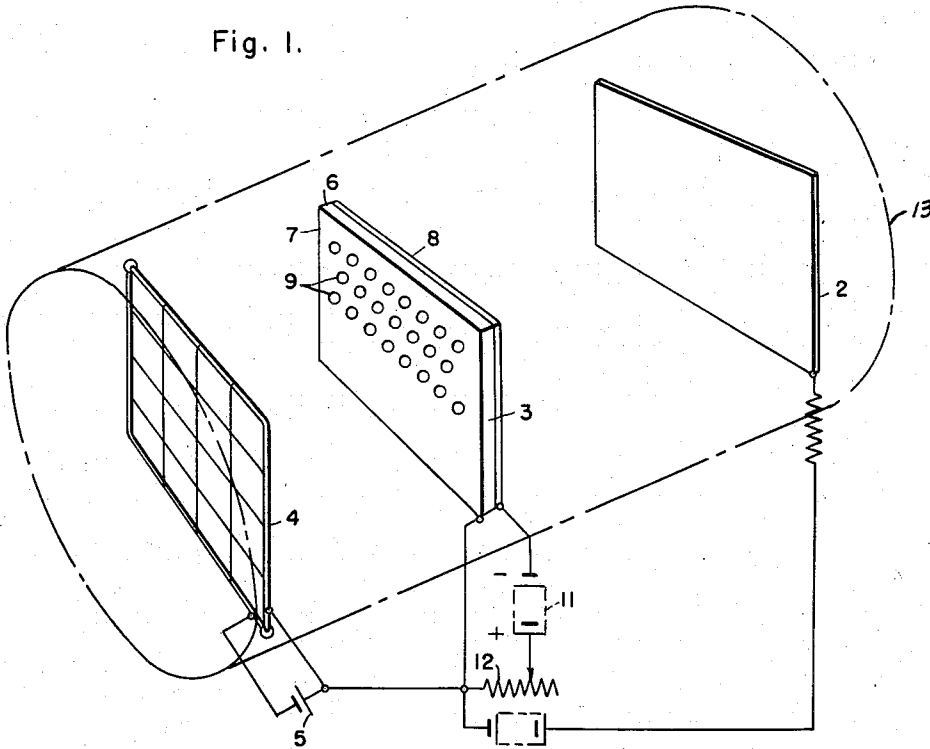
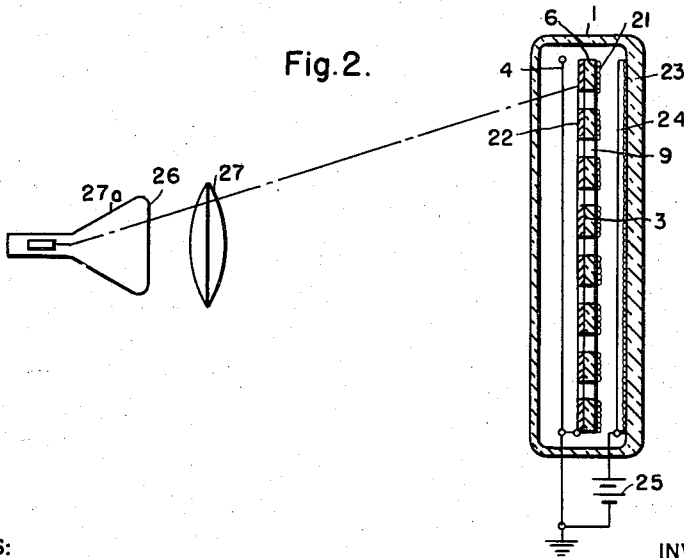


Fig. 2.



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2 Sheets-Sheet 2

Fig. 3.

