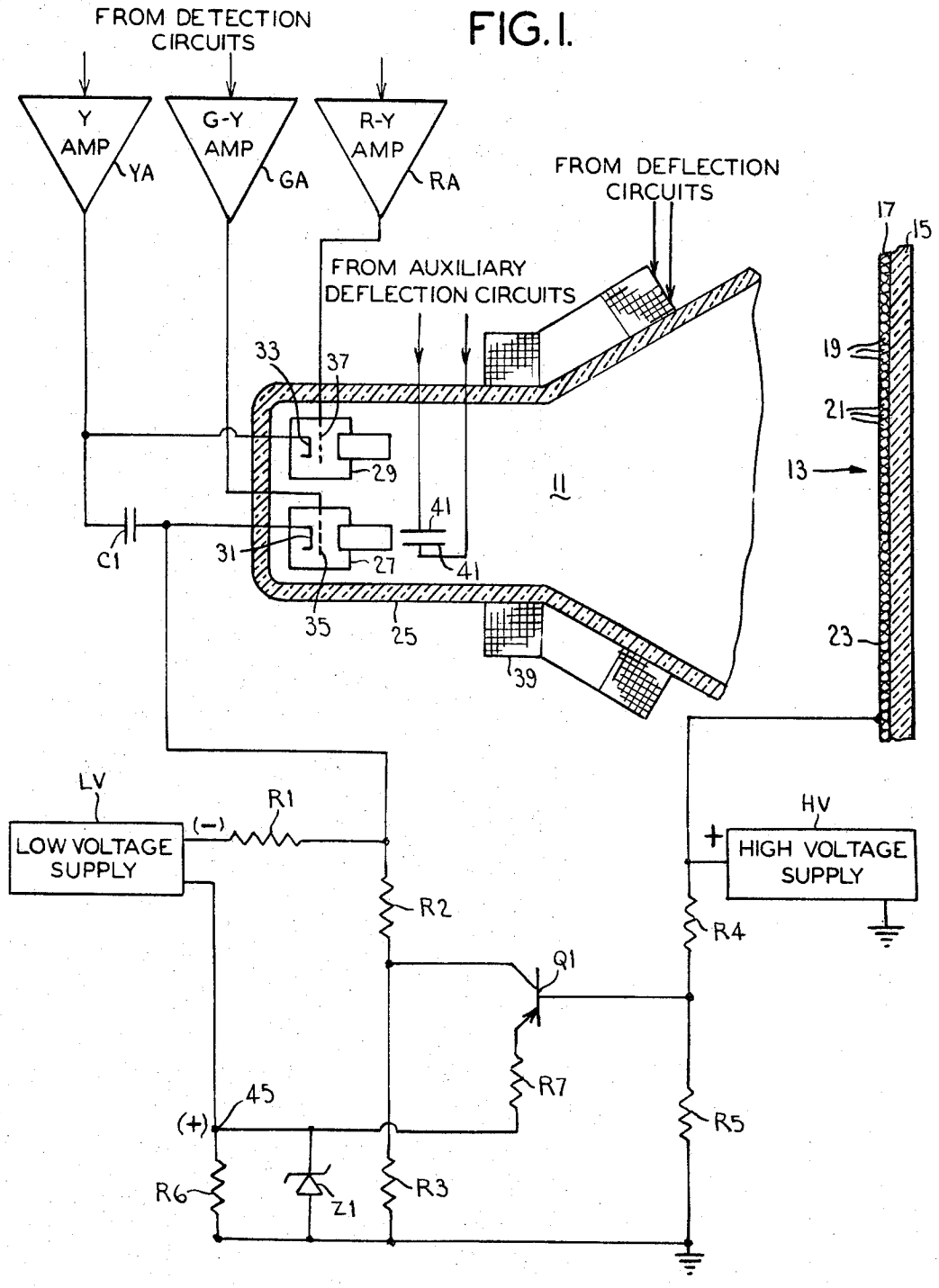
Dec. 17, 1968 W. T. MATZEN 3,416,731

COLOR DISPLAY SYSTEM

Filed April 30, 1965 2 Sheets-Sheet 1

FIG. 1.

