July 1, 1958 A. J. BIGGS 2,841,644

COLOR-TELEVISION IMAGE-REPRODUCING APPARATUS

Filed Jan. 14, 1955 3 Sheets-Sheet 1

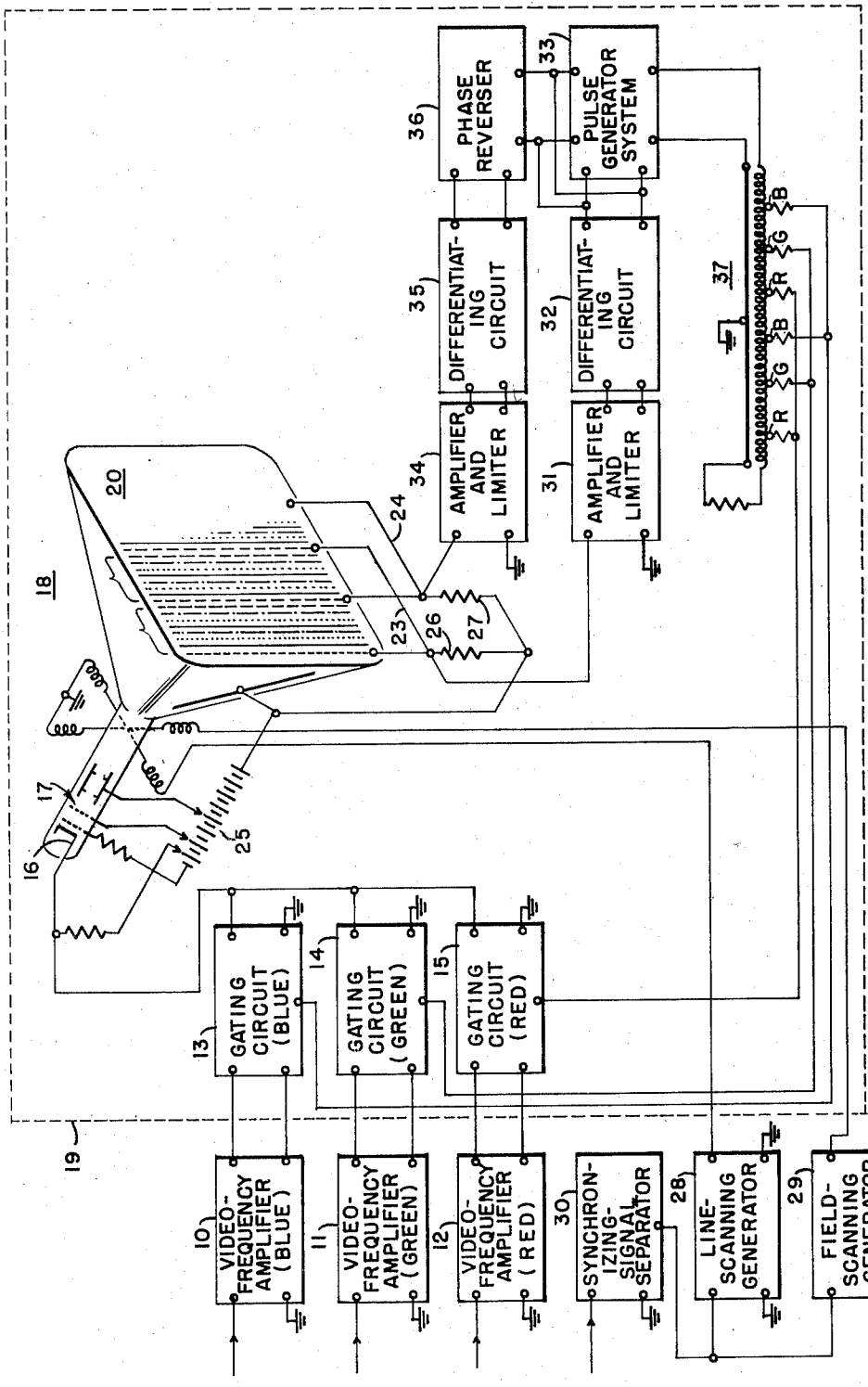


FIG. 1

COLOR-TELEVISION IMAGE-REPRODUCING APPARATUS

Filed Jan. 14, 1955 3 Sheets-Sheet 2

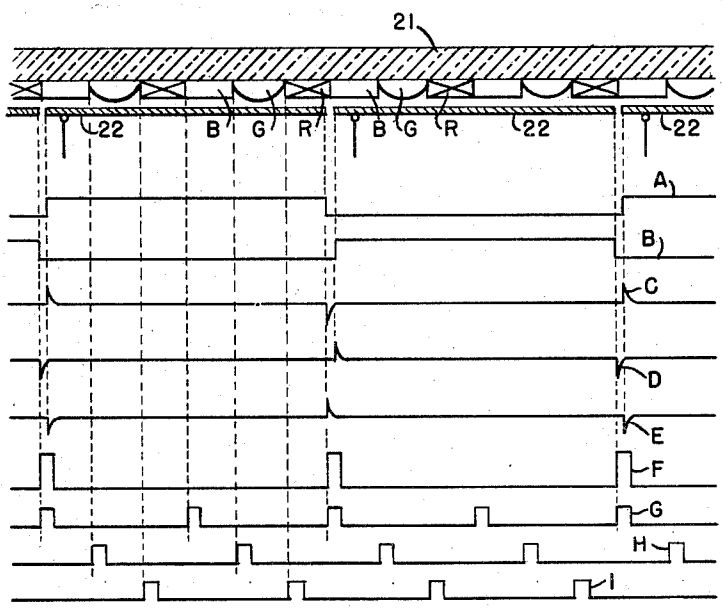


FIG. 2

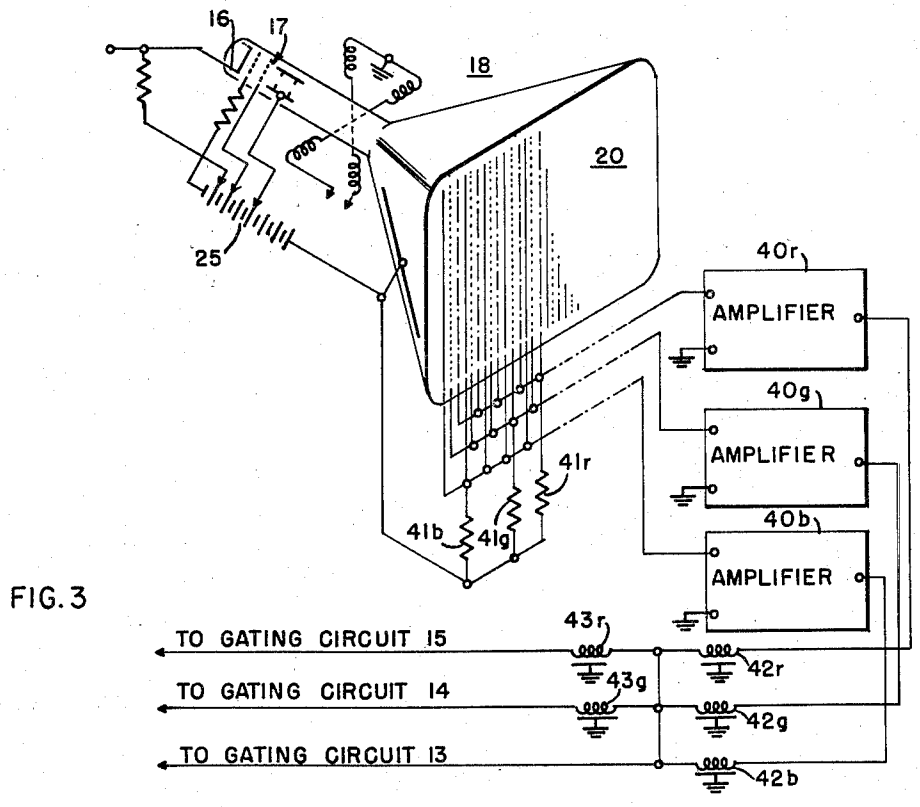


FIG. 3

July 1, 1958 A. J. BIGGS 2,841,644

COLOR-TELEVISION IMAGE-REPRODUCING APPARATUS

Filed Jan. 14, 1955 3 Sheets-Sheet 3

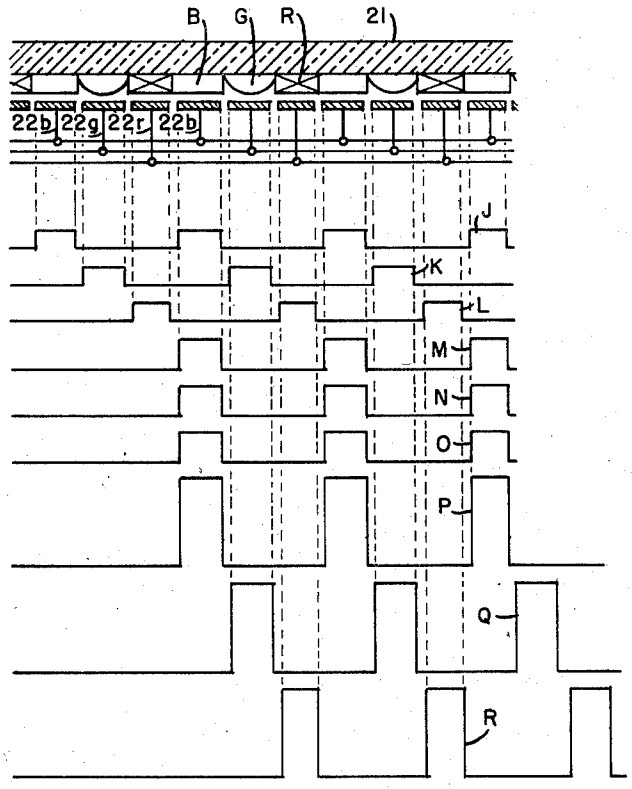


FIG.4

United States Patent Office 2,841,644 Patented July 1, 1958

2,841,644

COLOR-TELEVISION IMAGE-REPRODUCING APPARATUS

Albert J. Biggs, Wembley, England, assignor to Hazeltine Research, Inc., Chicago, Ill., a corporation of Illinois

Application January 14, 1955, Serial No. 481,907

6 Claims. (Cl. 178—5.4)

The present invention relates to color-television image-reproducing apparatus for use in color-television receivers.

In such receivers it is common practice to reproduce the picture by combining separate images representing a plurality of color components (usually red, green, and blue) into which the picture may be analyzed. In order to avoid the difficulties inherent in receivers in which these images are reproduced on separate screens, various proposals have been made for providing color-television receivers in which all the images are reproduced on the screen of a single cathode-ray tube, the screen comprising separate interspersed sets of appropriately colored luminous elements. By a colored luminous element is meant an element adapted to emit or transmit light of a specified color.

