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COLOR IMAGE TUBE UTILIZING ELECTROLUMINESCENT SCREEN

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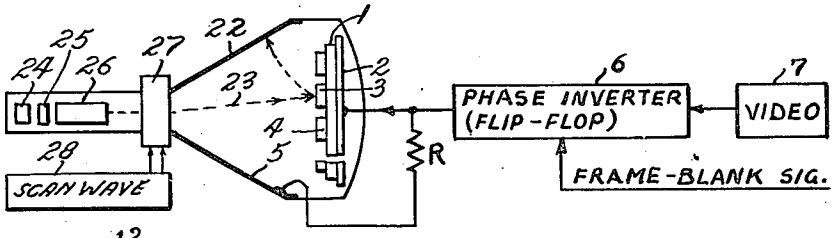


Fig. 1

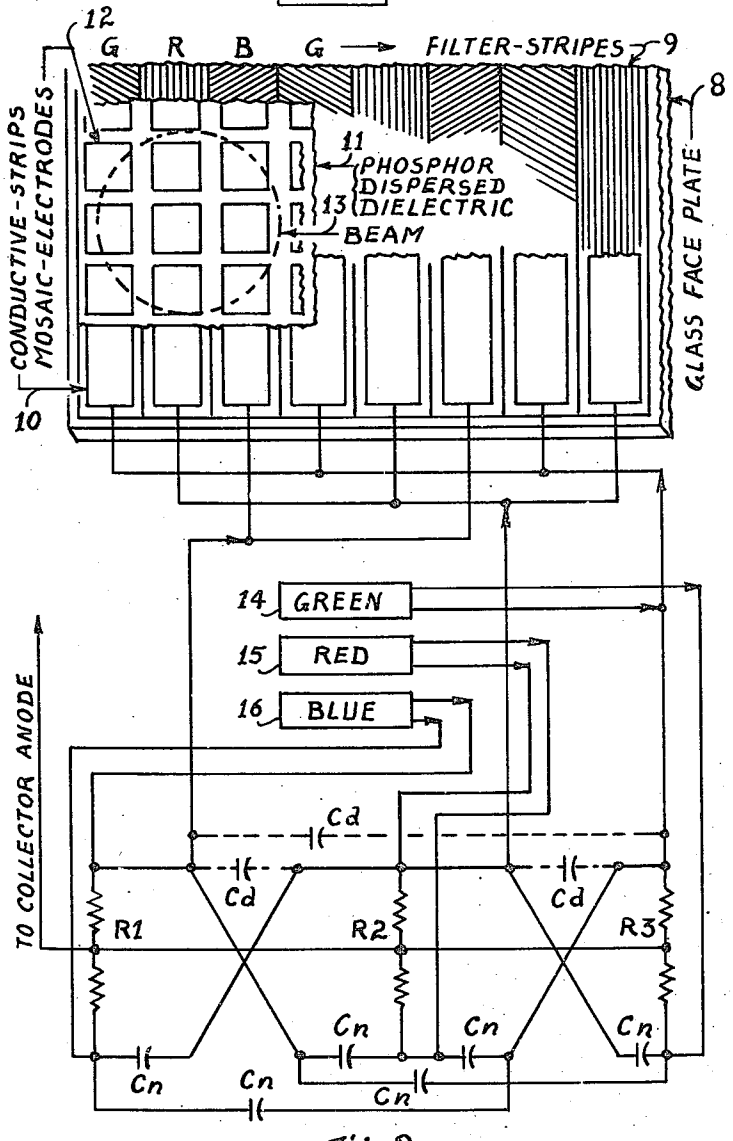


Fig. 2

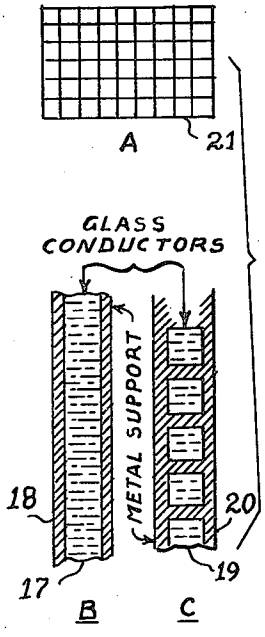


Fig. 3

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COLOR IMAGE TUBE UTILIZING ELECTRO-LUMINESCENT SCREEN

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5 Claims. (Cl. 315—12)

This invention relates to color television, and more particularly to the provision of electroluminescent color screen in image reproducing cathode ray devices. Its main object is to provide an electroluminescent color screen, which may be activated by an electron beam for the production of images in natural colors. Another object is to provide an electroluminescent color screen, the primary colors of which may be selectively activated within the spot-area of a single electron beam, in either simultaneous or sequential additive systems, without altering the direction of the beam from its normal deflection of forming a scanning raster on the image screen. A corollary object is to provide a composite screen which is capable of forming images in different primary colors without the necessity of synchronous imaging process.