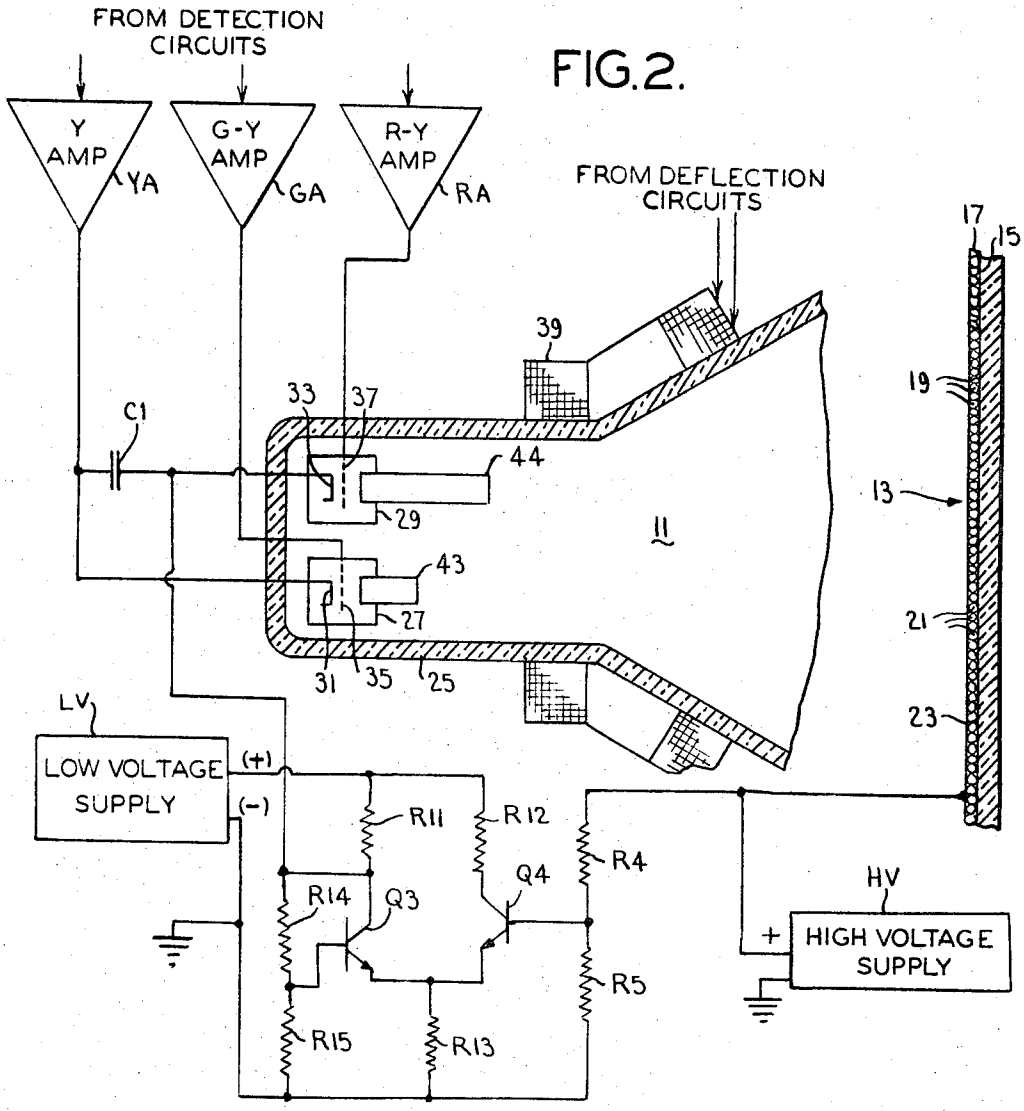


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COLOR DISPLAY SYSTEM

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FIG.2.