In one such form of color-television receiver, the luminous elements take the form of a series of parallel strips, the picture being reproduced by repeatedly scanning the screen with a single electron beam in such a manner that small areas of elements of the different sets of luminous elements are scanned in regular succession, for example by scanning in a series of parallel straight lines transverse to the lengths of the elements. In this form of color-television receiver, the color component signals (that is signals representing the spatial distribution of the intensity of the respective color components of the picture) are applied one at a time to the cathode-ray tube to control the intensity of the electron beam, and it is necessary to provide some means for synchronizing the application of the color component signals and the scanning of the corresponding colored luminous elements.

In one proposed color-television receiver, this means takes the form of a series of metal strips interspersed between the luminous elements and disposed parallel to them, the pulses of current flowing into the metal strips as the electron beam passes over them being used to control the synchronizing. This proposal has the disadvantages that it is not possible to apply the conventional metalizing to the screen of the cathode-ray tube, and the metal strips represent a waste of space on the screen as far as the reproduction of the picture is concerned and may lead to the production of a series of undesirable dark stripes superimposed on the picture.

It is an object of the present invention, therefore, to provide a color-television image-reproducing apparatus of the general form referred to above, in which one or more of these disadvantages is substantially overcome.

In accordance with the invention, a color-television image-reproducing apparatus comprises an image-reproducing device including an input circuit responsive to an applied signal having components representative of a plurality of colors combined in a predetermined relation, means for scanning a target in a predetermined raster with an electron beam, a target which effectively has a plurality of elemental portions and when scanned by that beam are productive of individual ones of the aforesaid colors, a plurality of electron-permeable light-reflecting conductive members disposed in a predetermined spaced relation over substantially the entire area of the aforesaid target intermediate the scanning means and the target for augmenting the intensity of the colors and simultaneously therewith translating energy concurrently with the scanning of the elemental portions by the beam, and means for controlling the intensity of the beam. There is also provided for the image-reproducing apparatus control circuits including the electron-permeable light-reflecting conductive members responsive to the aforesaid translated energy for deriving a control signal having components representative of the position of the beam with relation to the aforesaid elemental portions during the scanning mentioned above. The image-reproducing apparatus also includes a control system coupled to the control circuits and to the control means for utilizing the control signal to control the beam intensity in a predetermined relation to the application to the aforesaid input circuit of the color-representative components, whereby the image-reproducing device reproduces an image in color.