Cathode ray tubes for reproducing televised images in natural colors usually utilize some form of composite screen, comprising elemental primary-color component areas in the path of the scanning beam. In conjunction with these screens, a simultaneous system requires continuous control of the direction of approach of three separate electron beams impinging upon the screen. In a sequential system, either the direction of approach or the normal direction of a single beam is altered in a time sharing arrangement according to the arriving primary-color signals. These systems in their present forms require extremely accurate register-control adjustments, which are not desirable for practical purposes. In order to obviate these objections, a new type of color screen is provided herein, the primaries of which may be selected simultaneously by a single scanning beam without altering either its normal direction or direction of approach upon the image screen.

In ordinary cathode ray devices, luminescence is effected by an electron beam bombarding the phosphorescent image surface; this action being termed as electron impact luminescence. Other methods of producing luminescence are also known and practiced, for example, by subjecting the phosphorescent material to a fluctuating electric field; this action being termed as electroluminescence. The device utilized for the latter practice comprises a phosphor dispersed thermoplastic dielectric matrix placed between two plane parallel conducting electrodes; one of the latter having light transparency. When an alternating voltage is applied to these electrodes, the electric field produced between them causes the phosphor cells to glow and emit light through the translucent electrode. Since luminescence is produced by the electric field between two plane parallel electrodes, this type of structure is also termed as luminous capacitor. The magnitude of luminescence emission depends both upon the frequency and amplitude of the applied voltage. As the frequency of the applied voltage is increased, the light brilliance is increased. However, the translucent electrode, as utilized in its present form, is made of conductive glass, having high resistance electrically. This high resistance increases the RC time constant of the luminous capacitor, and prevents full charge and discharge at very high frequencies, resulting in drop in output brilliance. To reduce this resistive component in the structure, the present invention contemplates to provide fine wire metallic screen in electrical contact with the conductive glass, whereby rendering the luminous capacitor operative at high frequencies, and at the same time providing wide window area for viewing purposes. For further descriptive matter relating the luminous capacitor, reference may be made to an article in Electrical Engineering by Butler et al. on page 524, June 1954 entitled "The Electroluminescent Lamp."

According to the brief description of the characteristic behavior of the luminous capacitor, as given above, the object of the present invention is to provide a color image reproducing screen which comprises a mosaic of luminous capacitors having luminescence in different primary colors, and selectable simultaneously by a single scanning electron beam without either altering its normal direction of flow or the direction of approach upon the color screen. The function of the electroluminescent color image reproducing system will be better understood from the following detailed specification when read in connection with the accompanying drawings, wherein: Fig. 1 is a cross sectional view of the electroluminescent image reproducing screen, including associate component parts essential therefor; Fig. 2 is partly schematic and partly diagrammatic illustration of the color image reproducing electroluminescent screen, and circuitry associated therefor; and A, B, and C in Fig. 3 are details of component parts of the color screen.

Monochrome image

In order to realize how the elemental luminous capacitors of the electroluminescent image reproducing target may be activated individually by the scanning beam, the system will be first described for monochrome image reproduction by way of the illustration in Fig. 1, wherein, the target comprises a phosphor dispersed dielectric matrix 1; a translucent conductor electrode 2; and secondarily emissive electrodes 3, 4, etc. This target is disposed perpendicularly with respect to the normal flow of the beam 23, in a vacuum envelope 22. The electron beam 23 is formed by a focusing electron gun of conventional structure (such as used in television image tubes), which comprises an electron emitter cathode 24; intensity control electrode 25; and a focusing electrode 26. The scanning movement of the electron beam is achieved by the magnetic yoke 27 (of conventional structure), which is energized by the output of the scanning wave generator block 28. The secondarily emitted electrons from mosaic elements 3, 4, etc., are collected by the electrode 5, which may be in various physical forms, for example, the graphite coating upon the inner surface of the funnel section of the envelope 22, as generally referred to ultor anode. Functionally, when the beam-accelerating field is so adjusted that the ratio of secondary current to the primary current is greater than unity, the potential of bombarded electrode 3 may be raised positive substantially equal to the potential of collector anode 5, where an equilibrium state is reached, and the net secondary emission is then substantially unity. At this point, when the potential of electrode 2 is varied by the video signal through resistance R, the potential of electrode 3 will also vary through capacitive coupling, and effect corresponding change in secondary emission, thus varying the collector current. The effect, therefore, is the same as if the electrode 2 were acting as the control grid, the electrode 3 as the cathode; and the collector 5 as the anode of an ordinary triode; causing the luminous capacitor to charge