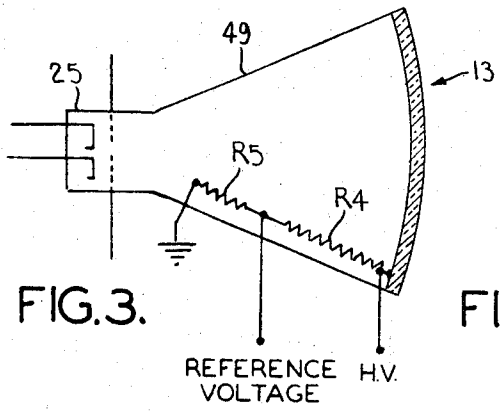


FIG.3.

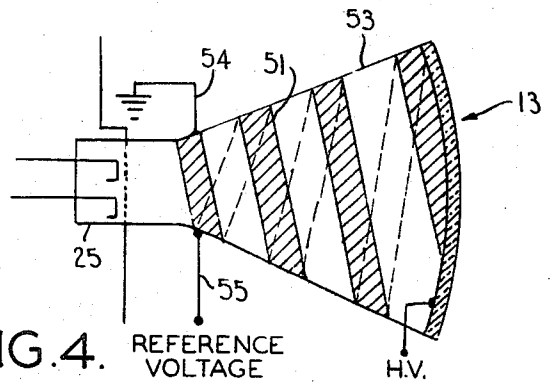


FIG.4.

United States Patent Office 3,416,731
Patented Dec. 17, 1968

3,416,731

COLOR DISPLAY SYSTEM

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Filed Apr. 30, 1965, Ser. No. 452,301
8 Claims. (Cl. 315—13)

ABSTRACT OF THE DISCLOSURE

This specification discloses a combination, employed in a color display system, characterized by a viewing screen having phosphors which emit light of different colors when energized by electron beams of different energies; electron beam guns and deflection coils for scanning the screen with beams of electrons under different accelerating voltages and, hence, different velocities; high voltage supply in combination with the electron beam guns for providing a first and a second accelerating voltage; and regulator circuit for regulating the voltage differential between the first accelerating voltage and the second accelerating voltage in accord with the differential deflection force applied to the first beam of electrons and to the second beam of electrons and in response to feedback from the high voltage portion of the first accelerating voltage, such as may be applied to the screen. In this way registration is maintained between the image components provided by the beams of electrons on the screen despite variations in the absolute value of the accelerating voltages.

This invention relates to a color display system and more particularly to an improved color display system employing an electron beam at different electron energies to differently energize various phosphors to emit light of various hues.

Various polychromatic color display systems have been proposed in which the different color phosphors are differently responsive to electron beams of different energies or velocities so that various hues of light can be produced by varying the beam electron accelerating voltage. However, the use of more than one accelerating voltage requires that the system include some form of deflection compensation to correct for variations in deflection caused by the varying velocities of different electrons. If uncorrected, these variations in deflection cause misregistration between the different component monochromatic images which constitute the polychromatic display. Since the amount of correction necessary depends upon the particular accelerating voltage applied, typical color displays have heretofore employed relatively complicated and expensive systems for regulating the high potential accelerating voltages.

Among the several objects of the invention may be noted the provision of a composite multicolor display system having improved registration between component monochromatic images; the provision of such a system which avoids the necessity of regulating high electron beam accelerating voltages; the provision of such a system in which variations due to the contamination of exposed high voltage circuits are minimized; the provision of a multigun kinescope system in which the voltage differential between guns is precisely regulated; and the provision of such a system which is relatively simple in construction and is reliable in operation. Other objects and features will be in part apparent and in part pointed out hereinafter.