Also in accordance with the invention, a color-television image-reproducing device comprises an input circuit responsive to an applied signal having components representative of a plurality of colors combined in a predetermined relation, means for scanning a target in a predetermined raster with an electron beam, and a target which effectively has a plurality of parallel strips of different phosphors arranged in a repeating cyclic order forming n sets of said strips which when scanned by that beam are productive of elemental areas of an image in individual ones of the aforesaid colors, n being an integer much greater than one. The image-reproducing device also includes

$$\frac{n}{2}$$

electron-permeable light-reflecting conductive members disposed in a predetermined relation over substantially the entire area of the aforesaid target intermediate the scanning means and the target and responsive to the electron beam for developing a control effect representative of the position of that beam during scanning and for augmenting the intensity of the colors of the aforesaid image.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring to the drawings:

Fig. 1 is a schematic representation of a portion of a television receiver including a color-television image-reproducing apparatus and a color-television image-reproducing device in accordance with the present invention;

Fig. 2 is a fragmentary portion of the viewing screen of the device of Fig. 1 and a related graph utilized in explaining the operation of the apparatus of Fig. 1;

Fig. 3 represents a portion of a modified form of the color-television image-reproducing apparatus, and

Fig. 4 is a fragmentary portion of the viewing screen of Fig. 3 and a graph for explaining the operation of the Fig. 3 apparatus.

Description of Fig. 1 apparatus

One arrangement in accordance with the invention will now be described by way of example with reference to a color-television receiver suitable for use with a simultaneous color-television system. In this arrangement the receiver is adapted for use in connection with color-television transmissions in which three color component signals (corresponding to red, green, and blue components of the picture) are simultaneously transmitted as

modulations of a high-frequency carrier wave. The signal received at the receiver is fed to a synchronous detector (not shown), the output from which comprises three video-frequency color component signals which are fed to three separate video-frequency amplifiers **10**, **11**, and **12** through which the blue, green, and red color component signals are respectively passed. The outputs of the three video-frequency amplifiers are respectively fed to a control system comprising three pentode-type gating circuits **13**, **14**, and **15** of the image-reproducing apparatus **19** in accordance with the invention, each of the gating circuits being adapted when operated to feed one of the color component signals to the cathode **16** of the electron gun **17** of the cathode-ray tube **18** of the receiver so as to control the intensity of the electron beam in the tube. The three gating circuits **13**, **14**, and **15** are operated in sequence, in a manner which will be described in detail below, so that the color component signals are fed in succession to the electron gun **17** of the cathode-ray tube **18**.

The screen **20** of the cathode-ray tube comprises a glass plate **21** (see also Fig. 2) which has formed on its inner side three sets of luminous elements in the form of phosphor strips, respectively composed of a blue fluorescing phosphor, a green fluorescing phosphor, and a red fluorescing phosphor. The strips are identified in Fig. 2 by the reference characters B, G, and R and are all disposed vertically as represented in Fig. 1 and have equal widths somewhat greater than the diameter of the spot formed on the screen by the electron beam. For convenience of illustration, in Fig. 1 the blue fluorescing strips of the screen **20** are represented by the solid lines, the green fluorescing strips by the dotted lines, and the red fluorescing strips by the dot-dash lines. The strips are so arranged that a regular sequence of a blue fluorescing strip, a green fluorescing strip, and a red fluorescing strip recurs across the screen. Superimposed upon the phosphor strips is a series of metal strips **22**, **22** disposed parallel to the phosphor strips, and each covering two complete sequences of the phosphor strips as represented more clearly in Fig. 2. In Fig. 1, the edges of the metal strips are represented by the dash-line construction. Each pair of adjacent metal strips **22**, **22** is separated by a very narrow gap, and the metal strips are electrically connected together by conductors **23** and **24** in two sets of alternate strips which are provided with separate lead-in connections through the envelope of the cathode-ray tube. The metal strips may for example be produced by a technique similar to that used for the conventional metalizing of cathode-ray tube screens, and are all maintained at a high positive potential as in the case of a conventional cathode-ray tube with a metalized screen. To this end the high-potential terminal of a source represented as a battery **25** is connected through resistors **26** and **27** to the conductors **23** and **24**, respectively.

