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IMAGE INTENSIFICATION TUBE SYSTEM

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FIG. 1

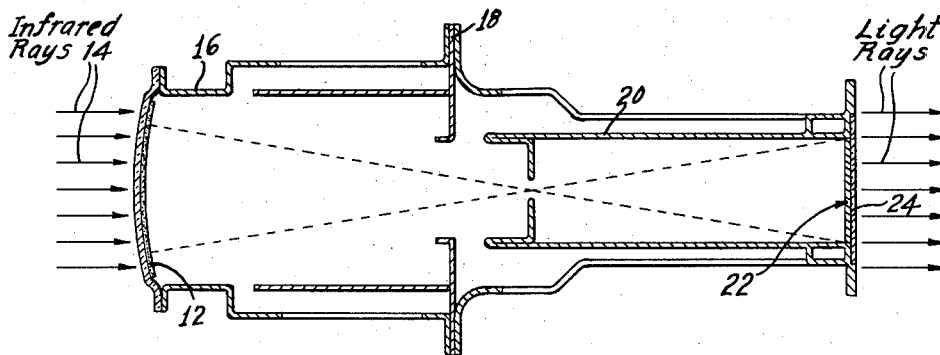
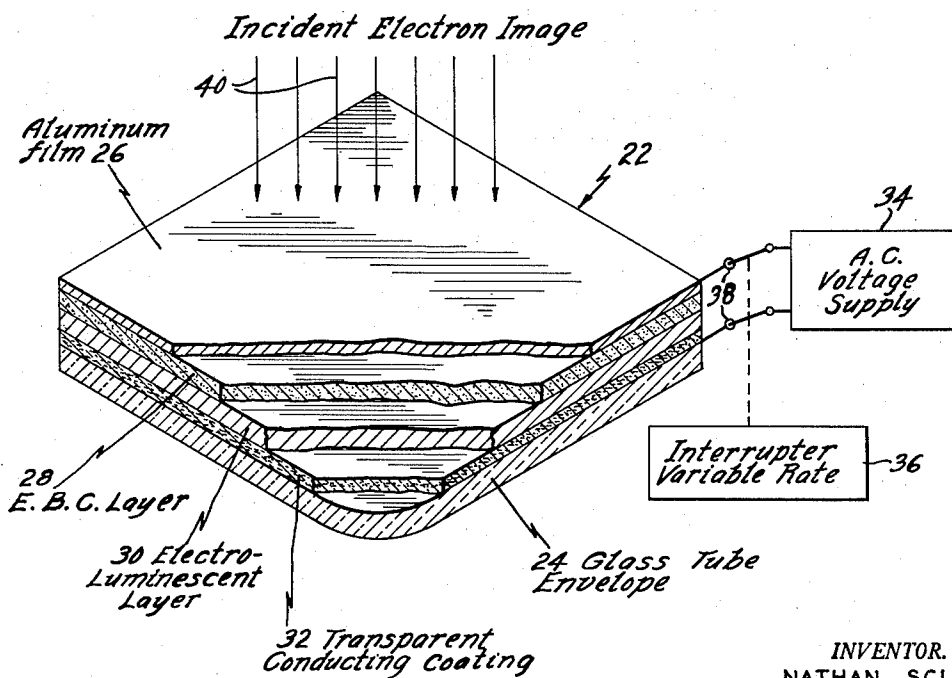


FIG. 2



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## IMAGE INTENSIFICATION TUBE SYSTEM

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2 Claims. (Cl. 250-213)

This invention relates to image intensification, and more particularly to image intensifiers in which electron images are converted into visible images

In image tubes which have been used heretofore, the viewing surface, such as the screen of a cathode ray or a television tube, is normally provided with a phosphor coating. When electrons impinge on this coating, a visible image is produced. However, the resultant images in many cases are less intense or less bright than might be desired.

Accordingly, a principal object of the present invention is to increase the intensity or brightness of visible images which are derived from electron images.