Briefly, the invention involves a color display system having a viewing screen including phosphors which emit light of different colors when energized by electron beams of different energies. An electron beam gun is provided for scanning the screen with a beam of electrons and at least two electron beam accelerating voltages are provided for energizing said phosphors to emit light of different colors. The system also includes means for regulating the voltage differential between the two accelerating voltages as a function of the total value of one of these accelerating voltages for maintaining registration between the image components provided by electrons accelerated by the two different voltages even though their absolute values fluctuate due to any of a variety of causes.

The invention accordingly comprises the apparatus and methods 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 illustrates, in diagrammatic form, a color display system including a two-gun kinescope in which a negative voltage differential is applied between the guns;

FIGURE 2 illustrates another embodiment in which a positive voltage differential is applied between the two guns of a kinescope;

FIGURE 3 illustrates a kinescope including a resistive voltage divider sealed within the kinescope envelope; and

FIGURE 4 shows a modification of the kinescope of FIGURE 3 in which the divider is in the form of a deposited resistive film.

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

Referring now to FIGURE 1, the color display system illustrated there includes a kinescope **11** for two-color presentation of polychromatic images. The two colors which can be produced by the tube are red and white. The kinescope **11** comprises a viewing screen **13** including a glass face plate **15** through which the image is viewed. Coated on the inside surface of plate **15** is a phosphor layer **17** which when energized emits light through the face plate **15**. Layer **17** is constituted by a mixture of phosphor particles **19** and **21**. Particles **19** emit substantially red light when energized while the particles **21** emit substantially cyan light when energized. Layer **17** of phosphor particles is in turn coated with a thin deposited aluminum film **23** by means of which an electron beam accelerating voltage is applied to the screen **13** from a high voltage power supply HV.

The particles **19** and **21** respond differently to electron beams of varying energy. The particles **19** are energized when struck by electrons which have been accelerated by a relatively low voltage so as to possess a relatively low electron energy while the cyan particles **21** emit light only when struck by electrons which have been accelerated by a relatively high voltage. The difference in sensitivity of the phosphors to electron beams of different energies is produced by providing a barrier layer on the cyan-emitting particles. The barrier produces a raised voltage or electron energy threshold which must be exceeded before the particle is energized to emit light. Alternatively, both particles **19** and **20** are provided with barriers with the cyan particles being given a thicker barrier to achieve the desired differential between the threshold of the two different kinds of particles. A suitable barrier layer is a coating of silicon dioxide deposited on individual particles. This coating is deposited, for example, by the cracking of a tetraethoxysilane atmosphere within which the phosphor particles are suspended.

It can be seen that an electron beam accelerated by a voltage which is intermediate the energization threshold voltages of the particles **19** and **21** will excite only the red phosphor particles **19** whereas an electron beam accelerated by a voltage greater than both of these thresholds

will energize both the red and the cyan phosphors. Since cyan is complementary in color to red, the high energy electrons will thus cause a substantially white or achromatic light to be emitted. It should further be understood that various mixtures of white and red light can be obtained by producing an electron beam containing electrons of both energies. The composite beam can be formed either by the mixture of two beams, both operative simultaneously, or by providing a single beam of alternating energy levels.

Kinescope **11** also includes a neck portion **25** within which are supported two essentially conventional electron beam guns **27** and **29**. Each gun **27** and **29** includes a cathode, **31** and **33** respectively, which emits electrons when heated by a suitable heater (not shown). The flow of electrons from each gun **27** and **29** is controlled in conventional manner by a grid, **35** and **37** respectively.

Cathodes **31** and **33** are operated at different potentials with respect to screen **13** by means described in greater detail hereinafter so that electrons emitted from the two guns are accelerated to different energies. The voltage between gun **29** and screen **13** is such that the electrons emitted from this gun will energize only the red light emitting phosphor particles **19**. Gun **27**, on the other hand, is at such a potential with respect to screen **13** that electrons emitted from that gun will energize both the red and cyan light emitting particles **19** and **20** respectively to cause substantially white light to be produced at screen **13**.

