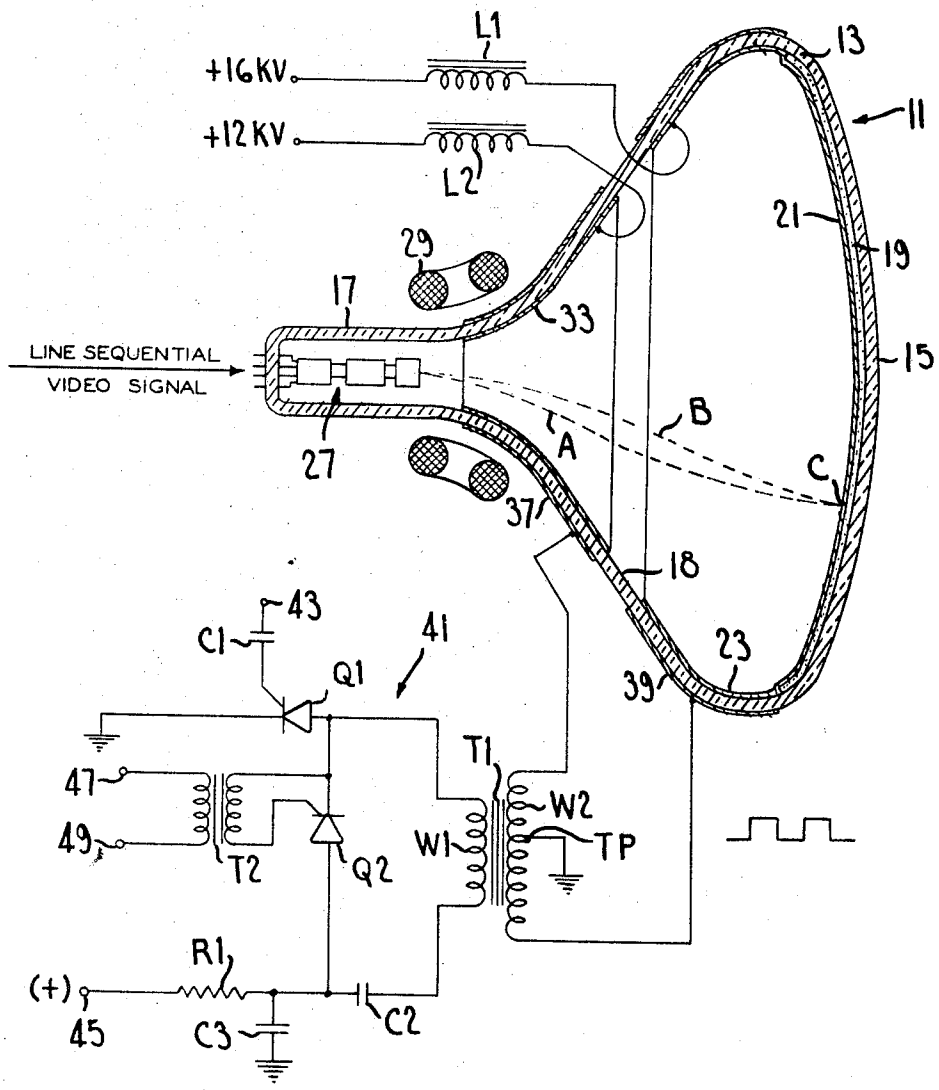
April 15, 1969 S. R. SHORTES 3,439,217

COLOR DISPLAY SYSTEM

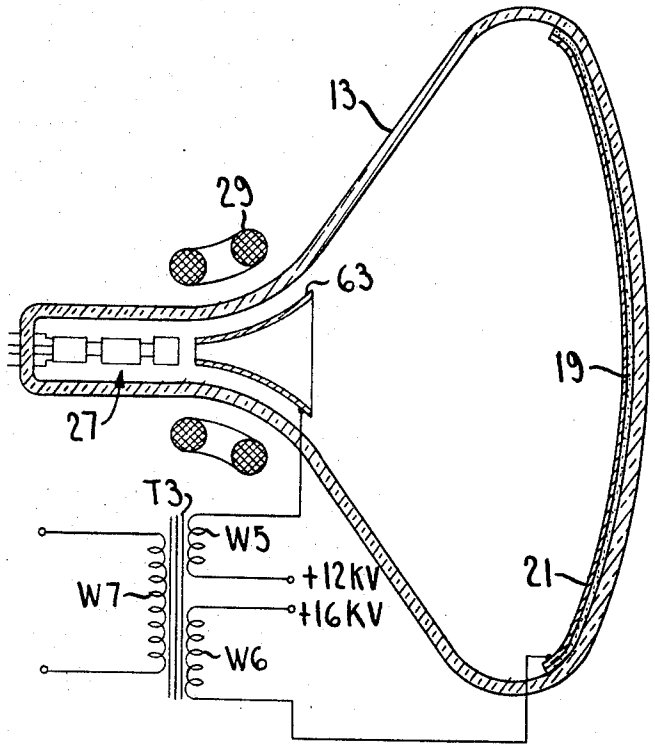
Filed May 31, 1966 Sheet 1 of 2

FIG. 1.



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FIG.2.



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COLOR DISPLAY SYSTEM

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U.S. Cl. 315—14 5 Claims

ABSTRACT OF THE DISCLOSURE

This specification discloses a color display system, characterized by a screen including phosphors which emit light of different colors when struck by electrons of different energies and including an electron permeable conductive film, a single electron gun for emitting a beam of electrons toward the screen, field generating means for deflecting the beam of electrons in a scanning raster, a generally annular electrode concentric with the gun and axially displaced therefrom toward the screen and into the region of the field produced by the field generating means, means for applying D.C. bias voltage to the screen and to the electrode to accelerate the electrons emitted from the gun toward the screen, and means for applying a first time varying voltage of a first phase to the annular electrode, in response to a first triggering signal, and for simultaneously applying a second time varying voltage of opposite phase to the conductive film of the screen and for reversing the phases of the first time varying voltage and the second time varying voltage in response to a second triggering signal.

This invention relates to a color display system and more particularly to such a system which produces multiple color images having color image components which are in substantial registration.

Various kinescope color display systems have been proposed in which electrons of different energies are employed to produce light of different colors. These known systems typically employ a phosphor screen including a plurality of phosphors which emit light of different colors when struck by electrons having different energies. One problem with this type of display system is that it is difficult to scan the screen uniformly with the electrons