April 10, 1956 J. M. LAFFERTY 2,741,526

COLOR SWITCHING CIRCUITS FOR REFLECTOR TYPE COLOR TELEVISION TUBE

Filed July 24, 1952 2 Sheets-Sheet 1

Fig. 1.

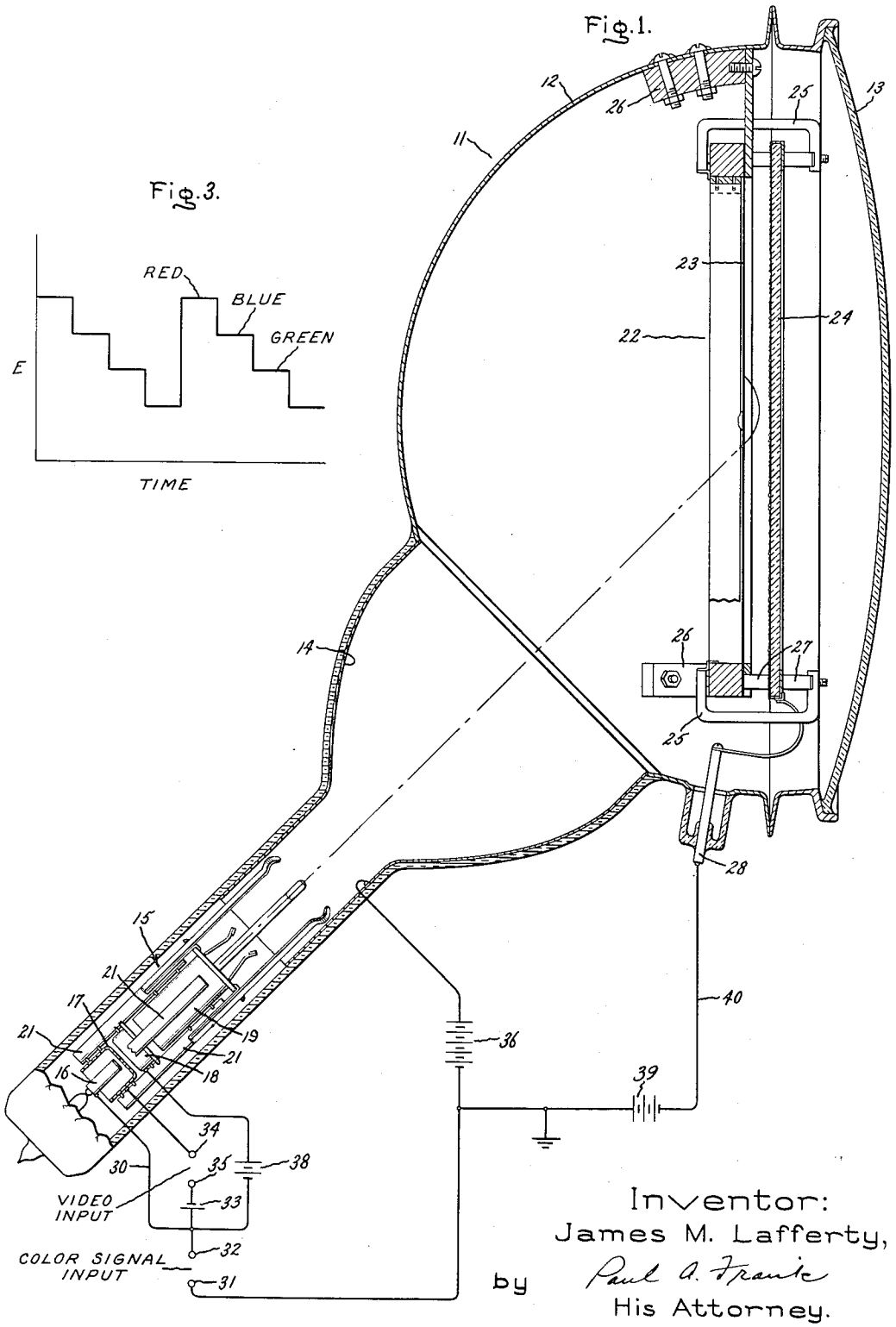


Fig. 3.

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Fig. 2.