A line-scanning generator **28** and a field-scanning generator **29** are provided for the cathode-ray tube **18** and are arranged so that the screen **20** of the cathode-ray tube is scanned by the electron beam in the conventional manner, that is in a series of fields each consisting of a large number of substantially horizontal lines. The operation of the scanning generators is synchronized by means of synchronizing pulses transmitted with the color component signals and derived by the synchronizing-signal separator **30**. The scanning of the screen **20** causes a small area of each phosphor strip to be excited in turn, and the application of the color component signals to the cathode **16** of the electron gun is synchronized in the manner described below with the scanning of the corresponding phosphor strips. The electron gun of the cathode-ray tube **18** is biased in a conventional manner so that during scanning the intensity of the electron beam is never reduced quite to zero, even when the color component signal being applied to the electron gun is at the black level; this may result in a slight distortion of the color values of the reproduced picture, but should not cause any unacceptable depreciation in its quality.

The conductor **23** connected to alternate ones of the metal strips **22**, **22** is coupled to a pulse generator system **33** through a wave-shaping network comprising an amplifier and amplitude limiter **31** and a differentiating circuit **32**. The pulse generator system **33** comprises two pulse generators, one of which responds to positive polarity applied signals for developing output pulses and the other of which develops output pulses in response to applied pulses of negative polarity. Accordingly, this system may comprise a pair of multivibrators. The conductor **24** is coupled to the pulse generator system **33** through a similar network comprising in cascade a limiter **34**, a differentiating circuit **35**, and a phase reverser **36** which may be a suitable amplifier. The output circuit of the pulse generator **33** is connected to a nonreflecting time-delay network **37** having its remote end terminated in its characteristic impedance. Network **37** has a series of taps identified from right to left in Fig. 1 by the reference characters B, G, R, B, G, and R. The B taps are connected to the gating circuit **13** while the G and R taps are connected, respectively, to the gating circuits **14** and **15**.

Operation of image-reproducing apparatus 19 of Fig. 1

In considering the operation of the image-reproducing apparatus of Fig. 1, it will be assumed that the synchronizing signals derived by the synchronizing-signal separator are effective to cause the line-scanning and field-scanning generators **28** and **29** to develop and apply sawtooth waves to the deflecting windings of the cathode-ray tube **18**, thereby causing a low-intensity cathode-ray beam thereof to scan the screen **20** in the usual raster. The blue, green, and red color component signals derived in the well-known manner by the synchronous detector of the receiver are amplified in their respective amplifiers **10**, **11**, and **12** and are applied to an input circuit of each of the pentode gating circuits **13**, **14**, and **15**.

The scanning of the screen **20** causes a flow of current through the two sets of metal strips **22**, **22** and the resistors **26** and **27** connected thereto. This develops across resistor **27** a series of control pulses of the type which, after amplification and limiting in unit **34**, appear as represented by curve A of Fig. 2. Similarly, there is developed across resistor **26** a series of control pulses which appear in the output circuit of unit **31** as the pulse signal represented by curve B. After differentiation in units **35** and **32**, the pulses of curves A and B appear, respectively, as the pulses represented by curves C and D. The pulses of curve C are reversed in polarity in the phase reverser **36** and appear as represented by curve E. The application of the pulses of curves D and E to the pulse generator system **33** causes it to develop the series of output pulses represented by curve F for application to the time-delay network **37**. The time delays afforded at the various taps of the network **37** are such that the pulses of curve G appear at the B taps, the pulses of curve H at the G taps, and the pulses of curve I at the R taps. It will be noted from Fig. 2 that the individual pulses of curve G are developed at times when the cathode-ray beam is impinging on individual ones of the blue fluorescing phosphor strips, those of curve H appear when the beam is impinging on individual ones of the green fluorescing phosphor strips, and those of curve I are developed when it is impinging on individual ones of the red fluorescing phosphor strips. The pulses of curve G are applied to another input electrode of the gating circuit **13** and, similarly, the pulses of curves H and I are applied, respectively, to the corresponding input circuits of gating circuits **14** and **15**. Consequently, the gating circuits are operated at times such that the blue color component signal is applied to the electron gun of the cathode-ray tube only when the electron beam

is passing over a strip of the blue phosphor, and similarly for the green and red color component signals. Thus the images corresponding to the three color components are accurately reproduced on the screen of the cathode-ray tube.