of differing energies, since the higher energy electrons are less subject to deflection by the magnetic or electric fields conventionally employed to sweep a beam of electrons in a raster over a phosphor screen than the lower energy electrons. Thus, if this difference in deflection is not compensated for, misregistration will result.

Among the several objects of the present invention may be noted the provision of a color display system which produces multiple-color images having color image components which are in substantial registration; the provision of such a system in which the energy of an electron beam is varied to produce light of different colors on a screen including a plurality of phosphors which emit light of different colors when struck by electrons of different energies; the provision of such a system which requires only a single electron gun; the provision of such a system which is reliable and which is relatively simple and inexpensive. Other objects and features will be in part apparent and in part pointed out hereinafter.

Briefly, a color display system of this invention includes a screen having phosphors which emit light of different colors when struck by electrons of different energies. A single electron gun emits a beam of electrons toward the screen. Field generating means are provided for deflecting the beam of electrons in a scanning raster. A generally annular electrode is positioned concentric with the gun and is axially displaced therefrom toward the screen and into the region of the field produced by the field generating means. D.C. bias voltages are applied to the screen and to the annular electrode to accelerate electrons emitted from the gun toward the screen. Out-of-phase, time-varying voltages are applied to the screen and to the annular electrode thereby to accelerate electrons emitted from the gun to at least two different energies for energizing the screen to produce multiple-color images having color image components which are in substantial registration.

The invention accordingly comprises the constructions hereinafter described, the scope of the invention being indicated in the following claims.