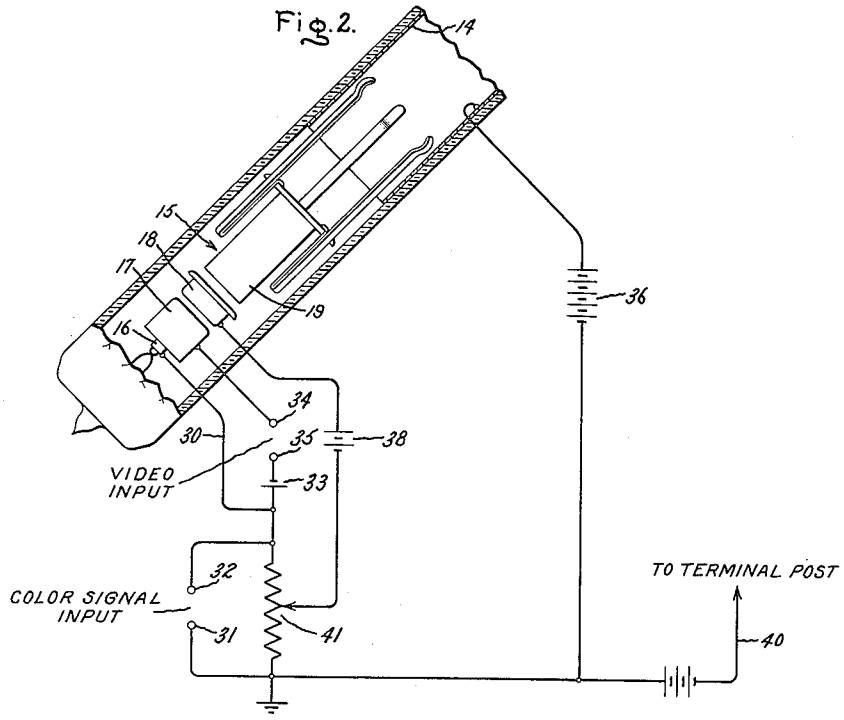
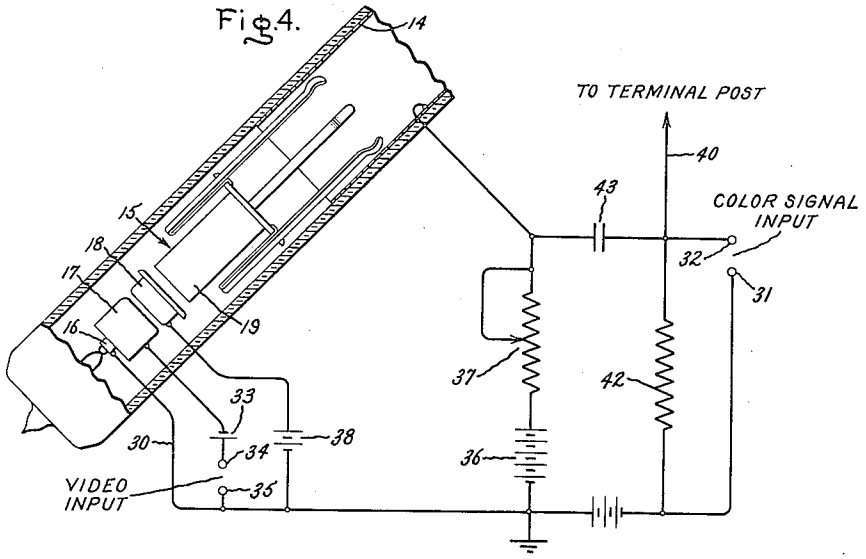


Fig. 4.



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2,741,526

COLOR SWITCHING CIRCUITS FOR REFLECTOR TYPE COLOR TELEVISION TUBE

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Application July 24, 1952, Serial No. 300,700

9 Claims. (Cl. 315—14)

The present invention relates to new and improved color switching circuits for cathode ray color image reproducing tubes.

More particularly, the invention relates to new methods and means for effecting color switching of the colored image reproduced by reflection type, cathode ray color image reproducing tubes used in color television receivers.

Reflection type, cathode ray color image reproducing tubes are generally comprised of a vacuum sealed envelope having an electron gun disposed therein and a color image reproducing electrode structure disposed in the path of the electron beam produced by the electron gun, and adapted to have the electron beam scanned thereover while reproducing a color image. The color image reproducing electrode structure includes a first electrode member having a plurality of concentrically arranged apertures formed therein with a plurality of symmetrically arranged different color light emitting phosphorescent materials secured to one of the surfaces thereof intermediate the apertures, and is supported within the tube envelope so that the phosphorescent material coated surface is adapted to be viewed through the face of the tube. The first apertured electrode member is supported with relation to the electron gun in a manner such that the electron beam produced by the electron gun must pass through the apertures in the member before it can impinge upon any one of the different color light emitting phosphorescent materials. Disposed between phosphorescent material coated surface of the first apertured electrode member and the face of the tube envelope, is a second, transparent, electrically conductive reflecting electrode member to which a reflecting electric potential is applied that coacts with an electric potential applied to the first apertured electrode member to produce a retarding electric field between the two members. This retarding electric field causes the electron beam passing through the apertures in the first electrode member to be reflected back, and to impinge on a desired color light emitting phosphorescent material. Thus, as the electron beam is caused to sweep out the desired image by properly positioned vertical and horizontal electron beam displacing means disposed adjacent the electron beam bath, the image thereby reproduced is caused to have a desired color by controlling the particular color light emitting phosphorescent material upon which the reflected electron beam impinges.

The particular color light emitting phosphorescent material excited by the reflected electron beam is, of course, determined by the point at which the electron beam impinges on the first apertured electrode member, and this in turn is determined by a number of factors, included amongst which is the spacing of the two electrode members, their relative electric potentials, and the angle of incidence of the electron beam with respect to the plane of the apertured electrode member. A more detailed description of the construction and operation of cathode ray color image reproducing tubes of this type, can be obtained from applicant's copending United States

patent application, Serial No. 208,875, for a "Color Television Apparatus and Method," filed February 1, 1951, and application Serial No. 269,978, "Tri-Color Cathode Ray Image Reproducing Electron Tube," filed February 5, 1952. The above applications disclose a number of methods and circuit arrangements for obtaining color switching in reflection type, color image reproducing electron tubes; however, the method that has been most widely adopted heretofore is that of varying the value of the reflecting field in order to effect color switching of the image reproduced by the tube.