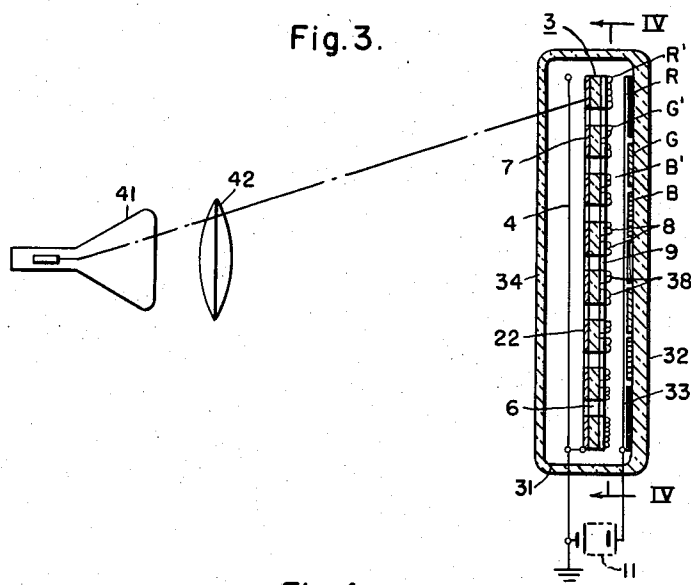
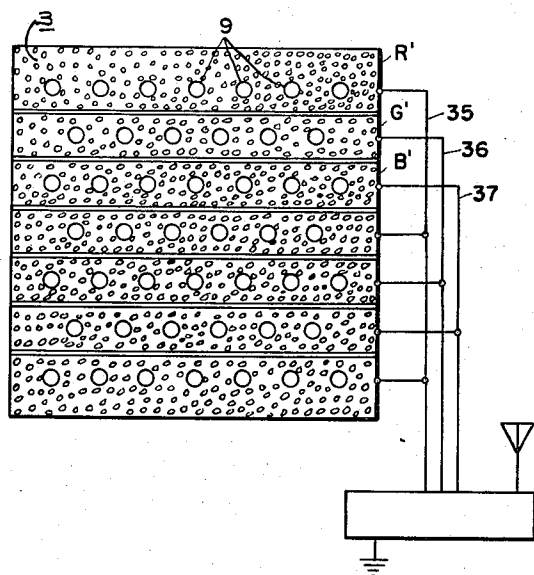


Fig. 4.



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IMAGE INTENSIFIER

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3 Claims. (Cl. 313-66)

My invention relates to light intensifying devices and in particular relates to a novel arrangement for obtaining intensified images in color television systems. In carrying out such purposes, I have devised an ancillary device which is applicable to the intensification of monochrome images, and also an improved type of photoelectric cell.

One object of my invention is to provide a new and improved arrangement for reproducing in colors at a greatly intensified brightness a television or other colored image.

Another object is to provide a new and improved television system.

Another object is to provide a novel arrangement for obtaining an enlargement on a viewing screen of a light image, which enlarged image is free from the falling off of intensity in lateral directions that is characteristic of simple optical projection onto a ground glass screen.

Another object is to provide a new and improved type of intensifier for images generally.

Another object is to provide a new and improved type of photoelectric cell that shall be capable of furnishing currents so much larger than present-day cells as to make the employment of output amplifiers unnecessary for many purposes.

Other objects of my invention will become apparent upon reading the following description taken in connection with the drawings in which:

Figure 1 is a schematic exploded perspective view, though with axial distances expanded for clarity, of a photoelectric cell in accordance with my invention;

Fig. 2 is a schematic longitudinal section of a monochrome picture intensifier embodying the principles of my invention;

Fig. 3 is a schematic longitudinal view of an intensifier for color pictures particularly applicable to color television; and

Fig. 4 is a schematic diagram of the circuits for controlling the color reproduction in the tube of Fig. 3.

Referring in detail to Figs. 1 and 2, the photoelectric cell of my invention comprises a vacuum-tight container 13 containing a collector electrode 2 of any suitable material such as conducting glass, a screen electrode 3 and cathode 4 which may be a criss-cross of incandescent filaments of a type which emit electrons copiously when heated. The cathode 4 may, for example, consist of a framework forming a square and having insulators at a pair of diagonally opposite corners, the individual incandescent filaments extending from one half of the framework to the other but without contact at their intersections. A source of voltage 5 is connected to the respective halves of the framework and supplies current to heat the individual filaments to a temperature at which they emit electrons freely. Any other type of electron source emitting electrons over an area like that of rectangle 4 might be substituted for it; for example, a plate coated with a secondary emitter and rendered emissive by impact thereon of electrons emanating from incandescent cathodes positioned just inside the periphery of the container.