In the accompanying drawings, in which several of various possible embodiments of the invention are illustrated,

FIGURE 1 is a partially schematic diagram of a color display system of this invention; and

FIGURE 2 is a similar diagram of a modification of this color display system.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring now to FIGURE 1, there is indicated at **11** a color kinescope constructed according to the present invention. Kinescope **11** includes a conventional glass envelope **13** having a screen portion **15**, a neck portion **17** and a generally bell-shaped intermediate portion **18** connecting the neck and screen portions. Coated on the inner surface of the screen portion **15** is a phosphor layer **19** which includes phosphors which emit light of different colors when struck by electrons of different energies. Phosphor screen **19** may, for example, be constituted by a mixture of two different kinds of phosphor particles one of which emits red light when energized by electrons having energies above a relatively low predetermined level and the other of which emits cyan light when energized by electrons having energies above a relatively high predetermined level. Such a screen will emit red light when struck by electrons at the relatively low level and will emit white or substantially achromatic light when struck by electrons at the relatively high energy level, which electrons can energize both of the phosphors. Such red-white image displays are known in the art for the presentation of color images and images so presented appear to have a relatively wide range of hues subjectively having a greater saturation than that which is actually present in the colorimetric sense. Methods of preparing phosphors useful in the present invention are disclosed in my copending application Ser. No. 459,582, filed May 28, 1965, entitled Phosphors for Color Display System.

Over phosphor screen **19** is deposited a film **21** of aluminum which is conductive and yet is also thin enough to be substantially electron permeable. By means of film **21** suitable electron accelerating voltages may be applied to the phosphor screen **19**. Aluminum film **21** also extends beyond the face portion **15** of kinescope **11** onto a preselected margin of the intermediate portion **18** of envelope **13** thereby constituting a first conductive band **23** on the intermediate portion.

Within the neck portion **17** of envelope **13** there is mounted a conventional electron gun **27** for emitting a beam of electrons directed toward phosphor screen **19**. For the purpose of the example described herein, it is assumed that this color display system is operated in a line sequential mode. For this purpose a line sequential, color video signal is applied to gun **27** for varying the electron beam current, that is, the rate at which electrons are emitted by the gun. The video signal thus controls the instantaneous brightness of the light produced by the beam on phosphor screen **19**. It should be understood,

however, that a dot sequential or field sequential presentation of the different colors may also be employed by appropriately varying the different switching rates described hereinafter and applying a corresponding video signal to gun **27**.

Electrons emitted from gun **27** pass through the magnetic influence of a deflection yoke **29**. Yoke **29** is energized in conventional manner to deflect the beam of electrons in a scanning raster over the envelope face portion **15**. However, as is understood by those skilled in the art, the raster will be of uniform size only if the electrons emitted by gun **27** are all accelerated to the same energy or if compensation is made for the different deflection effects experienced by electrons having different energies.

The inner surface of the part of the intermediate envelope portion **18** adjacent neck **17** is coated with a conductive band as indicated at **33** thereby to constitute a generally horn-shaped electrode which is concentric with gun **27** and through which the beam of electrons emitted by the gun pass on their way to phosphor screen **19**. Band **33** may conveniently be constituted by a so-called "dag" coating on envelope **13**. As is explained in greater detail hereinafter, electrode band **33** is employed to exercise a radial corrective effect on the deflection of the electron beam passing therethrough. Electrical connections are made to the electrode band **33** and to the phosphor screen-covering aluminum film **21** as indicated at **37** and **39** and these connections extend through envelope **13** by means of conventional feed-through terminals (not shown). Respective D.C. biasing potentials are applied to electrode band **33** and to the screen **19** through inductors **L1** and **L2** which serve to effectively block A.C. or time-varying voltages as explained hereinafter. Appropriate nominal D.C. potentials for electrode **33** and screen **19** are approximately 12 and 16 kilovolts, respectively.

On the outside of the intermediate portion **15** of envelope **13** there is deposited a band **37** of conductive aluminum film in juxtaposition with band **33**. Band **37** is thus spaced substantially equidistantly outwardly from electrode band **33** and is thus capacitively coupled to it through the glass envelop **13**. A similar aluminum band **39** is deposited on the envelope **13** in juxtaposition with the marginal band **23** of the aluminum film covering phosphor screen **19**. Aluminum band **39** is thus capacitively coupled to the screen **19** through the glass envelope **13**.