While the particular method of color switching mentioned above has been generally suitable, some operational difficulties have been experienced due to certain phenomena which occur, and are inherent in the operation of the tube when color switching is effected by this method. One such phenomenon is the rather large charging currents which occur at relatively high switching rates, and which are brought about by the comparatively large capacitance between the reflector electrode and the apertured color image reproducing electrode. A second phenomenon brought about by effecting color switching in this manner is the occurrence of phase change in the reflector voltage over the face of the reflector electrode due to the resistive character of the transparent conductive coating disposed over its surface. As the resistance of the transparent conductive coating is directly related to the transparency of the coating (i. e. the better the transparency, the higher the resistance of the coating), it can be appreciated that this factor is not inconsequential. Another characteristic of the presently known reflection type color image reproducing tubes which is not associated with the particular method of color switching used with the tube, but which is nevertheless a source of trouble, is brought about by the difference in luminosity of the presently available, different color light emitting phosphorescent materials formed on the image reproducing electrode member.

It is therefore a primary object of the present invention to provide new and improved color switching circuit arrangements for reflection type cathode ray color image reproducing tubes which obviate the above difficulties. More specifically, it is an object of the invention to provide a color switching circuit arrangement of the above type which overcomes the need for the occurrence of relatively large charging currents at comparatively high switching rates.

Another, more specific object of the invention is to provide a color switching circuit arrangement for use with reflection type, image reproducing electron tubes, which minimizes the possibility of phase shift occurring over the face of the reflecting electrode member of the tube due to the relatively high resistance of the transparent conductive coating disposed thereover.

A further object of the invention is to provide a cathode ray color image-reproducing tube, color switching circuit arrangement which compensates for differences in luminosity of the different color light emitting phosphorescent material used in the tube.

A feature of the invention is the provision of a new and improved method and apparatus for switching the color of an image reproduced by a tri-color cathode ray image reproducing electron tube having at least one electron gun and a color image reproducing electrode structure disposed in the path of the electron beam produced by the gun and adapted to have the electron beam scanned thereover while reproducing an image. The improved apparatus utilizes the method of varying the velocity of the electrons in the electron beam in accordance with a desired color arrangement by the provision of a color control signal input means coupled to the energization circuit of the electron gun, the color con-

trol signal input means serving to vary the electron beam accelerating potential field of the tube with a control electric signal representative of the desired color arrangement.

Another feature of the invention is the provision of a new and improved method and means for switching the color of an image reproduced by a tricolor cathode ray image reproducing electron tube having at least one electron gun and a color image reproducing electrode structure disposed in the path of the electron beam produced by the electron gun, and adapted to have the electron beam scanned thereover in reproducing an image. In this embodiment of the new and improved switching arrangement, an apparatus is provided which utilizes the method of varying the average intensity of the electron beam as the same is switched from one color to the next by the inclusion of additional means in the energization circuit of the image reproducing tube for varying the average intensity of the electron beam as the same is switched from one color light emitting phosphorescent material to the next.

Other objects, features, and many of the attendant advantages of this invention will be appreciated more readily as the same becomes better understood by reference to the following detailed description, when considered in connection with the accompanying drawings, wherein like parts are identified by the same reference character, and wherein; Fig. 1 is a schematic circuit diagram of a color switching circuit arrangement constructed in accordance with the invention, for use with a reflection type cathode ray color image reproducing tube (shown in section); Fig. 2 is a schematic circuit diagram of a modified form of an improved color switching circuit arrangement which provides a means for compensating for the differences in luminosity of the different color light emitting phosphorescent materials of a reflection type cathode ray image reproducing tube included in the circuit; Fig. 3 is a graph showing the wave form of a suitable switching potential for use with the arrangement shown in Fig. 2; and Fig. 4 is a schematic circuit diagram of still another improved color switching circuit arrangement for a reflection type cathode ray color image reproducing tube.

One form of an improved color switching circuit arrangement for a cathode ray color image reproducing tube which incorporates the novel features of construction and method of operation made possible by the invention, is shown in Fig. 1. The switching circuit arrangement shown in Fig. 1 is particularly suitable for use in a color television receiver, and includes a reflection type cathode ray color image reproducing tube **11** that comprises an electrically conductive, hemispherical body portion **12** having a transparent face **13**, and a conical neck portion having a conductive coating **14** secured thereto. Disposed in the conical neck portion is an electron gun, indicated at **15**, which includes a cathode electrode **16**, a control electrode **17**, a first accelerating electrode **18**, and a second accelerating electrode **19** that is electrically connected to the conductive coating **14** through a plurality of resilient contact fingers. The electrode elements of electron gun **15** are supported in physical relationship by cylindrical insulating members **21** that serve to maintain each of the electrode elements in proper physical relationship with the others, and to electrically isolate each of the electrodes from the others.

Disposed in the hemispherical body portion **12** of cathode ray tube **11** is a color image reproducing electrode structure **22** that comprises an apertured color image reproducing electrode member **23** having a plurality of symmetrically arranged different color light emitting phosphorescent materials secured to one face thereof, and a transparent reflecting electrode member **24** having a transparent electrically conductive coating on one surface thereof. The two electrode members **23** and **24** are secured in spaced apart, parallel relationship with the phosphorescent material coated surface of apertured image reproducing electrode member **23** opposite the transparent electrically conductive coated surface of reflecting electrode member **24**. The electrode members **23** and **24** are held together in assembled relationship by a plurality of mounting structures **25** described more fully in the above-identified United States patent application, Serial No. 269,978, and the assembled electrode structure thus comprised is supported within hemispherical body member **12** transversely to the path of the electron beam produced by electron gun **15** by means of a plurality of electrically conductive projections **26** secured to the mounting assemblies **25** and to hemispherical body portion **12** of the tube envelope. By this construction, the apertured image reproducing electrode member **23** is maintained at the same electric potential as the electrically conductive hemispherical body portion **12** of the tube envelope, and therefore the same electric potential as the second accelerating electrode **19** of electron gun **15**. The electric potential of the color image reproducing electrode member **23** is different from that of transparent reflecting electrode member **24**, however, by reason of the inclusion of a pair of insulating blocks **27** in the mounting structure **25** which serve to electrically isolate the two electrode members **23** and **24**, and the provision of an electric operating potential supplied to transparent reflecting electrode **24** through a terminal post **28**. For this purpose, the terminal post **28** is insulatingly supported by the envelope of tube **11**, and has a resilient contact arm connecting it to the transparent electrically conductive coating on transparent reflecting electrode member **24**.