From the foregoing explanation it will be seen that the metal strips of the cathode-ray tube and the units **31—37** constitute control circuits responsive to energy translated by the passage of the cathode-ray beam over those strips for deriving a control signal having pulse components representative of the position of the beam with relation to the phosphor strips during the scanning operation.

It will be appreciated that the width and spacings (if any) of the phosphor strips are chosen so that the required degree of fineness of detail is obtained in the reproduced picture. In the specific arrangement described above the strips were all of equal width, but this is not essential. Where the efficiencies of the three phosphors differ appreciably it may be desirable to make the red, green, and blue strips of different widths in order to achieve a satisfactory rendering of the colors in the reproduced picture.

It will be understood that the luminous elements may, instead of consisting of phosphor strips, consist of colored optical filter strips, a uniform layer of a white phosphor being applied between the filter strips and the metal strips.

It will be appreciated that in the arrangement described above, the metal strips, in addition to serving for the derivation of the synchronizing signal for the gating circuits **13**, **14**, and **15**, serve the same purposes as the conventional metalizing of the screen of a cathode-ray tube. Furthermore, since the metal strips are superimposed on the luminous elements, they do not involve any waste of space on the screen as far as the reproduction of the picture is concerned. A further advantage of the invention is that only a single high-voltage supply is required for operation of the cathode-ray tube.

Description of Apparatus in Fig. 3

Referring now to Fig. 3 of the drawing, the portion of a color-television image-reproducing apparatus there represented in generally similar to that represented in Fig. 1. Accordingly, corresponding elements are designated by the same reference numerals. The screen **20** of the cathode-ray tube includes the glass plate **21** (see also Fig. 4) which has formed on its inner surface three sets of luminous elements in the form of phosphor strips, respectively composed of a blue fluorescing phosphor, a green fluorescing phosphor, and a red fluorescing phosphor. The strips are all disposed vertically and have widths somewhat greater than the diameter of the spot formed on the screen **20** by the electron beam. The strips are separated by narrow gaps, and are so arranged that a regular sequence of a blue fluorescing strip, a green fluorescing strip, and a red fluorescing strip recurs across the screen. Each phosphor has superimposed upon it a metal strip of substantially the same width as the phosphor strip, and the metal strips are electrically connected together in three sets corresponding, respectively, to the sets of phosphor strips. The metal strips associated with the blue, green, and red fluorescing phosphor strips are designated, respectively, **22***b*, **22***g*, and **22***r* as shown in Fig. 4. Each of the sets of metal strips is provided with a separate lead-in connection through the envelope of the cathode-ray tube. The interconnected strips **22***b* are connected to the input circuit of an amplifier **40***b* and are also connected through a resistor **41***b* to the high-potential terminal of the source **25**. Similarly, the strips **22***g* and **22***r* are respectively connected to amplifiers **40***g* and **40***r* and to the source **25** through resistors **41***g* and **41***r*.

The output circuits of the amplifiers **40***b*, **40***g*, and **40***r* are coupled, respectively, through time-delay networks **42***b*, **42***g*, and **42***r* which have interconnected output circuits. The network **42***b* is proportioned to afford a time delay of three units equal to the time required for the cathode-ray beam in its scanning to traverse the distance between a metal strip **22***b* and a next adjacent strip **22***b*. The network **42***g* provides a delay of two units corresponding to the time required for the beam to traverse the distance between a metal strip **22***g* and the next adjacent strip **22***g* while network **42***r* provides one-half the delay of network **42***g*.

The interconnected output circuits of the time-delay networks just mentioned are coupled, respectively, to the gating circuit **15** and the gating circuit **14** through time-delays networks **43***r* and **43***g* which afford respective time delays of two and one units. The gating circuit **13** is directly coupled to the output circuits of networks **42***r*, **42***g*, and **42***b*.