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The screen 3 comprises a dielectric sheet 6 sandwiched between a conducting plate 7 and a conducting layer 8 which is coated with photoelectrically-emissive material. The screen 3 is perforated by holes 9 of small diameter, e. g., several mils in diameter, spaced as closely together as mechanical strength will allow. A voltage source 11 in series with a variable resistor 12 gives the layer 8 a negative potential relative to conductive plate 7 which is, in turn, connected to the cathode 4. The conducting plate 7 may be a thin layer of metal formed by deposition of metal vapor; the dielectric sheet 6 may be of photoetched glass; and the layer 8 may be formed by depositing a thin metallic layer and coating it with a photoelectric layer such as cesiated antimony.

When no light is incident on the photoelectric layer 8, the space between cathode 4 and conductive layer 7 contains a cloud of electrons of low velocity which are unable to pass through the holes in dielectric layer 6 because of the slight negative potential given to layer 8 by the bias-source 11. When light is focused on the photoelectric layer 8 it emits electrons producing a voltage drop through resistor 12 thereby making layer 8 more positive. Electrons from the space in front of layer 7 can now pass through the holes in layer 6 to the space in front of layer 8 and can thus be attracted to electrode 2. The number of electrons passing through the holes in dielectric layer 6 is dependent upon the voltage drop in resistor 12, which is itself a function of the total light striking photoelectric layer 8. The current flowing to electrode 2 is thus a function of the light flux incident on the photoelectric surface. There is no tendency for electrons entering the holes in dielectric layer 6 to strike and neutralize the charge on photoelectric layer 8 because the electrons will travel in straight lines and because of the negative potential impressed on layer 8 by voltage-source 11. Layer 8 thus acts purely as a control electrode and the current flowing to collector-electrode 2 may be many times the charging current flowing to or from photoelectric layer 8.

One convenient way of making the control-electrode plate just described would be to form the layer 7 as a thin perforated nickel plate on to the back of which is evaporated a layer of dielectric material, e. g., barium fluoride or magnesium oxide, and then the latter be covered with evaporated metal and coated with photoelectric material, e. g., cesiated antimony. Alternative arrangements would be to employ a photoconductive coating, such for example as thallous sulfide or amorphous selenium in place of layer 8; to use a mesh screen instead of the perforated metal plate 7; and to use secondary electron-emissive material energized from a primary electron source position near it as the source of electrons in the space in front of layer 7. For instance, the primary electron source might be a heated filament supported parallel to the edges of a sheet of metal having a surface which is a good secondary emitter.

Fig. 2 shows in section an arrangement for reproducing monochrome pictures with greatly increased brightness, and would be particularly valuable for producing large size television pictures of a high order of brightness. This arrangement comprises a vacuum-tight container 1 which may for example be of glass and which contains a cathode 4 and a sandwich-type screen comprising a perforated transparent dielectric 6 coated on its remote face with a mosaic 21 of photoelectric material, the elements 4 and 6 being similar to those already given the same reference numerals in describing Fig. 1. The face of dielectric layer 6 which faces cathode 4 is coated with a layer 22 of transparent conductive material; for example, with the conductive glass sold under the trade name NESA by the Pittsburgh Plate Glass Company of Pittsburgh, Pa. The wall of container 1 facing the photo-

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electric mosaic 21 is covered with a layer 23 of zinc sulphide or other phosphor material. The free face of layer 23 may be coated with a thin layer 24 of aluminum. The layer 23 is connected to the positive terminal of a direct current source 25 which has its negative terminal connected to the cathode 4 and conductive layer 22 and also grounded. A light image 26, such for instance as that generated on the screen of a television kinescope, is focused through a suitable optical system symbolized by lens 27.

One suitable way to make the structure comprising layer 6 would be to make layer 6 from a sheet of transparent photosensitive glass such as is sold by the Corning Glass Company of Corning, New York, etched with holes of 15 to 20 mils diameter spaced about 30 mils on centers.