The respective intensities of the beams emitted from the guns **27** and **29** are controlled by signals derived in accordance with the presently standard NTSC system of television broadcasting. It is to be understood that signals derived according to other transmission systems, e.g., PAL or SECAM, may also be used to modulate the beams. A luminance signal (Y), obtained from a luminance amplifier YA, is applied to cathode **33** directly and, through a D.C. blocking capacitor C1, to the cathode **31**. Cathode **33** is maintained at D.C. ground potential. A conventional R-Y signal is obtained from an R-Y amplifier RA and is applied to the grid **37** of gun **29**. Accordingly, as the electron beam from this gun is scanned over screen **13** by means described hereinafter, its intensity is modulated in accordance with the long wavelength record or red component of the composite video signal being received. Since the electron beam from gun **29** energizes only the red phosphor particles **19** as explained previously, a corresponding red image is produced on screen **13** to be seen through face plate **15**.

Similarly, a G-Y amplifier GA provides to grid **35** the conventional G-Y signal. Thus the electron beam from gun **27** is modulated in accordance with the green or short wavelength information in the composite video signal. As it is scanned across the screen **13**, the beam from gun **27** energizes both kinds of phosphor particles **19** and **21** so that a substantially white or achromatic image is produced. The red and white images produced on screen **13** combine to form a composite image which subjectively appears to include a full range of hues, including those which are not actually present in the colorimetric sense. This general two-color system of presenting full color images is known in the art and provides a pleasing appearance in which the hues appear more saturated than they really are.

The steps necessary for detecting the Y, R-Y and G-Y signals are conventional and, since they form no part of the present invention, are not discussed further herein.

The electron beams emitted from guns **27** and **29** pass through the influence of a magnetic deflection yoke **39** which includes both horizontal and vertical deflection coils. The yoke is driven by conventional deflection circuits (not shown) to deflect the electron beams for obtaining a scan or raster which sweeps screen **13**. However, as the electrons in the two beams travel at different velocities due to their different accelerating voltages, the electron beams are not equally deflected by the same magnetic field. The beam which is accelerated by the greater voltage will be less subject to deflection than the other beam or, in other words, will be stiffer. For small differences in the accelerating voltages, the difference in deflection in relation to the total deflection is satisfactorily represented by one-half the voltage difference in relation to the total accelerating voltage, i.e., $\Delta D/D$ is approximately equal to one-half $\Delta E/E$.

To offset or compensate for the difference in beam deflection, gun **27** is provided with auxiliary electrostatic deflection plates **41** driven by booster or auxiliary circuits (not shown) to obtain additional deflection. Only vertical deflection plates are shown, the horizontal plates being omitted from the drawing to avoid obstructing the view. The additional electrostatic deflection augments the magnetic deflection of the electron beam from gun **27** by yoke **39** thereby to achieve a total deflection which is equal to that experienced by the beam emitted from gun **29** under the influence of the yoke **39** alone. Thus with a compensating signal of proper amplitude applied to the plates **41**, the scanning patterns of the respective beams will be in register.

However, as may be seen from the deflection/accelerating voltage relationships discussed above, the magnitude of the signal which must be applied to plates **41** is highly dependent upon the voltage differential between guns **27** and **29** in relation to the total accelerating voltages between the guns and screen **13**. If either the total accelerating voltage or the voltage differential between the guns varies independently, the needed amount of deflection compensation will also vary and exact registration will be lost. To vary the amplitude of the compensating signal would be cumbersome and expensive.

The present invention avoids this variation in the amount of deflection compensation needed by controlling the magnitude of the voltage differential in relation to total accelerating voltage in accordance with the relationships presented above so that the required deflection compensation remains constant despite variations in the absolute magnitude of the accelerating voltages. For small voltage changes, the necessary relationships are maintained when the voltage differential is regulated as a fixed proportion of the total accelerating voltage between one gun and the screen. Thus a compensating signal of uniform amplitude applied to the plates **41** gives satisfactory registration even though there is some variation in the high voltage applied to screen **13**. Accordingly, the need for regulation of the high voltage supply HV is avoided.