Operation of Fig. 3 Apparatus

The scanning of the screen **20** causes a periodic flow of current through the three sets of interconnected metal strips **22***b*, **22***g*, and **22***r* and their associated resistors **41***b*, **41***g*, and **41***r*. As a result, a train of pulses such as those represented by curve J of Fig. 4 is applied to amplifier **40**b, another train of pulses such as those represented by curve K is applied to amplifier **40***g*, and a third train such as those represented by curve L is applied to amplifier **40***r*. The amplified output pulses of the amplifiers **40***b*, **40***g*, and **40***r*, after translation through the networks **42***b*, **42***g* and **42***r*, appear in the order named as the pulses of curves M, N, and O and, when combined, appear as represented by curve P. The pulses of curve P are developed at a time when the cathode-ray beam is scanning the blue fluorescing phosphor strips and are applied without any appreciable time delay to the gating circuit **13** momentarily to increase the intensity of the cathode-ray beam in proportion to the intensity of the blue color component signal. Curves Q and R represent the delayed pulses applied to the gating circuits **14** and **15** so as momentarily to increase the intensity of the cathode-ray beam at the times of those pulses in proportion to the intensities of the green and blue color component signals supplied to those gating circuits. Accordingly, the gating circuits are operated in a manner to increase their transconductances at times such that the blue color component signal is applied to the electron gun of the cathode-ray tube **18** only when the electron beam is passing over a strip of the blue fluorescing phosphor, and similarly, for the green and red color component signals. Thus, the images corresponding to the three color components are accurately reproduced on the screen of the cathode-ray tube.

It will be appreciated that since the control signals are derived in response to the scanning of all three sets of phosphor strips, the synchronizing of the cathode-ray beam will for the most part be unaffected by the color content of the part of the picture which is being scanned at any particular moment. Consequently, the image-reproducing apparatus is not subject to the disadvantages which might arise if the synchronizing signal were derived in response to the scanning of only one of the sets of phosphor strips. It will be further appreciated that no control signal will be generated while the electron beam is scanning an area of the picture which is completely black, so that there is some possibility of a slight color distortion at the edge of a colored area of the picture which is scanned immediately after a black area. However, this should not result in any appreciable deterioration of the subjective quality of the picture. In any case, it would be possible to arrange that the control signals are generated at all times during scanning by ensuring that the intensity of the electron beam was never reduced quite to zero during scanning, even when the color component signal being applied to the electron gun was at the black level, although this might itself result in some slight distortion of the color values of the reproduced picture.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A color-television image-reproducing apparatus comprising: an image-reproducing device including an input circuit responsive to an applied signal having components representative of a plurality of colors combined in a predetermined relation, means for scanning a target in a predetermined raster with an electron beam, a target which effectively has a plurality of elemental portions and when scanned by that beam are productive of individual ones of said colors, a plurality of electron-permeable light-reflecting conductive members disposed in a predetermined spaced relation over substantially the entire area of said target intermediate said scanning means and said target for augmenting the intensity of said colors and simultaneously therewith translating energy concurrently with the scanning of said elemental portions by said beam, and means for controlling the intensity of said beam; control circuits including said members responsive to said translated energy for deriving a control signal having components representative of the position of said beam with relation to said elemental portions during said scanning; and a control system coupled to said circuits and to said control means for utilizing said control signal to control said beam intensity in a predetermined relation to the application to said input circuit of said color-representative components, whereby said device reproduces an image in color.

2. A color-television image-reproducing apparatus comprising: an image-reproducing device including an input circuit responsive to an applied signal having components representative of a plurality of colors combined in a predetermined relation, means for scanning a target in a predetermined raster with an electron beam, a target which effectively has a plurality of elemental portions and when scanned by said beam are productive of individual ones of said colors, a plurality of electron-permeable light-reflecting conductive members disposed in a predetermined spaced relation over substantially the entire area of said target intermediate said scanning means sand said target for augmenting the intensity of said colors and simultaneously therewith translating energy concurrently with the scanning of said elemental portions by said beam, and means for controlling the intensity of said beam; control circuits including said members responsive to said translated energy for deriving a control signal having pulse components representative of the position of said beam with relation to said elemental portions during said scanning; and a gating system coupled to said circuit and to said control means for utilizing said control signal to control said beam intensity in a predetermined relation to the application to said input circuit of said color-representative components, whereby said device reproduces an image in color.