In operation, the electron gun **15** produces an electron beam that is caused to scan over the surface of the apertured color image reproducing electrode member **23** in tracing out the color image to be reproduced by suitably positioned vertical and horizontal deflection means (not shown) disposed about the conical neck portion **14**. As the electron beam is scanned back and forth over apertured electrode member **23** it passes over the apertures in the member and a portion of the beam passes through each aperture, is reflected by the retarding field existing between the two electrode members, and is returned to the electrode member **23** where it impinges upon one of the different color light emitting phosphorescent materials to excite the same. The particular point at which the reflected beam returns to and strikes the apertured electrode member **23**, that is the displacement of the beam, can be determined from the expression:

$$S=\frac{2d \sin 2\alpha}{1-V_c/V_o} \tag{1}$$

where S is the displacement of the electron beam measured from the point where the beam enters the retarding field to the point where it impinges on the phosphorescent material, d is the spacing between the apertured electrode member and the transparent reflecting electrode member, α is the angle of incidence of the electron beam measured with respect to a normal to the plane of the apertured electrode member **23**, V_c is the value of the potential applied to the reflecting electrode member, and V_o is the value of the potential applied to the apertured electrode member **23**.

From an examination of Expression 1, it can be readily seen that the displacement S of the reflected electron beam is a function of the potentials applied to each of the electrode members **23** and **24**, the spacing between the two electrode members, and the angle of incidence of the electron beam. The above-identified United States Patent Application 269,978 discloses a tube construction for overcoming or minimizing the effect of changes in the angle of incidence α of electron beam as the same is scanned over the image reproducing electrode structure, and for controlling the displacements S by varying the value of the electric potential applied to reflecting electrode **24** to thereby control the color of the image reproduced by the tube. An expression for the change in

displacement in response to a change in the electric potential applied to reflecting electrode **24**, is given by the following expression:

$$\frac{dS}{dV_c}=\frac{S}{V_o(1-V_c/V_o)} \tag{2}$$

From an inspection of Equation 2, it can be readily appreciated that if the value of the electric potential applied to apertured electrode member **23** is maintained constant, then displacements S will vary in accordance with the variations in the expression

$$\left(1-\frac{V_c}{V_o}\right)$$

While this particular method of color switching has been generally suitable to all intents and purposes, certain difficulties have been experienced due to the occurrence of certain characteristic phenomena which arise when the reflection type color image reproducing tube is operated in this manner. One such observed phenomenon is the rather large charging currents which are necessitated by the capacitance existing between the reflector electrode member **24**, and the apertured, color image reproducing electrode member **23**. Since the large charging currents are required to vary at relatively high switching rates, this phenomenon complicates the operation and construction of the tube. The second observed phenomenon is the occurrence of phase change in the reflector voltage over the face of the reflecting electrode member **24** when its potential is changed. This phase change is brought about due to the resistive character of the transparent conductive coating disposed over the surface of the reflecting electrode member, and since the resistance of the coating is directly related to the transparency, that is the more transparent the coating, the higher its resistance, it can be appreciated that this factor becomes more and more important if the brightness of the picture is to meet required standards.

In order to obviate the above cited difficulties, the color switching circuit arrangements comprising the present invention are provided. The particular color switching circuit arrangement illustrated in Fig. 1, utilizes an energization circuit means coupled between the cathode element of the electron gun **15** and the image reproducing electrode structure **22**. In the embodiment of the invention shown in Fig. 1, this energization circuit means includes a first energizing branch circuit operatively coupled between the cathode **16** of the electron gun **15** and a source of reference electric potential (ground). The first energizing branch circuit includes a direct current conductor section **30** connected between the cathode **16** and a color control signal input means that comprises a pair of signal input terminals **31** and **32** having the terminal **32** connected to conductor section **30**, and the terminal **31** directly connected to the source of reference potential. The energization circuit means also includes a second energizing circuit coupled between the cathode electrode **16** and control electrode **17** which comprises a source of grid biasing potential, such as a battery **33**, and an image forming signal input means including a pair of input terminals **34** and **35** adapted to have an image forming control signal coupled thereacross. The battery **33** and input terminals **34** and **35** are interconnected in series electrical circuit relationship between the cathode **16** and control electrode **17** with direct current connections including the direct current conductor section **30** so that the image forming signal input means **34** and **35**, and the color control signal input means comprises a series electrical circuit connected between the control electrode **17** and the source of reference potential.

The energization circuit means of the color switching circuit arrangement also includes further energizing branch circuits which comprise at least a third energizing branch circuit having a source of relatively large, positive direct current potential **36** connected through suitable direct current conductors between the second accelerating electrode **19** of the electron gun **16** and the source of reference electric potential (ground). In addition to the third energizing branch circuit, fourth and fifth energizing branch circuits are also provided for supplying desired operating potentials to electron tube **11**. The fourth energizing branch circuit comprises a source of positive direct current potential **38**, connected by direct current conductors between the first accelerating electrode **18** and the source of reference potential in a series electric circuit which also includes the color control signal input means **31** and **32**. The fifth energizing branch circuit comprises nothing more than a source of biasing potential **39** and a section of direct current conductor **40** that serves to operatively connect the terminal post **28**, and therefore the reflector electrode **24** to the source of reference potential.