In FIGURE 1 an additional negative voltage is applied to cathode **31** with respect to cathode **33**, which additional negative voltage is regulated with respect to the high voltage positive potential applied to screen **13** by the high voltage supply HV. The negative side of a low voltage supply LV is connected to cathode **31** through a resistance R1 which permits the voltage at cathode **31** to be shunt regulated. Resistance R1 may, for example, be the inherent source impedance of supply LV. Cathode **31** is also connected, through a current limiting resistor R2, to the collector of a PNP transistor Q1. The collector is also connected to ground through a bleeder resistor R3.

A pair of resistors R4 and R5 constituting a voltage divider extend between the high voltage applied to screen **13** and ground. The junction between resistors R4 and R5 is connected to the base terminal of transistor Q1 to provide a positive reference voltage which is a fixed proportion of the screen voltage. The positive side of the low voltage supply LV is connected to ground through a resistor R6 and a Zener diode Z1, connected in parallel, thereby to provide a positive potential source with respect to ground at a junction **45**. The parameters of resistor R6 and diode Z1 are chosen such that this positive supply voltage is essentially equal to or of the same order of magnitude as the reference voltage applied to the base of transistor Q1 by resistors R4 and R5. The emitter

terminal of transistor Q1 is connected to this positive potential source through a current limiting resistor R7.

The conductivity of the collector-emitter circuit of transistor Q1 is a function of the relative values of the positive supply voltage at terminal 45 and the positive reference voltage applied at the base of transistor Q1, the transistor Q1 being forward biased into conduction when the reference voltage falls below the positive source voltage. Accordingly, if the voltage applied to the screen 13 should decrease for any reason, the transistor Q1 will be biased into greater conduction. Conduction in transistor Q1 shunts negative current away from cathode 31 so that the voltage differential between the two cathodes is reduced. The voltage differential between cathodes 31 and 33 is thus regulated substantially in proportion to the total accelerating voltage applied between cathode 33 and screen 13. As noted previously, such regulation essentially eliminates variations in the deflection correction needed so that registration between the component images is maintained even though there may be some change in image size.

In the embodiment illustrated in FIGURE 2, the cathode 31 is the one maintained at D.C. ground potential and a positive voltage is applied to the cathode 33 to produce the desired difference between the energies of the electrons emitted from the respective electron beam guns 27 and 29. Accordingly, the capacitor C1 is placed in the lead between cathode 33 and the Y amplifier YA so as to provide the necessary D.C. isolation.

In this embodiment auxiliary electrostatic deflection is not used but rather the electron beam guns 27 and 29 are provided with tubular magnetic shunts, 43 and 44 respectively, which are of different lengths. The shunts 43 and 44 are operative to shield the respective electron beam, over the length of the respective shunt, from the magnetic fields created by the yoke 39. The shunt 43 is shorter than the shunt 44 so that the electron beam from gun 27, which is emitted at a higher velocity than that from gun 29, will be subjected to magnetic deflecting forces for a longer portion of its path. Due to the longer exposure to the deflection forces, the faster electrons emitted from gun 27 experience a total deflection which is substantially equal to that experienced by the beam from gun 29 over a longer exposure path. Thus deflection compensation is obtained so that the images produced by the two guns will be in register. This form of deflection compensation is discussed in greater detail in U.S. Patent 3,114,795. However, this form of deflection compensation also is dependent upon the magnitude of the voltage differential between the two guns in relation to the total accelerating voltage.

To maintain the needed amount of compensation at a constant level, the voltage differential between the cathodes 31 and 33 is requlated in response to the relative values of both the accelerating voltage and the differential voltage thereby to obtain an error-reducing feedback mode of operation. The positive side of a low voltage supply LV is connected to cathode 33 through a resistance R11. Resistance R11 is also connected as the load resistance of one (Q3) of a pair of NPN transistors Q3 and Q4 which are interconnected as a differential amplifier. The collector terminal of transistor Q4 is provided with a load resistance R12 and the emitters of transistors Q3 and Q4 are connected to ground through a common-emitter resistor R13. Emitter resistor R13 effects the cross-coupling which provides the differentially responsive mode of operation of this circuit.