Aluminum bands **37** and **39** are provided with out-of-phase time-varying voltages, and in particular with voltage waves of rectangular waveform and of several kilovolts amplitude, by the circuit indicated generally at **41**. Other known circuits for generating such waveforms may also be used. Bands **37** and **39** are connected to the opposite ends of the secondary winding **W2** of a transformer **T1**. Winding **W2** includes an intermediate tap **TP** which is connected to ground. Transformer **T1** also includes a primary winding **W1**, one end of which is connected to ground through the anode-cathode circuit of an SCR (silicon controlled rectifier) **Q1**. Triggering signals applied to a terminal **43** are coupled to the gate terminal of SCR **Q1** through a coupling capacitor **C1**. The other end of winding **W1** is connected to a positive supply terminal **45** through a D.C. blocking capacitor **C2** and a current limiting resistor **R1**. The voltage existing between capacitor **C2** and resistor **R1** is smoothed by a filter capacitor **C3**. Primary winding **W1** and capacitor **C2** together are shunted by the anode-cathode circuit of a second SCR **Q2**. Triggering signals for SCR **Q2** applied to a pair of terminals **47** and **49** are coupled to the gate-cathode circuit of the SCR by a transformer **T2**.

The operation of circuit **41** is explained in greater detail in copending application Voltage Switching Apparatus For Color Kinescopes, Ser. No. 553,946, filed May 31, 1966, by William H. Clingman, Jr. and assigned to the assignee of the present application. For the purpose of the present invention, however, the following brief explanation of its operation is sufficient.

When SCR's **Q1** and **Q2** are triggering alternately, a voltage of rectangular waveform is applied to each of the bands **37** and **39**, the two signals being out-of-phase with respect to ground potential. The rectangular waveforms applied to bands **37** and **39** are capacitively coupled to the electrode band **33** and to the screen **21** respectively. These waveforms are, however, effectively blocked from the D.C. sources biasing these elements by the chokes **L1** and **L2** as noted previously. Electrons emitted by gun **27** during the different time intervals corresponding to the two different voltage levels of the rectangular waveform are thus accelerated to different energy levels before reaching phosphor screen **19**. The energy levels are adjusted in relation to the characteristics of the phosphors which make up screen **19** so that the lower energy electrons excite only the red phosphor while the higher energy electrons excite both the red and cyan phosphors thereby causing white light to be emitted.

The frequency of the rectangular wave is adjusted and synchronized so that the different accelerating voltages are produced during periods which correspond to the sequencing of the color video signal applied to gun **27**. The beam current is thus modulated to reproduce the various image components in their respective colors. In the example illustrated this is assumed to be at a line sequential rate.

The color display system illustrated in FIGURE 1 is operated to produce color images having component color images which are in substantial registration as follows, a red-white, line sequential mode of operation being assumed. At the start of a white line, SCR **Q1** is triggered so that the aluminum band **39** is driven positive with respect to ground. Because of the capacitive coupling between this band and the aluminum layer **21**, the screen **19** is driven to the higher of its two potentials and electrons emitted from gun **27** are accelerated to a relatively high energy level. These electrons thus produce white light when they strike phosphor screen **19** as explained previously. As the band **39** is driven to a positive voltage, the band **37** is driven to a negative voltage and thus the electrode **33** is capacitively driven to the lower of its two voltage levels. Accordingly, electrons emitted from gun **27** are not greatly accelerated as they first leave the gun but rather attain only a relatively low velocity in the region of the yoke **29**. These electrons are thus relatively highly subject to deflection by the yoke's field and therefore follow a path having an early high curvature as represented at A in FIGURE 1. As these electrons leave the vicinity of electrode **33**, however, they are subjected to a relatively intense electric field and are thus accelerated to approach screen **19** at a relatively steep angle, impinging at a point indicated at C.

When a red line is to be displayed, the SCR **Q2** is triggered and the aluminum band **39** is driven negatively with respect to ground. The screen **19** thus assumes the lower of its two voltage levels. The total acceleration experienced by electrons emitted by gun **27** is then relatively small and only the red phosphor is energized.