The operation of the Fig. 2 arrangement is as follows. The light image 26 to be intensified is focused on the mosaic 21, where bright areas on the image cause the discrete spots of photoelectric material on which they are incident to emit electrons and acquire a positive charge, while those discrete spots which are less brightly illuminated acquire a correspondingly less positive potential. Where the image 26 is that on the screen of a conventional television kinescope 27a the image really consists, of course, of a bright spot at the end of the kinescope cathode ray beam traveling over the picture line-by-line with the conventional scanning movement. Persistence of light emission of the kinescope screen, however, maintains luminosity of each picture element for a brief period after passage of the scanning beam, so that even in the case of television intensification, the light image 26 is something more than a mere moving spot, and there is a progressive storage of positive charges on the mosaic spots which adds to the brightness of the picture on output-screen 23.

The distance between the respective charged particles of mosaic 21 and grounded layer 22 on the opposite side of dielectric sheet 6 is so small that even a relatively small positive potential (of the order of several volts) on the mosaic surrounding one of the holes 9 in dielectric 6 produces a strong potential gradient in the hole which is able to attract electrons from the space between cathode 4 and layer 22 and impel them into the space between mosaic layer 21 and phosphor screen 23. Thereupon the potential gradient impressed by voltage source 25 accelerates the electrons to high velocity impact with phosphor layer 23. Bright and dark areas, duplicating the varying intensity of the positive charge image stored over the surface of mosaic layer 21, thus appear on phosphor layer 23 presenting a highly intensified picture duplicating the light image 26 to the eyes of the observer.

Dielectric layer 6 is made with sufficient leakage between its faces so that the charge on the mosaic particles can substantially leak off in approximately one-thirtieth of a second where the image 26 is a television picture, and thus the mosaic will be practically uniformly discharged and at ground potential at the time the succeeding picture frame is being scanned.

The electron currents passing through the respective holes in dielectric layer 6 may be many times the electron currents emitted from the mosaic particles which produce the electric control gradients in the holes; and correspondingly the light image produced on phosphor screen 23 may be much brighter than that focused on mosaic layer 21. Likewise, the light-image produced in the phosphor screen has a depth which renders it readily visible at large angles to one side of the normal to the screen, which contrasts sharply with pictures on the ground-glass screens of projection-type television receivers.

The Fig. 2 arrangement, while useful for intensifying television pictures, is of course not limited to such use

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but is useful for intensifying light-images generally. It is also applicable, with the simple replacement of the photoelectric mosaic particles by electron-emitters responding to X-rays or other types of radiant energy, to production of light images which are replicas of radiation fields of any type.

In choosing the photoelectric material to form the mosaic 21 it should be borne in mind that the cathode 4, if of the heated type, emits radiation likely to produce a steady background electron emission from photoelectric mosaic 21. This difficulty may be largely eliminated by using photoelectric material in mosaic 21 which is predominantly sensitive to blue light, such as is emitted by modern kinescope screens, and largely insensitive to long wave lengths such as are emitted by heated cathodes, particularly if operated at lower temperatures. Another expedient toward elimination of the above-mentioned difficulty would be to employ for dielectric layer 6 or conducting layer 22 a substance opaque to wave lengths other than those present in the light image 26.

Still another expedient would be to use for cathode 4 a non-heated electron source such as the layer of secondary-electron emitting material described in connection with Fig. 1, or a layer of photoelectric material such as silver-cesium oxide-cesium commonly referred to as an S1 surface which is sensitive only to light, such as red, which does not excite the photoelectric mosaic 21, and flooding the layer with a constant flux of said light.

The layer 24 of aluminum backing the phosphor layer 23 is made thin enough to be permeable to electrons accelerated by the voltage source 25, but thick enough to prevent light from phosphor 23 from being radiated backward into incidence with the mosaic 21. Instead this light is reflected forward, increasing brightness of the image screen by the observer looking at the output screen.