and discharge according to the applied video voltages. With the assumption that the thickness of dielectric sheet **1** is less than the width of electrode **3**, the transverse distribution of electric field between the electrodes **2** and **3** will be practically minimized, and the electroluminescence will be constrained within this region. As will be noted, when the beam is moved upon electrode **4**, the electroluminescence will accordingly move to that region. Thus, when the screen is made of a mosaic of minute electrodes **3**, **4**, and a raster formed by the scanning beam, they will act as individual triodes, and produce the desired luminescence according to the applied image signals. Since luminescence is produced by changing electric field, however, the stored charge in each luminous capacitor must discharge before the scanning beam arrives at that point; so as to effect the required changing electric field. This may be achieved either, first, by rendering the dielectric sheet slightly conductive to a degree where the discharge time of each capacitor may be approximately equal to one frame period, or second, by changing the polarity of the video signal by a phase inverting flip flop trigger circuit, which may be operated by the frame blanking signals in a television system. The light emission from an elemental image area, in the latter case, will go through a low level dip during half of the frame period, and rise again at the end of the same frame, due to change of the electric field from a stored state to zero state, and finally resolve to a value representative of the same image element in the succeeding frame period. This condition may be attributed to the fact that different number of electroluminescent crystallites will be activated, within an elemental image area, at each reversal of the potential across the electroluminescent cell. Briefly stated, each crystallite of an agglomerate will glow strongly when its physical shape has a definite relationship with the electric field vector of the applied voltage; thus manifesting a rectifying action. Since however, in practical application these crystallites will have random physical orientation in the electroluminescent layer, it is accordingly evident that different number of crystallites will glow during each reversal of the applied video voltage. To increase the brilliancy of light emission, the inner surfaces of electrodes **3**, **4**, facing electrode **2**, may be made mirror-like, for example, by electrodepositing the metal electrodes **3**, **4**, on highly smooth surface of the dielectric sheet **1**. As illustrated in Fig. 1, the flip flop circuit is shown in block diagram **6**, and the source of video signals in block diagram **7**. Since production of video signals, including frame blanking signal, and the circuitry of various forms of flip flop triggers are all known and practiced in the art of electronics, no further description of these parts of the invention is deemed necessary to be given herein.

Color image screen

In reference to the above given specification, and by way of the illustration given in Fig. 1, the practicality of a novel imaging process is revealed. Since color imaging process is a multiple repetition of the monochrome imaging process, the monochrome image reproducing electroluminescent screen, as given in Fig. 1, is accordingly considered as the basic novel invention, and the color imaging process including associate apparatus thereof, are considered as novel improvements thereupon. Thus, in accordance with the preferred embodiment of the present invention, the color image reproducing screen will now be described by way of the illustration in Fig. 1, wherein, the electroluminescent color screen is shown supported by a transparent face plate **8**, which may serve as the end wall of the image tube, through which the image is viewed. A color-filtering film, **9**, is mounted over the inner surface of the face plate. This film contains a large number of very narrow color selective stripes, corresponding to suitable primary colors—e. g., green (G), red (R) and blue (B). Next to each stripe, and aligned therewith, is translucent conductor strip **10**. The conductor strips on stripes of each color are electrically connected to a corresponding resistor—e. g., those on green stripes to resistor **R1**, those on red stripes to resistor **R2**, and those on blue stripes to resistor **R3**. Next over the conductor strips **10** is a sheet of thermoplastic dielectric matrix **11**, dispersed with phosphorescent luminous cells. Finally, a mosaic of mutually insulated conductor elements, **12**, cover the dielectric sheet in the region to be scanned by the electron beam **13**. In this assembly, the resistors **R1** to **R3** are separately energized by primary-color video signals arriving from sources in blocks **14** to **16**. Thus, when the high velocity electron beam **13** strikes one or several of the elemental electrodes **12**, the secondary emission establishes an electron path between these elemental electrodes and the electrode strips **10** through the resistors **R1** to **R3** and electron collector anode (not shown for simplicity of drawing) in the manner as described by way of the arrangement given in Fig. 1. The primary-color video signals are thus varied between the three sets of electrode strips **10** and the elemental electrodes **12** within the given area of electron bombardment. As described above by way of the arrangement given in Fig. 1, the voltage phases of primary-color video signals arriving from sources **14** to **16** are reversed at the beginning of each succeeding frame; the phase reversing arrangements not being shown in Fig. 2, for simplicity of drawing.