A reference voltage which is a fixed percentage of the voltage applied to screen 13 by supply HV is applied to the base terminal of transistor Q4 by resistors R4 and R5, as in the previous embodiment. A pair of resistors R14 and R15 connected between cathode 33 and ground constitutes a second voltage divider which applies to the base terminal of transistor Q3 a feed-back voltage which is a fixed proportion of the voltage differential existing between cathodes 31 and 33. The differential amplifier circuit is responsive to the difference between the reference voltage and the feed-back voltage to regulate the kinescope cathode voltage differential as a predetermined proportion of the screen voltage. If the screen voltage should fall for any reason, the forward bias applied to the base terminal of transistor Q4 is reduced and the voltage at the connected emitter terminals of transistors Q3 and Q4 tends to fall. A reduction in the voltage at the emitter of transistor Q3 tends to increase its forward drive and thus increase the current drawn from R11. The current drawn from R11 is shunted away from cathode 33 and thus the cathode differential voltage is lowered until the feed-back voltage, applied at the base of transistor Q3, is again substantially equal to the reference voltage at the base of transistor Q4. Accordingly, it is seen that the differential voltage is maintained at a fixed proportion of the screen voltage relative to cathode 31 and thus the amount of deflection compensation needed remains substantially constant.

FIGURE 3 schematically illustrates an embodiment in which the high voltage divider resistors R4 and R5 are enclosed within a sealed kinescope envelope 49. As these resistors, particularly resistor R4, operate at very high voltages, they tend to attract and hold dust particles if they are not protected. Thus, if these resistors are in an exposed location, the accumulation of foreign material may create leakage paths which change the effective operation of the divider and interfere with the proper operation of the voltage regulator according to the invention. By placing the divider within the sealed kinescope envelope this problem is avoided.

FIGURE 4 illustrates a further embodiment of a kinescope incorporating a voltage divider structure. In this construction a resistive film 51 is applied to the inner surface of a kinescope envelope 53 in the general form of a helical spiral which progresses from a screen 13 toward the neck portion 25 at which point it is grounded at a terminal 54. A tap 55 allows a fixed proportion of the screen voltage to be taken off and employed as the reference voltage in the regulator or control circuits described previously.

While regulator circuits employing transistors have been shown, it is to be understood that vacuum tubes may be used as the circumstances dictate. Also, while two guns operating simultaneously to provide two component images have been shown, a single gun may be used by switching between voltage levels to obtain a time sharing mode of operation. The regulation of the voltage difference between the sequentially applied voltage levels as a fixed proportion of the absolute value of one of them yields the same deflection compensation advantages as in the illustrated embodiments. Similarly, if more than two guns are used, e.g., to obtain three or four color image presentations, the voltage differences between the guns are advantageously regulated as functions of one of the total accelerating voltages. A continuous or incremental variation of accelerating voltages over a predetermined range can be used to vary hue in response to chrominance information. In such a case the range traversed may be regulated as a function of the peak accelerating voltage so as to maintain the deflection compensation needed at a constant value.

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 and methods 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 viewing screen including phosphors which emit light

of different colors when energized by electron beams of different energies;

electron beam gun means for emitting a beam of electrons toward said screen thereby to energize said phosphors;

voltage supply means for providing at least first and second electron beam accelerating voltages, said second electron beam accelerating voltage being higher than said first electron beam accelerating voltage, to effect a beam of electrons of a first accelerating voltage and a beam of electrons of a second accelerating voltage for energizing said phosphors to emit light of different colors;