By reason of the above-described construction, the color signal input serves to vary the potential of the cathode **16**, control electrode **17** and first accelerating electrode **18** simultaneously in order that the potential difference between these electrodes be maintained constant, and the color signal not affect the intensity of the electron beam produced by the gun. The image forming signal input is applied between the control electrode and cathode electrode of electron gun **15** and serves to vary the intensity of the electron beam in accordance with the image desired to be reproduced. Thus, the two intelligence conveying signals are coupled to the energization circuit means of electron tube **11** in a manner such that each one operates independently of the other, the image forming signal input serving to vary the intensity of electron beam in accordance with the intelligence it conveys, and the color switching signal serving to vary the velocity of the electrons in the electron beams in accordance with the intelligence it conveys.

That the color switching circuit arrangement will indeed operate independently of each other in the above-described manner, can be determined from the physical relationship set forth in Expression 1. Expression 1 was derived by assuming that the cathode voltage V_k of the electron gun was maintained at zero reference potential. If the cathode electrode voltage is not held at zero reference potential, but is varied, then Equation 1 takes the form:

$$S=\frac{2d(1-V_k/V_o)}{(1-V_c/V_o)}\sin 2\alpha \tag{3}$$

By differentiating Expression 3 with respect to the cathode voltage V_k, the following expression is derived

$$\frac{dS}{dV_k}=-\frac{S}{V_o(1-V_k/V_o)} \tag{4}$$

From a comparison of Expressions 2 and 4, it can be seen that if the average value of V_k is equal to V_c, the color switching sensitivity of the circuit arrangement is the same (except for sign) regardless of whether one modulates the reflector voltage V_c, or the cathode voltage V_k. Since the color switching sensitivities of the two methods of effecting color switching, are essentially the same, either method could be used equally well, assuming that there are no other factors which would affect the choice of the method used. There are other factors which affect the choice of the color switching method used, however, and these factors are the previously mentioned effects brought about by characteristics inherent in the construction of the reflection type tube when the method of color switching by modulating the reflector voltage V_c is used. One such effect is the occurrence of relatively large charging currents that vary at high frequencies, and are brought about mainly by reason of the relatively high capacitance (approximately 100 micromicrofarads for a 16 inch diameter tube) between the apertured image reproducing electrode member **23** and the transparent reflecting electrode member

24. Since the method of color switching illustrated in Fig. 1 does not change the potential existing between the apertured image reproducing electrode member 23 and reflector electrode member 24, this difficulty is obviated by the applicant's novel switching circuit arrangement. Another factor which affects the choice of color switching methods used, is the possibility of the occurrence of a phase change in the reflector voltage over the face of the transparent reflecting electrode member 24, when the color switching potential is applied thereto. This phase change is brought about due to the resistive character of the transparent conductive coating on the surface of the member, and, since the transparency of the coating is directly related to the resistance thereof, it can be readily appreciated that improvements in the brightness of the image reproduced by the tube are incompatible with improvements in the color switching sensitivity. Since in the arrangement provided by the present invention, there is no variation in the potential of the reflecting electrode member 24 as a result of the color switching operation, the possibility of a phase change in the voltage over the face thereof normally does not arise, and improvements may be made in the brightness of the image reproduced by the tube without substantially affecting the color switching sensitivity of the tube. From the above discussion, it can, therefore, be appreciated that the color switching circuit arrangement disclosed in Fig. 1 of the drawings offers certain definite advantages over the known color switching circuit arrangements for electron tubes of the reflection type.

There are certain factors in the new and improved switching arrangement disclosed herein, which are not at once apparent and should be pointed out. The most important of these factors is the change brought about in the deflection of the electron beam by reason of the changes in velocity of the electrons thereof. This shift in deflection occurs along a line extending radially outward from the center of the image reproducing electrode member 23, and can be theoretically computed from the following equation:

$$\Delta X = 1/2\left(\frac{\Delta S}{S}X\right) \tag{5}$$

where X is the desired beam deflection, S is the total beam displacement defined in Expression 1, ΔS is the shift in beam displacement required to change color, and ΔX is the undesired shift in beam deflection. From an examination of Equation 5, it can be readily determined that the undesired shift deflection of the electron beam is practically negligible, and does not substantially affect the operation of the tube. Therefore for all intents and purposes, this limitation of the switching circuit arrangements comprising the present invention, can be ignored.