An arrangement embodying certain features of Figs. 1 and 2 but which is particularly adapted to intensification of color television images is shown in Figs. 3 and 4. A vacuum-tight enclosure 31 which, in the case of home television pictures, might be of the order of twenty by thirty inches by one or two inches from front to back has its transparent front face 32 coated on the inside by groups of three parallel strips R, G and B of phosphors which respectively emit red, green and blue light when excited by the impact of electrons. An aluminum layer 33, thin enough to be pervious to the bombarding electrons used, covers the free faces of the strips R, G, B which latter are of such width that there are as many groups as there are scanning lines in an ordinary monochrome television picture. Spaced at a distance of the order of .1 to .2 inch from the layer 33 is a control-screen comprising a thin dielectric layer 6 pierced with holes 9 of the order of 15 to 20 mils in diameter spaced about 30 mils on centers and coated on the side remote from aluminum layer 33 with a layer 22 of transparent conductive material such as the conductive glass described in connection with Fig. 2. Between layer 22 and the transparent face 34 of container 31 may be positioned an area-type cathode 4 such as was described in Fig. 1. In fact, the structural elements 6, 22 and 4 may be of any of the types described for the elements of similar number in Figs. 1 and 2.

The face of layer 6 facing aluminum layer 33 is coated with parallel strips R', G' and B' of transparent conductive material, which may for example be the same as that mentioned for conductive layer 22, there being one such strip aligned with each of the strips R, G, B on face 34. As shown in Fig. 4, all the strips R' are connected to one inlead 35, all the strips G' to a second inlead 36 and all the B' strips to a third inlead 37. The inleads 35, 36, 37 are impressed with incoming color-control signals of the television transmission.

The free surfaces of the strips R', G', B' are coated

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with mosaics of photoelectric or photoconductive dots which may be of the same type as the mosaic dots in Fig. 2.

Where the television color-control signals are of the simultaneous type covered by the National Television Systems Committee standards described in detail in "Electronics," February 1952 the leakage resistance from the mosaic dots should be sufficiently low so that the positive charge produced by light areas in the picture can leak away in the time interval that the scanning beam of a kinescope spends in passing over a picture area corresponding to the area of the mosaic element. In such service, the fluorescent phosphor on the exciting kinescope should have a similarly small light-persistence. Where the television system is of the line-sequential or field-sequential type the leakage time of a mosaic element can be anything up to the line-scanning period or field-scanning period.

Where the television transmission is of the line-sequential or the field-sequential type, the video modulation is applied to the control grid of a monochrome kinescope 41 having the picture on its output screen focused on the mosaic elements 38 by an optical system symbolized at 42. The color signal indicating the starts of the successive red, green and blue picture lines or fields is then impressed on leads 35, 36, 37 to make the conductive strips R', G' and B' more positive relative to conductor layer 22, cathode 4 and ground at the time a red, green or blue picture area is being transmitted. However, the degree of positiveness thus imparted is kept at too low a value to impel electrons through the holes 9 except at spots on the strip where the mosaic is also made positive by photoemission of electrons due to a light-area focused on it by optical system 42.

Thus on a line-sequential or field-sequential system the cathode ray beam of the kinescope 41 will move a luminous monochromatic spot line-by-line over its output screen which will produce a corresponding positive charge image on the mosaic 38. If a red field or line is being transmitted, this charge image will correspond in distribution to the red-light picture. Since the green and blue strips G' and B' are kept negative in potential by the color signal impressed on leads 36, 37 the positive mosaic particles around holes located in the G' and B' strips are unable to attract electrons through these holes; but the positive potential imparted to the R' strip by the color signal on inlead 35 is sufficient to impel electrons through any hole which is surrounded by mosaic particles having a positive charge. An electron stream thus flows through holes corresponding to red-light areas focused on the mosaic-screen and these strike the red-emitting strip R on the output screen aligned with conductive strip R' and show a red spot corresponding to the position and intensity of the scanning spot on the screen of kinescope 41.

When the transmission of a green line or field is signaled the conductive strip R' is given a negative potential but the strip G' is made more positive. At the same time the luminous spot starts to move over a line on the output screen of kinescope 41. The light therefrom, representing intensity of green light in the picture, distributes a corresponding positive charge on the corresponding line on the mosaic screen. Electron flow corresponding in intensity to the combined effect of the mosaic charge and the potential on the G' strip follows through the holes in dielectric layer 6 and paints a picture on the green-emitting strip G on the output screen. Similar operation occurs upon transmission of the following blue line or field, as long as the picture continues.