deflection means for applying a first defletcion force to said beam of electrons of said first accelerating voltage and for applying a second deflection force to said beam of electrons of said second accelerating voltage to effect scanning of said screen by said beams of electrons, said deflecting means incorporating means for magnetically scanning said electron beam and incorporating means adjacent said electron beam gun means for applying an additional electrostatic deflection force to said beam of electrons of said second accelerating voltage, whereby said deflection force is greater for said beam of electrons of said second and higher accelerating voltage;

a voltage divider for obtaining a reference voltage which is a fixed proportion of the accelerating voltages from said voltage supply means; and

a relatively low voltage supply which is responsive to said reference voltage for providing a voltage differential between said first electron beam accelerating voltage and said second electron beam accelerating voltage, which voltage differential is a predetermined function of said reference voltage;

whereby registration is maintained between image components provided by electrons accelerated by said first and second electron beam accelerating voltages respectively despite variations in the absolute value of said accelerating voltages.

2. A color display system of caim **1**, wherein said electron beam gun means includes two guns and wherein only said second gun is provided with said second and higher electron beam accelerating voltage and only the electron beam from said second gun is additionally deflected by an electrostatic deflection force as a part of said deflection means, and both electron beams from both of said guns are subjected to said magnetic deflection means effecting magnetic scanning of said electron beams.

3. A color display system comprising:

a viewing screen including phosphors which emit light of different colors when energized by electron beams of different energies;

a first electron beam gun;

a high voltage supply for providing an electron beam accelerating voltage at said screen with respect to said first gun;

a voltage divider for obtaining a reference voltage which is a fixed proportion of said accelerating voltage;

a second electron beam gun; and

a relatively low voltage supply which is responsive to said reference voltage for providing a voltage differential between said first and second guns which voltage differential is a predetermined function of said reference voltage whereby registration is maintained between the image components provided by said guns despite variations in the voltage provided by said high voltage supply.

4. A color display system as set forth in claim **3** in which said screen and said guns are incorporated into a kinescope having a sealed envelope and in which said voltage divider is enclosed within said envelope.

5. The color display system of claim **3** wherein:

said low voltage supply is connected to afford an additive voltage of polarity opposite to the voltage at said screen, and

said voltage differential is effected by a non-inductive solid state regulating circuit interconnected with said low voltage supply to lower said additive voltage in response to a lower voltage at said screen.

6. The color display system of claim **3** wherein:

said low voltage supply is connected to afford a partial voltage of the same polarity as said voltage at said screen, and

said voltage differential is effected by a non-inductive solid state differential amplifier interconnected with said low voltage supply to adjust said partial voltage as a function of said voltage at said screen.

7. A color display system comprising:

a viewing screen including phosphors which emit light of different colors when energized by electron beams of different energies;

a first electron beam gun;

a high voltage supply for providing an electron beam accelerating voltage at said screen with respect to said first gun;

a voltage divider for obtaining a reference voltage which is a fixed proportion of said accelerating voltage;

a second electron beam gun;

a relatively low voltage supply for providing a voltage differential between said first and second guns, said low voltage supply including an appreciable source impedance; and

a regulator circuit responsive to said reference voltage for shunting current from said low voltage supply away from said second gun thereby to control said differential voltage as a predetermined function of said accelerating voltage.

8. A color display system comprising:

a viewing screen including phosphors which emit light of different colors when energized by electron beams of different energies;

a first electron beam gun;

a high voltage supply for providing an electron beam accelerating voltage at said screen with respect to said first gun;

a voltage divider for obtaining a reference voltage which is a fixed proportion of said accelerating voltage;

a second electron beam gun;

a relatively low voltage supply for providing a voltage differential between said first and second guns;

a voltage divider for obtaining a feed-back voltage which is a fixed proportion of said voltage differential; and

a regulator circuit, responsive to the voltage difference between said reference voltage and said feed-back voltage, for controlling current flow from said low voltage supply to said second gun thereby to maintain said voltage differential equal to a fixed proportion of said accelerating voltage.

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U.S. Cl. X.R.

136—83, 90, 114