While in the color switching circuit arrangement shown in Fig. 1, the color switching signal does not affect the intensity of the electron beam produced by electron gun 15, because of the fact that different color light emitting phosphorescent materials have different luminosites, it may prove desirable to change the average intensity of the electron beam when the same is switched from one color light emitting phosphorescent material to the next. For example, in their present state of development, the red light emitting phosphorescent materials now available do not have as high luminosity as the green or blue light emitting phosphorescent materials. Hence, it would be desirable to have the average intensity of the electron beam increased as the same impinges upon the red light emitting phosphorescent material, and for this purpose, the circuit arrangement shown in Fig. 2 is provided. With the exception of the differences illustrated in Fig. 2, the overall color switching circuit arrangement is the same as that shown in Fig. 1, and includes the reflection type cathode ray color image reproducing electron tube partially shown at 11. Secured in electron tube 11 is an electron gun 15 comprised of a cathode electrode 16, a control electrode 17 a first accelerating electrode 18 and a second accelerating electrode 19, for producing an electron beam, and a reflection type color image reproducing electrode structure (not shown) disposed transversely to the path of the electron beam produced by electron gun 15. Electron tube 11 is operatively connected in an energization circuit means that includes a first energizing branch circuit coupled between the cathode electrode 16 and the source of reference potential (ground), and comprising conductor section 30, and an impedance 41 that is preferably a resistor. The impedance 41 has the pair of color switching signal input terminals 31 and 32 connected to opposite ends thereof in a manner such that a potential drop is developed thereacross which serves to vary the electric potential of cathode electrode 16 in accordance with the color switching signal. The electron tube energization circuit means also has a second energizing branch circuit coupled between the control electrode 17 and the cathode electrode 16, and having the image forming signal input terminals 34 and 35 included therein for applying an image forming input signal to the control electrode 17 to thereby vary the intensity of electron beam produced by electron gun 15 in accordance with the image to be reproduced by the tube. By constructing the first and second energizing branch circuits in this manner, the image forming signal input means 34 and 35 comprise a part of a series electrical circuit which includes the impedance 41, and the series electrical circuit thus formed is coupled between the control electrode 17 and the source of reference potential (ground).

A further or third energizing branch circuit is coupled between the first accelerating electrode 18 and the impedance 41 which comprises a source of positive direct current potential 38 connected through suitable direct current conductors between the accelerating electrode 18 and a variable tap connection to the impedance 41. To complete the energization circuit means of the color switching circuit arrangement a fourth energizing branch circuit is provided which comprises a source of positive direct current potential 36 connected by suitable direct current electrical conductors between the second accelerating electrode 19 and the source of reference potential (ground). A fifth energizing branch circuit (not shown) may also be provided for supplying energization potential to the transparent reflecting electrode member (likewise not shown).

By reason of the above-described circuit construction, the image forming signal input applied to terminals 34 and 35 serves to vary the intensity of the electron beam produced by electron gun 15, and the color signal input applied to terminals 31 and 32 serves to vary the velocity of the electron beam independent of the intensity modulation in much the same manner as that of the circuit arrangement illustrated in Fig. 1. The circuit arrangement of Fig. 2 differs from that of Fig. 1, however, in that the excitation potential applied to the first accelerating electrode 18 varies in accordance with the variations in the color switching potential applied across the impedance 41 due to the fact that a predetermined portion of the color signal is applied to the accelerating electrode 18. Hence, if the color switching potential is in the form of a stepped square wave such as that shown in Fig. 3 of the drawings, it can be appreciated that the potential developed across impedance 41, and therefore the potential applied to the first accelerating electrode 18 has a relatively high positive value with respect to the cathode 16 when the red color light emitting phosphorescent material is to be excited, a lesser value for the blue color light emitting phosphorescent material, and a still lesser value for the green light emitting phosphorescent material. Consequently, the average value of the intensity of the electron beam produced by electron gun 15 will vary as the color switching signal changes from one value to the next to thereby compensate for differences in luminosity of the different color light emitting phosphorescent materials.

Because it may sometime prove impracticable to apply

color switching potentials to the cathode electrode of the electron gun in the manner illustrated in Figs. 1 and 2, a novel switching circuit arrangement such as that shown in Fig. 4 of the drawings is also provided which embodies the basic principles of the invention. The switching circuit arrangement shown in Fig. 4 includes a reflection type, cathode ray, color image reproducing tube 11 (similar to that shown and described in connection with Fig. 1) connected in a color switching circuit arrangement having an energization circuit means coupled thereto which is considerably different in construction and operation from the energization circuit means of the arrangement shown in Fig. 1. The energization circuit means of Fig. 4 includes a first energizing branch circuit that consists of the direct current conductor section 30 between the cathode electrode 16 of electron gun 15 and the source of reference potential (ground).

In order to obtain color switching in the circuit arrangement shown in Fig. 4, a second energizing branch circuit comprising a source of biasing potential 33, an adjustable resistor, if desired, and the input terminals 34, 35 of the image forming signal input means, is suitably interconnected through direct current conductors in a series electrical circuit between the control electrode 17 and the source of reference potential. The energization circuit means also has further energizing branch circuits connected therein which include a third energizing branch circuit comprising a source of positive direct current potential 36 and a variable resistor 37 connected in series electrical relationship with suitable direct current connectors between the second accelerating electrode 19 of electron gun 15 and the source of reference potential. A fourth energizing branch circuit is also provided which comprises an adjustable resistor if desired, and a source of positive potential 38 interconnected by suitable direct current connectors between the first accelerating electrode 18, and the source of reference potential. The fourth energizing branch circuit, together with the third energizing branch circuit then serves to develop an accelerating potential field for the electrons emitted by cathode electrode 16. For the purpose of applying an operating potential to the reflecting electrode member 23, a fifth energizing branch circuit is also provided which comprises a direct current conductor 40 and an impedance 42, preferably a resistor, connected in series circuit relationship between the reflecting electrode and grounded through a source of biasing potential. The color switching signal input means comprising input terminals 31 and 32 is connected across the impedance 42. Impedance 42 is coupled to the second accelerating electrode 19, and therefore to the apertured color image reproducing electrode member 23 through an alternating current coupling means comprising a coupling capacitor 43. The coupling capacitor 43 is connected between second accelerating electrode 19 and the terminal of impedance 42. The terminal of impedance 42 is connected directly to reflecting electrode member 24, and therefore serves to maintain accelerating electrode 19 and apertured color image reproducing electrode member 23 at the same alternating current potential as the reflecting electrode member 24. By connecting the color signal input means in this fashion, variations in the potential developed across resistor 42 due to the color switching signal applied to terminals 31 and 32, serve to vary the accelerating potential field of the electron tube (and therefore the velocity of the electrons in the electron beam) in accordance with the input color switching signal, but does not vary the value of the retarding electric field existing between electrode members 23 and 24.