Where the transmission is of the NTSC standard simultaneous type the video modulation is not impressed on the control-grid of kinescope 41, but only on the inleads 35, 36, 37 to strips R', G' and B'. The luminous spot on the output screen of kinescope 41 merely acts as a light source of constant intensity traveling over the pic-

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ture area and correspondingly producing a positive charge of constant magnitude which moves over the face of the mosaic layer. If a red-light distribution is being transmitted over the television system, a signal varying in intensity with time as the transmitter scans a picture line is impressed on all the R' strips; but the potential thus impressed is insufficient to cause electrons to flow through any hole in dielectric layer 6 except that one on which the above-mentioned moving positive charge rests at that particular instant. Since the position of the moving charge at the receiver is the same as the position on the transmitter screen of the scanning beam which is transmitting red-light intensity there, the electron flow through the hole which is surrounded by the moving charge correctly represents intensity of red light at the corresponding point on the transmitter screen. The red light excited at the aligned point on the output phosphor R by that electron flow correspondingly represents correctly, in position and intensity, the red light at the said point on the transmitted picture.

Similar operation of the system occurs in transmitting a point in green light or blue light.

While the control-strips R', G', B' are driven at video frequencies when the simultaneous system is used, the capacitance of each to the grounded layer 22 is limited by the fact that its area is only that of one third of the picture; and the charging current to that capacitance is limited by the low voltage to which it is charged. Moreover, Kruper and Miller application, Serial No. 359,626, filed on or about June 4, 1953 for Method for Reducing Control Current for Picture Tube Employing Multiple Deflection shows an expedient by which such charging currents may be limited.

I claim as my invention:

1. A color television picture reproducer comprising a vacuum-tight container enclosing an output screen having groups of first parallel strips, the strips in each group responding to electron-impact by emitting light of different primary colors, a control electrode comprising a substantially transparent layer of dielectric coated on one side with a radiation-transparent conducting layer and on the other side with substantially transparent second parallel strips which are of substantially transparent conducting material and aligned with said first parallel strips, said control electrode having a plurality of aligned perforations extending through said layer of dielectric, said radiation-transparent conducting layer and said second parallel strips, inleads connected respectively to those of the second parallel strips which are aligned with said first parallel strips which emit light of the same color, discrete areas of a material which emits electrons upon impact of radiation on the free faces of said second parallel strips, and substantially transparent means for producing an electron atmosphere on said one side of said control electrode.

2. A color television picture reproducer comprising a vacuum-tight container enclosing an output screen having groups of first parallel strips, the strips in each group responding to electron-impact by emitting light of different primary colors, a control electrode comprising a substantially transparent layer of dielectric coated on one side with a radiation-transparent conducting layer and on the other side with second parallel strips which are of substantially transparent conducting material and aligned with said first parallel strips, said control electrode having a plurality of aligned perforations extending through said layer of dielectric, said radiation-transparent conducting layer and said second parallel strips, inleads connected respectively to those of the second parallel strips which are aligned with said first parallel strips which emit light of the same color, discrete areas of a photoelectric material on the free faces of said second parallel strips, and substantially transparent means for

producing an electron atmosphere on said one side of said control electrode.

3. A color television picture reproducer comprising a vacuum-tight container enclosing an output screen having groups of first parallel strips, there being three strips in each said group emitting respectively red, green and blue light, a control electrode comprising a substantially transparent layer of dielectric coated on one side with a radiation-transparent conducting layer and on the other side with substantially transparent second parallel strips which are of substantially transparent conducting material and aligned with said first parallel strips, said control electrode having a plurality of aligned perforations extending through said layer of dielectric, said radiation-transparent conducting layer and said second parallel strips, three inleads connected respectively to those of the second parallel strips which are aligned with said first parallel strips which respectively emit red, green and blue light, discrete areas of photoemissive material on the free faces of said second parallel strips, and substantially transparent means for producing an electron atmosphere on said one side of said control electrode.

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