This object is secured in accordance with the present invention by the substitution of a complex including several layers for the conventional phosphor screen. One of the layers is of electro-luminescent material. Adjacent the electro-luminescent layer on the side facing the incident electrons is a layer of "E.B.C." material. The letters "E.B.C." stand for Electron Bombardment-induced Conductivity. Materials of this type are normally insulating and become conductive when they are bombarded with electrons. Thus, when an electron image is focused on the E.B.C. element, a voltage applied across the two layers is transferred to the electro-luminescent phosphor. This produces a light pattern in the electro-luminescent layer corresponding to the electron image. This pattern is many times brighter than the pattern which would appear if a conventional phosphor coating were employed.

In accordance with a feature of the invention, therefore, an electron tube is provided with a multi-layer coating, including an electro-luminescent layer and an adjacent E.B.C. layer. Arrangements are also provided for applying a voltage across the two layers, and for applying an electron image to the E.B.C. layer. In accordance with another feature of the invention, image storage and additional intensification may be obtained by utilizing an E.B.C. layer which is also photoconductive

Other objects, features, and advantages of the invention will become apparent from a consideration of the following detailed description, and from the accompanying drawing, in which:

FIGURE 1 is a schematic drawing of an image tube provided with an image intensifier in accordance with present invention; and

FIGURE 2 represents the layers at the output of the tube of FIGURE 1, and certain associated electrical circuits shown in block diagram form.

In FIGURE 1, the tube includes the inner photo-emissive cathode surface 12. Rays of light or infrared energy are incident upon the cathode 12, as indicated by the arrows 14 in FIGURE 1. Electrons corresponding to the incident image are emitted from the cathode 12 within the tube.

A series of electrodes 16, 18, and 20 are arranged to form an electrostatic electron lens. The electrodes 16, 18, and 20 are biased to appropriate D.C. voltage levels. The general nature of the electron tube of FIGURE 1 up to this point in the discussion is well known and is described, for example, in an article entitled "Image Converters and Image Intensifiers for Military and Scientific Use," by Myron W. Klein, on pages 904 through 909 of the May 1959 issue of the Proceedings of the

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IRE, volume 47, No. 5. This article is of particular interest for the extensive background of cited articles which is included.

Following acceleration by the electron lens system 16, 18, and 20, high energy electrons are focused upon the composite output layer 22 which is within the glass surface 24 at the viewing end of the image intensification tube.

As shown in detail in FIGURE 2, the composite layer 22 on the inner surface of the glass plate 24, includes a thin conducting film 26; a layer of E.B.C. material 28, an electro-luminescent layer 30, and a transparent conducting coating 32, in that order; thus, the two conductive layers 26 and 32 include between them the E.B.C. layer 28 and the electro-luminescent layer 30, and the entire complex is mounted on the glass plate 24 which forms a portion of the tube envelope.

An alternating current voltage supply 34 is connected to the two conducting layers 26 and 32. The supply voltage 34 may, for example, have a frequency of 1,000 cycles per second at a voltage of 500 volts. The interrupter 36 is provided to break the circuit from voltage source 34 to layers 26 and 32 by means of suitable electronic or mechanical switching arrangements 38. The interrupter 36 is not needed in all cases, and will only be employed when it is desired to control image storage phenomenon.

In operation, the incident electron image from the cathode 12 is focused on the composite layer 22, as indicated by the arrows 40 in FIGURE 2. When the high energy electrons strike the E.B.C. layer 28, localized areas of the E.B.C. layer become conductive and serve to apply the voltage from source 34 directly across the electro-luminescent layer. The localized energization of the electro-luminescent layer 30 produces light emission corresponding to the incident electron image. However, the light image is intensified in comparison with the light output produced by a simple phosphor screen by a large factor, the additional power for the amplification being supplied from source 34. Accordingly, the image which is visible from the outside of the glass plate 24 is much brighter than would be obtained with a conventional image tube.

With regard to the materials which may be used, the conducting film 26 is preferably of aluminum, and thin conducting films of other materials may be used. The E.B.C. layer may be of any of a group of known electronic bombardment-induced conductivity materials, such as selenium, antimony sulfide, cadmium sulfide, or cadmium zinc sulfide. For the electro-luminescent layer, zinc sulfide or other suitable efficient electro-luminescent materials may be employed. The transparent conducting coating is preferably of "Nesa" which refers to a tin oxide layer baked into the glass.