Neutralization of capacitive coupling between adjacent strips

In an image reproducing system of high image resolution, the number of interleaved strips should be substantially high. This means that the inherent capacitances *Cd* between adjacent strips will consequently be high, as they will necessarily be in close proximity; especially when the number of strips is so high that more than one strip (for each primary color) occupy the beam area simultaneously. This tends to cause cross fire between the signals representing different primary colors, and accordingly, special compensating arrangement is utilized in the form as shown schematically in Fig. 2, wherein, the inherent capacitances are indicated by *Cd* connected between the upper ends of resistors **R1**, **R2**, **R3**, and the neutralizing capacitors *Cn* connected between the upper end of one resistor, and the lower end of each of the other resistors. Each of these resistors has a center tap (electrically connected to the collector anode of secondary emission, not shown in the drawing) maintained at group potential, so that the video voltage appearing at the lower end of each of the resistors is opposite in polarity to that at its upper end, and when applied through a capacitance *Cn* adjusted to the proper value (approximately equal to capacitance *Cd*), will balance out the effect of the potential applied through capacitor *Cd*. Conversely, although part of the current from any of the resistors passes through capacitance *Cd* toward the upper end terminal of the other resistors, a similar current passes through capacitor *Cn* toward the lower end terminals of said resistors; and the two currents tending to flow in opposite directions cancel one another, producing no net effect on the three sets of conductor strips **13**. Thus each set of the strips **10** is energized selectively corresponding to primary-color signals arriving from sources **14** to **16**.

Target structure

In reference to the illustrative arrangement given in Fig. 1, for monochrome image reproduction, it was indicated that the electrode **2** is electrically conductive, but visually translucent, whereby the electroluminescence of the target may be emitted therethrough for viewing purposes. The translucent conductive electrode may be made by metal vaporization, few microns thick, on the sur-

face of thermoplastic dielectric sheet 1. While this film of metal provides the required electrical properties of the electrode, the light transparency is equal approximately to 50% of ordinary glass plate. Another form of translucent conductor, that is presently available, is the glass conductor, which is named "nesa" by trade name. This conductor has the desired light transparency, but its high electrical resistivity limits the operating efficiency of the electroluminescent target at high frequencies. In order to lower the resistivity of this glass conductor, a fine wire metallic screen 21, such as shown at A in Fig. 3, may be laid in electrical contact over the surface of the glass conductor coating. When the wire size of this metallic screen is made very thin, the holes through which the luminescent image is formed will be wide enough for viewing, without objectionable visibility of the metal screen. In the case of the color screen, as shown in Fig. 2, the translucent strips 10 may be made of conductor-glass strips supported by thin solid metal wires, in the form as shown at B or C of Fig. 3. The conductor glass strips 17, at B, is shown edged with thin wire metal 18; and at C, the conductor glass strip 19 is combined with a fine wire screen 20; either one of these forms being satisfactory for the purpose.

In constructing the electroluminescent image forming target, the thin wire screen may be first imbedded on the inner surface of the glass face plate of the cathode ray tube, for example, by a known technique of photographing; etching; and filling the etched grooves of the glass, for example, by electrodepositing the entire inner surface of the face plate, or as an alternative, by first coating the entire inner surface of the face plate; photographing it with the proper design; and finally etching the coated metal. The glass conductor may be coated either prior to, or after the metal screen is formed. The primary-color stripes 9 may be photographed over this structure. Finally, the thermoplastic dielectric sheet may be cemented over the photographed primary-color stripes. The mosaic electrodes 12 may be mounted over the dielectric sheet either prior to, or after cementing over the primary-color stripes. The mosaic electrodes may be formed in various ways, for example, by first electro-deposition of a continuous metal film over the smooth surface of the dielectric sheet; photographing a screen pattern over this metal surface; and finally etching it into the rudimental electrodes. In this manner, the inner surfaces of these rudimental electrodes will have highly reflecting surfaces for increasing the brilliance of the emitted luminous image.

Color filters, such as photographic color films, have the properties of reducing the brilliancy of the transmitted light. Accordingly, the striped color filter film 9 may be dispensed with, by constructing the thermoplastic dielectric sheet in narrow strips of phosphors having the properties of luminescing in different primary colors. Electroluminescent phosphors having characteristics of luminescing in different colors have been known, for example, they may be zinc sulfides, activated by combinations of lead, copper, chloride, and manganese, and can be made in a range of colors from deep blue through green to yellow and orange. By using a mixture, composed mainly of blue and yellow phosphors, white light of any desired color temperature between 2,500 K. and 25,000 K. also may be produced. In the making of the electroluminescent layer, the desired phosphor powder may be mixed (by stirring) with the dielectric material, for example, Lucite in its viscous state, and pressing between two smooth metal surfaces into a sheet of about 100, or less, microns thick.