Simultaneously with the application of the negative voltage to aluminum band **39**, a positive voltage is applied to band **37** so that the electrode **33** is capacitively driven to the higher of its two voltage levels. Electrons emitted from gun **27** during this period are thus rapidly accelerated as they first leave the gun and thus are not greatly deflected by yoke **29**. These electrons thus follow a path substantially as indicated at B in FIGURE 1. As the screen **19** is then at the lower of its two potentials, these electrons are not further greatly accelerated and therefore approach the screen substantially at the angle determined by their earlier deflection, striking the screen substantially at the same point C as the higher energy electrons following the path A.

As the particular configuration of the kinescope **11** will affect the distribution of the electric fields within the kinescope, as will be boundaries of the electrode

band **33** and the aluminum screen coating **21**, it may be seen that the particular D.C. biasing voltages and rectangular wave amplitudes which must be applied to achieve best registration will vary from tube to tube. Typically the rectangular waves coupled to the focusing electrode and to the screen will have to be of somewhat different amplitudes, the intermediate tap TP being shown off-center in FIGURE 1 for this reason.

In FIGURE 2 there is illustrated a modification of the kinescope of this invention, which modification employs a horn-shaped elctrode **63** which is separate from the tube envelope and may therefore be contoured independently thereof. Electrode **63** is mounted coaxially with gun **27** and spaced therefrom toward the phosphor screen **19**. In this embodiment also an aluminum layer is deposited over screen **19** for applying suitable accelerating votages thereto. Electrode **63** and aluminum layer **21** are each directly connected to one end of a respective secondary winding W5 and W6 of a transformer T3. Transformer T3 includes a primary winding W7 which is adapted to be driven by a suitable rectangular wave generator such as the circuitry illustrated in FIGURE 1. The opposite ends of the secondary windings W5 and W6 are connected to appropriate D.C. biasing potential sources as indicated.

When the primary winding W7 is driven by a rectangular wave, the electrode **63** and the screen **19** are each thus switched between two respective voltage levels in a manner substantially similar to the electrode **33** and screen **19** shown in FIGURE 1. While this construction does away with the need for the chokes L1 and L2 and for the construction of the coupling capacitances which feed the rectangular wave through the kinescope envelope **13**, it does require that the windings W5 and W6 be insulated to withstand the relatively high D.C. biasing potentials applied thereto.

In operation, the electrode **63** tends to reduce the acceleration of electrons emitted by gun **27** in the region of the yoke when the screen **19** is at its higher potential and to produce a relatively high early acceleration of the electrons when the screen is at its lower voltage thereby causing electrons having different energies to experience the same total deflection before reaching the screen in the same manner as the embodiment illustrated in FIGURE 1.

The present invention may also be employed to obtain proper registration of color image components in a three-color display system in which case out-of-phase time-varying voltages having three discrete steps may be applied to the compensating electrode and to the phosphor screen.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A color display system comprising:

a screen including a plurality of phosphors which emit light of different colors when struck by electrons of different energies and an electron permeable conductive film;

a single electron gun for emitting a beam of electrons toward said screen;

field generating means for deflecting said beams of electrons in a scanning raster;

a generally annular electrode concentric with said gun and axially displaced therefrom toward said screen and into the region of the field produced by said field generating means;

means for applying D.C. bias voltages to said conductive film of said screen and said electrode to accelerate electrons emitted from said gun toward said screen; and

means for applying a first time varying voltage of a first phase to said annular electrode and for simultaneously applying a second time varying voltage of phase opposite to said first phase of said first time varying voltage to said conductive film of said screen to accelerate said beam of electrons to a first energy level in response to a first trigger signal and energize part of said phosphors to produce first color image components and for reversing the phases of said first time varying voltage and said second time varying voltage in response to a second triggering signal and accelerate said electrons toward said screen to a second energy level and energize a part of said phosphors to produce second color image components which are in in substantial registration with said first color image components.

2. A color display system as set forth in claim **1** wherein said gun and said screen are supported within a kinescope envelope and wherein said electrode is a metal element mounted within said envelope coaxially with said gun.

3. A color display system as set forth in claim **2** wherein said electrode is generally horn-shaped.

4. A color display system as set forth in claim **1** wherein said gun and said screen are supported within a kinescope envelope and wherein said electrode comprises a conductive coating on the inner surface of said envelope adjacent said gun.

5. A color display system as set forth in claim **1** wherein said film extends beyond said screen over portions of said envelope adjacent thereto.

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