With regard to the foregoing materials, reference is also made to various articles on E.B.C. and electro-luminescent materials. Concerning E.B.C. materials, the following references are pertinent:

- 60 W. Ehrenfest, Chi-shi Lang and R. West, Proc. Phys. Soc., volume 64, page 424, 1951;
- Kenechi Takeya and Keiichi Nakamura, J. Phys. Soc. Japan, volume 2, page 223, 1958;
- 65 R. W. Decker and R. J. Schneeberger, I.R.E. National Convention Record, Part 3, page 156, 1957.

In connection with electro-luminescent materials, reference is made to "Electroluminescence and Related Topics," by G. Destreau and H. F. Ivey, Proceedings of the Institute of Radio Engineers, volume 43, page 1911, 1955.

The layers 26, 28, 30 and 32 should normally be quite thin, for example, of the order of 0.001 inch, but

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sufficiently thick to form continuous uniform layers. The thickness of the respective layers are arranged so that most of the voltage from source 34 for a given operating frequency is across the E.B.C. layer in the absence of the exciting electron beam. As the E.B.C. layer presents an impedance which is principally resistive and the electro-luminescent layer presents an impedance which is principally capacitive in nature, the required relative thicknesses of the two layers may be readily calculated for any given material and frequency of the source 34.

Surrounding the composite layer of image intensification coatings, suitable insulating material or space is provided in the vicinity of the electrode 20. This permits energization of the conducting layers from source 34 without interference with the D.C. potential applied to electrode 20.

In accordance with the present invention, image storage may be provided for increasing the sensitivity of the device for faint stationary images. The increase in sensitivity may be achieved by integrating the level of the image by a storage effect until the brightness is adequate for viewing. In the case of changing patterns, some blurring and lack of resolution may occur. To achieve image storage, optical feedback may be provided by a suitable choice of materials. Thus, by choosing an E.B.C. material which exhibits photo-conductivity, as well as electron bombardment-induced conductivity, the light emitted by the electro-luminescent phosphor will be in part fed back to cause photo-conductivity in the insulator. The photo-conductive effect will then reinforce the E.B.C. effect and provide storage of the image on the electro-luminescent phosphor even after the electron beam ceases. With regard to suitable materials, known materials having both E.B.C. and photo-conductivity properties include cadmium sulfide and cadmium zinc sulfide.

To clear the stored image from the tube, the voltage from the source 34 may be interrupted by the switching arrangements 38. When very dim stationary images are viewed, a relatively low rate of interruption is desired; with increasing brightness and slow movement, interruption at a higher rate is possible. Accordingly, the rate of interruption provided by circuit 36 may be varied to achieve the desired optical image. Interruption at a rate above the optical flicker-perception rate of about thirty to fifty frames per minute is particularly contemplated, as significant additional image intensification may be obtained even at these interruption rates.

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It is to be understood that the above described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A system for intensifying an image of incident radiation including in combination photo-emissive means responsive to said incident radiation for producing electrons, an assembly comprising a layer of electro-luminescent material and a layer of electron bombardment conductive material over said layer of electro-luminescent material, means for applying a voltage across said assembly and means for accelerating said electrons and for directing said electrons onto the surface of said layer of electron bombardment conductive material.

2. A system for intensifying an incident radiation image including in combination photo-emissive means responsive to said incident image for producing electrons, an assembly comprising a layer of electro-luminescent material having generally planar surfaces and a layer of electron bombardment conductive material extending over one of said generally planar surfaces of said electro-luminescent material layer, a thin film of conductive material pervious to electrons carried by said layer of electron bombardment conductive material and a thin transparent film of conductive material on the other surface of said electro-luminescent material layer, means for applying a voltage across said assembly and means for accelerating said electrons and for directing said electrons onto said electron bombardment conductive material through said conductive film carried thereby.

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