Various structural modifications may be made for improving the final performance of electroluminescent image formation. For example, in order to reduce lateral distribution of the secondarily emitted electrons over the mosaic electrodes, a barrier screen, or grid, may be placed in front of the electoluminescent target, intercepting the primary electron beam. In various applications, barrier grids have been utilized and described, and as an example, one form may be referred to an article by Kazan et al. in RCA Review, December 1951, p. 703. As an illustration, however, a barrier grid may be structurally in the form of a metal screen, such as shown at A in Fig. 3. A screen of this type may be utilized as a collector screen which may be placed between the primary electron beam, and the mosaic electrodes 3, 4, in Fig. 1. When the potential of this is adjusted equal to the final beam-accelerating potential, the primary electron beam will pass through the holes of the screen (part of the beam current returning to the primary cathode through the screen by interception), and hit the mosaic electrode 3, causing it to emit secondary electrons. These secondary electrons will travel toward the screen, where they will partly be collected by the screen, and partly pass therethrough; these latter electrons, however, eventually returning back to the screen, for collection; or partly traveling to the final beam-accelerating anode, which may be the aquaduct coating on the inner wall of the cathode ray image tube. With the utilization of a collector screen, the distance of secondarily emitted electrons from the mosaic electrodes to the electron collector will be substantially uniform throughout the image target, thereby substantially eliminating moire effects on the image screen.

Other modifications may also be made, for example, due to the low impedance structure of the color screen, the video-voltages across resistors R1 to R3 may be developed through cathode followers. With these few examples in view, I wish it to be understood that numerous substitutions of parts, adaptations and modifications are possible and will suggest themselves readily to the skilled in the art without departing from the spirit and scope of what is hereinabove set forth, and the limitations of this invention will accordingly be defined only by the appended claims.

I claim:

1. An image reproducing system which comprises means for projecting an electron beam; an image forming target in the path of said beam, comprising an electroluminescent phosphor layer disposed plane perpendicular to the normal direction of said electron beam a mosaic of secondarily emissive electrodes overlying the planar surface of said phosphor layer facing the beam, and a light-transparent electrode overlying the planar surface of said phosphor layer remote from the electron beam, whereby forming a mosaic of elemental capacitive elements between the opposite surfaces of said phosphor layer; beam deflection means and means therefor for forming a scanning raster upon said mosaic of electrodes with the beam; means for adjusting the velocity of said beam, whereby causing secondary emission from the scanned mosaic electrodes; a collector anode for collecting last-named emission; an impedance means between said collector and the light-transparent electrode, whereby forming secondary electron path between the light-transparent electrode and the collector anode through said impedance means; a source of image display signals; and means for applying these signals upon said impedance means, whereby energizing said mosaic of capacitive elements independently only at points of beam impingement proportionally corresponding to the applied image signals, and thereby effecting image electroluminescence emerging through said light-transparent electrode.

2. The system as set forth in claim 1, wherein is included means for reversing the polarity of said image signals in said impedance means at return periods of said raster by said scanning beam, whereby effecting charge and discharge of said mosaic of capacitive elements.

3. The system as set forth in claim 1, wherein said light-transparent electrode is divided into a plurality of adjacently positioned light-transparent strip-like electrodes, and electrically connected in sequential steps into first, second and third sections; wherein said phosphor

layer comprises electroluminescent phosphors having the characteristics of exhibiting luminescence in first, second and third primary colors in stripe-like sections adjacently aligned with said strip-like sections; wherein said impedance means comprises first, second and third means, and means therefor for terminating same electrically common to said collector anode and to said first, second and third strip-like sections, respectively; and wherein said source of image signals comprises first, second and third sources of image signals, and means therefor for applying same upon said first, second and third impedance means, respectively, whereby identifying the electroluminescence upon said phosphor layer in different primary colors representative of said first, second and third image signals.

4. The system as set forth in claim 1, wherein, said light-transparent electrode comprises light-transparent conductive glass.

5. The system as set forth in claim 1, wherein, said light-transparent electrode comprises light-transparent conductive glass electrically adjacent to a fine wire low resistance metallic screen, whereby lowering the inherent resistive component of said conductive glass, and at the same time allowing wide opening for the image forming electroluminescence to pass therethrough.

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