3. A color-television image-reproducing apparatus comprising: an image-reproducing device including an input circuit responsive to an applied signal having components representative of a plurality of colors combined in a predetermined relation, means for scanning a target in a predetermined raster with an electron beam, a target which effectively has a plurality of parallel strips of different phophors arranged in a repeating cyclic order forming n sets of said strips and when scanned by said beam are productive of an image in colors, n being an integer much greater than one,

$$\frac{n}{2}$$

electron-permeable light-reflecting conductive members disposed in a predetermined spaced relation over substantially the entire area of said target parallel to said strips and intermediate said scanning means and said target for augmenting the intensity of said colors and simultaneously therewith translating energy concurrently with the scanning of said elemental portions by said beam, and means for effectively controlling the intensity of said beam; control circuits including said members responsive to said translated energy for deriving a control signal having pulse components representative of the position of said beam with relation to individual ones of said strips during said scanning; and a gating system coupled to said circuit and to said control means for utilizing said control signal to control said beam intensity in a predetermined relation to the application to said input circuit of said color-representative components, whereby said device reproduces an image in color.

4. A color-television image-reproducing apparatus comprising: an image-reproducing device including an input circuit responsive to an applied signal having components representative of a plurality of colors combined in a predetermined relation, means for scanning a target in a predetermined raster with an electron beam, a target which effectively has a plurality of parallel strips of different phosphors arranged in a repeating cyclic order and when scanned by said beam are productive of an image in colors, a plurality of electron-permeable light-reflecting conductive members individually disposed over individual ones of said strips and over substantially the entire area of said target intermediate said scanning means and said strips for augmenting the intensity of said colors and simultaneously therewith translating energy concurrently with the scanning of said phosphor strips by said beam, and means for effectively controlling the itnensity of said beam; control circuits including said members responsive to said translated energy for deriving a control signal having pulse components representative of the positoin of said beam with relation to individual ones of said strips during said scanning; and a gating system coupled to said circuit and to said control means for utilizing said control signal to control said beam intensity in a predetermined relation to the application to said input circuit of said color-representative components, whereby said device reproduces an image in color.

5. A color-television image-reproducing apparatus comprising: an image-reproducing device including an input circuit responsive to an applied signal having components representative of a plurality of colors combined in a predetermined relation, means for scanning a target in a predetermined raster with an electron beam, a target which effectively has a plurality of elemental portions and when scanned by said beam are productive of individual ones of said colors, a plurality of electron-permeable light-reflecting conductive members disposed in a predetermined spaced relation over substantially the entire area of said target intermediate said scanning means and said target for augmenting the intensity of said colors and simultaneously therewith translating energy concurrently with the scanning of said elemental portions by said beam, and means for controlling the intensity of said beam; control circuits, including said members and time-delay means in cascade therewith, responsive to said translated energy for deriving a control signal having components representative of the position of said beam with relation to said elemental portions during said scanning; and a control system coupled to said circuit and to said control means for utilizing said control signal to control said beam intensity in a synchronous relation to the application to said input circuit of said color-representative components, whereby said device reproduces an image in color.

6. A color-television image-reproducing apparatus comprising: an image-reproducing device including an input

circuit responsive to an applied signal having components representative of a plurality of colors combined in a predetermined relation, means for scanning a target in a predetermined raster with an electron beam, a target which effectively has a plurality of elemental portions and when scanned by said beam are productive of individual ones of said colors, a plurality of electron-permeable light-reflecting conductive members disposed in a predetermined spaced relation over substantially the entire area of said target intermediate said scanning means and said target for augmenting the intensity of said colors and simultaneously therewith translating energy concurrently with the scanning of said elemental portions by said beam, and means for controlling the intensity of said beam; control circuits, including said members in cascade with wave-shaping means and time-delay means, responsive to said translated energy for deriving a control signal having

pulse components representative of the position of said beam with relation to said elemental portions during said scanning; and a gating system coupled to said circuit and to said control means for utilizing said control signal to control said beam intensity in synchronous relation to the application to said input circuit of said color-representative components, whereby said device reproduces an image in color.

References Cited in the file of this patent

UNITED STATES PATENTS

2,446,440	Swedlund	Aug. 3, 1948
2,657,331	Parker	Oct. 26, 1953
2,689,269	Bradley	Sept. 14, 1954
2,697,742	Evans	Dec. 21, 1954
2,706,216	Lesti	Apr. 12, 1955