While the circuit arrangement of Fig. 4 does not overcome the occurrence of relatively large charging currents at high switching rates, it does obviate the possibility of phase change occurring over the face of the transparent reflecting electrode member 24 since there is no change in the relative potentials of reflecting electrode member 24 and image reproducing electrode member 23. Hence, while the switching circuit arrangement of Fig. 4 is not so effective in its operation as the circuit arrangement shown in Figs. 1 and 2, it nevertheless constitutes a considerable improvement over previously known switching ararngements of the same general nature.

From the foregoing description, it can be appreciated that the invention provides new and improved color switching circuit arrangements for cathode ray color image reproducing tubes. The new and improved switching circuit arrangements make available a means for overcoming the attendant effects of obtaining color switching in the manner used heretofore which necessitated the occurrence of relatively high charging current at high switching rates. Further the invention furnishes improved color switching arrangements which overcome in an efficient manner the basic incompatibility of prior color switching circuit arrangements with improvements in the brightness of the color image reproduced by a color image reproducing electron tube. Additionally, the invention also provides improved color switching circuit arrangements having a means for compensating for differences in luminosity of the different color light emitting phosphorescent materials presently available for use in cathode ray, color image reproducing electron tubes.

Obviously, there are many modifications and variations of the present invention which will be suggested to those skilled in the art, in the light of the above teachings. It is, therefore, to be understood that changes may be made herein which are within the full intended scope of the invention as defined by the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A color switching circuit arrangement for a color television receiver image reproducing system including in combination a cathode ray color image reproducing electron tube having at least one electron gun and a color image reproducing electrode structure disposed in the path of the electron beam produced by said electron gun and adapted to have the electron beam scanned thereover in reproducing a received color television signal, energization circuit means operatively coupled to said electron gun for producing an electron beam accelerating potential field, video signal input means coupled to said energization circuit means between a control electrode element and a cathode element of the said electron gun for varying the intensity of the said electron beam in accordance with the video component of the received television signal, and color control signal input means coupled to said energization circuit means between the cathode element of said electron gun and said image reproducing electrode structure for varying the said electron beam accelerating potential field and therefore the velocity of the electrons in the electron beam in accordance with the color component of the received television signal.

2. A color switching circuit arrangement for a color image reproducing system including in combination a cathode ray color image reproducing electron tube comprising at least one electron gun having a cathode, a control electrode and at least one accelerating electrode, and a color image reproducing electrode structure disposed in the path of the electron beam produced by said electron gun and adapted to have the electron beam scanned thereover in reproducing a color image, a first energizing branch circuit operatively coupled between the cathode of said electron gun and a source of reference electric potential and including color control signal input means, a second energizing branch circuit operatively coupled between the control electrode and the cathode electrode of said electron gun and including image forming signal input means, said image forming signal input means being included in series electrical circuit relationship with said color control signal input means and the series circuit thus formed being connected between the control elec-

trode of said electron gun and the source of reference potential, and a further energizing branch circuit operatively connected between an accelerating electrode of said electron gun and said source of reference electric potential.

3. A color switching circuit arrangement for a color television receiver image reproducing system including in combination a cathode ray color image reproducing electron tube comprising at least one electron gun having a cathode, a control electrode and at least one accelerating electrode, and a color image reproducing electrode structure disposed in the path of the electron beam produced by said electron gun and adapted to have the electron beam scanned thereover in reproducing a received color television signal, a first energizing branch circuit operatively coupled between the cathode of said electron gun and a source of reference electric potential and including color control signal input means for varying the velocity of the electrons in the electron beam in accordance with the color component of the received color television signal, a second energizing branch circuit operatively coupled between the control electrode and the cathode electrode of said electron gun and including image forming signal input means for varying the intensity of the said electron beam in accordance with the video component of the received color television signal, said image forming signal input means being included in series electrical circuit relationship with said color control signal input means and the series circuit thus formed being connected between the control electrode of said electron gun and the source of reference potential, and a further energizing branch circuit operatively coupled between an accelerating electrode of said electron gun and said source of reference electric potential.

4. A color switching circuit arrangement for a reflection type color television receiver image reproducing system including in combination a cathode ray color image reproducing electron tube comprising at least one electron gun having a cathode, a control electrode and at least one accelerating electrode, and a reflection type color image reproducing electrode structure disposed in the path of the electron beam produced by said electron gun and adapted to have the electron beam scanned thereover in reproducing a received color television signal, a first energizing branch circuit operatively coupled between the cathode of said electron gun and a source of reference electric potential and including color control signal input means for varying the velocity of the electrons in the electron beam in accordance with the color component of the received color television signal, a second energizing branch circuit operatively coupled between the control electrode and the cathode electrode of said electron gun and including image forming signal input means for varying the intensity of the said electron beam in accordance with the video component of the received color television signal, said image forming signal input means being included in series electrical circuit relationship with said color control signal input means and the series circuit thus formed being connected between the control electrode of said electron gun and the source of reference potential, and a further energizing branch circuit operatively coupled between an accelerating electrode of said electron gun and said source of reference electric potential, said accelerating electrode and the image reproducing electrode member of said reflection type electrode structure being interconnected and maintained at the same excitation potential.

5. A color switching circuit arrangement for a color image reproducing system including in combination a cathode ray color image reproducing electron tube comprising at least one electron gun having a cathode, a control electrode and at least one accelerating electrode, and a color image reproducing electrode structure disposed in the path of the electron beam produced by said electron gun and adapted to have the electron beam scanned thereover in reproducing a color image, a first energizing branch circuit operatively coupled between the cathode of said electron gun and a source of reference electric potential, an impedance connected in said first energizing branch circuit, means for coupling an input color control signal across said impedance, a second energizing branch circuit operatively coupled between the control electrode and the cathode electrode of said electron gun and including image forming signal input means, said image forming signal input means being included in series electrical circuit relationship with said impedance and the series circuit thus formed being connected between the control electrode of said electron gun and the source of reference potential, and a further energizing branch circuit operatively connected to an accelerating electrode of said electron gun and to said impedance.

6. A color switching circuit arrangement for a reflection type color television receiver image reproducing system including in combination a cathode ray color image reproducing electron tube comprising at least one electron gun having a cathode, a control electrode and at least one accelerating electrode, and a reflection type color image reproducing electrode structure disposed in the path of the electron beam produced by said electron gun and adapted to have the electron beam scanned thereover in reproducing a received color television signal, a first energizing branch circuit operatively coupled between the cathode of said electron gun and a source of reference electric potential, an impedance connected in said first energizing branch circuit, means for coupling an input color control signal across said impedance for varying the velocity of the electrons in the electron beam in accordance with the color component of the received color television signal, a second energizing branch circuit operatively coupled between the control electrode and the cathode electrode of said electron gun and said source of reference electric potential and including image forming signal input means for varying the intensity of the said electron beam in accordance with the video component of the received color television signal, said image forming signal input means being included in series electrical circuit relationship with said impedance and the series circuit thus formed being connected between the control electrode of said electron gun and the source of reference potential, and a further energizing branch circuit operatively connected to an accelerating electrode of said electron gun and to said impedance, said accelerating electrode and the image reproducing electrode member of said reflection type electrode structure being interconnected and maintained at the same excitation potential.

7. A color switching circuit arrangement for a color image reproducing system of the reflection type including in combination a cathode ray color image reproducing electron tube comprising at least one electron gun having a cathode, a control electrode and at least one accelerating electrode, and a reflection type color image reproducing electrode structure disposed in the path of the electron beam produced by said electron gun and adapted to have the electron beam scanned thereover in reproducing a color image, a first energizing branch circuit operatively coupled between the cathode electrode of said electron gun and a source of reference electric potential, a second energizing branch circuit operatively coupled between the control electrode of said electron gun and said source of reference electric potential and including image forming signal input means, and a further energizing branch circuit operatively coupled between said reflection type image reproducing electrode structure and said source of reference electric potential and including color control signal input means.

8. A color switching circuit arrangement for a color image reproducing system of the reflection type including in combination a cathode ray color image reproducing electron tube comprising at least one electron gun having a cathode, a control electrode and at least one accelerating electrode, and a reflection type color

image reproducing electrode structure comprising an apertured tri-color image reproducing electrode member and a transparent reflecting electrode member spaced from and parallel to said image reproducing electrode member, said image reproducing electrode structure being disposed in the path of the electron beam produced by said electron gun and adapted to have the electron beam scanned thereover in reproducing a color image, a first energizing branch circuit operatively coupled between the cathode of said electron gun and a source of reference electric potential, a second energizing branch circuit operatively coupled between control electrode of said electron gun and said source of reference electric potential and including image forming signal input means, a further energizing branch circuit operatively coupled between said apertured image reproducing electrode member and said source of reference electric potential and including color control signal input means, and an alternating current coupling circuit interconnecting said apertured image reproducing electrode member and said transparent electrode member and serving to maintain a constant potential difference between each of said members.

9. A color switching circuit arrangement for a reflection type color television receiver image reproducing system including in combination a cathode ray color image reproducing electron tube comprising at least one electron gun having a cathode, a control electrode and at least one accelerating electrode, and a reflection type color image reproducing electrode structure comprising an apertured tricolor image reproducing electrode member and a transparent reflecting electrode member spaced from and parallel to said image reproducing electrode member, said image reproducing electrode structure being disposed in the path of the electron beam produced by said electron gun and adapted to have the electron beam scanned thereover in reproducing a received color television signal, a first energizing branch circuit operatively coupled between the cathode of said electron gun and a source of reference electric potential, a second energizing branch circuit operatively coupled between control electrode of said electron gun and said source of reference electric potential and including video signal input means for varying the intensity of the said electron beam in accordance with the video component of the received television signal, direct current connector means interconnecting said apertured image reproducing electrode member and the accelerating electrode of said electron gun, a further energizing branch circuit operatively coupled between said apertured image reproducing electrode member and said source of reference electric potential for producing an electron beam accelerating potential field and including color control signal input means for varying the said electron beam accelerating potential field and therefore the velocity of the electrons in the electron beam in accordance with the color component of the received television signal, and an alternating current coupling capacitor connected between said apertured image reproducing electrode member and said transparent electrode member and serving to maintain a constant potential difference between each of said members.

References Cited in the file of this patent

UNITED STATES PATENTS

2,307,188	Bedford	Jan. 5, 1943
2,461,515	Bronwell	Feb. 15, 1949
2,566,713	Zworykin	Sept. 4, 1951
2,577,038	Rose	Dec. 4, 1951
2,580,073	Burton	Dec. 25, 1951
2,590,764	Forgue	Mar. 25, 1952
2,617,876	Rose	Nov. 11, 1952
2,619,608	Rajchman	Nov. 25, 1952