Aug. 24, 1954 L. R. KIRKWOOD 2,687,493

DYNAMIC ELECTRON BEAM CONTROL SYSTEM

Filed Nov. 30, 1950 2 Sheets-Sheet 1

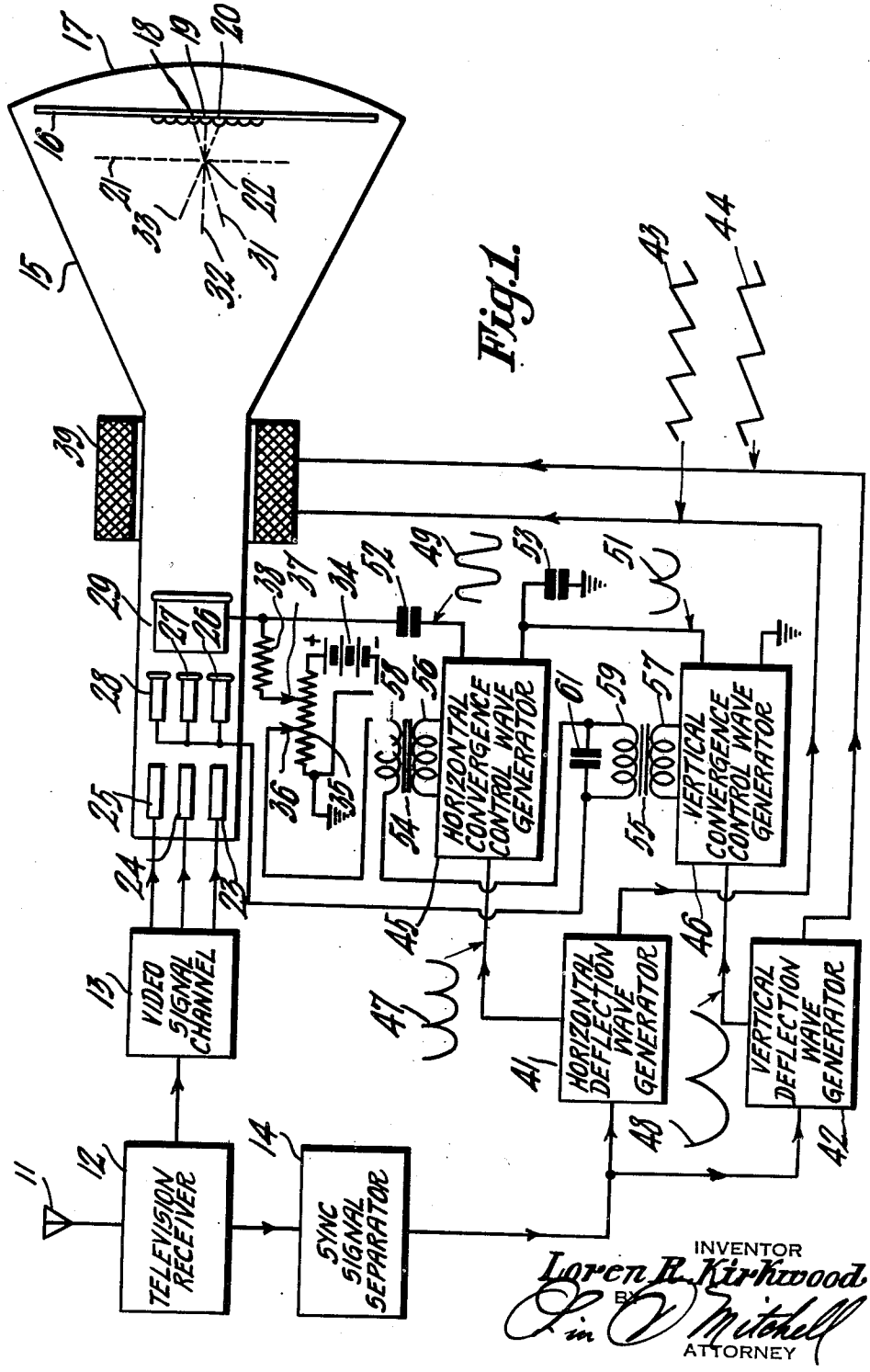


Fig. 1.

INVENTOR
Loren R. Kirkwood
BY
Lin Mitchell
ATTORNEY

Aug. 24, 1954 L. R. KIRKWOOD 2,687,493

DYNAMIC ELECTRON BEAM CONTROL SYSTEM

Filed Nov. 30, 1950

2 Sheets-Sheet 2

Fig. 2.

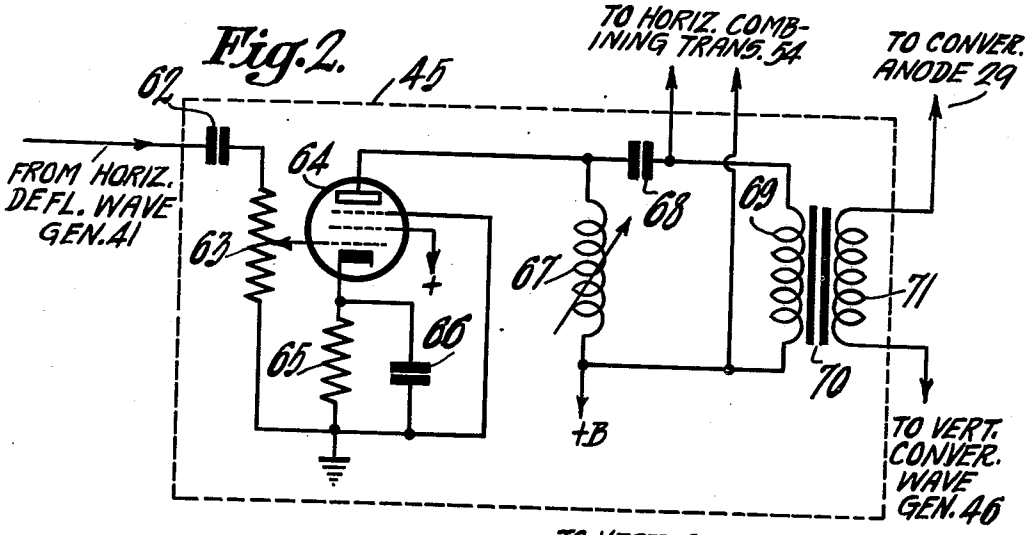
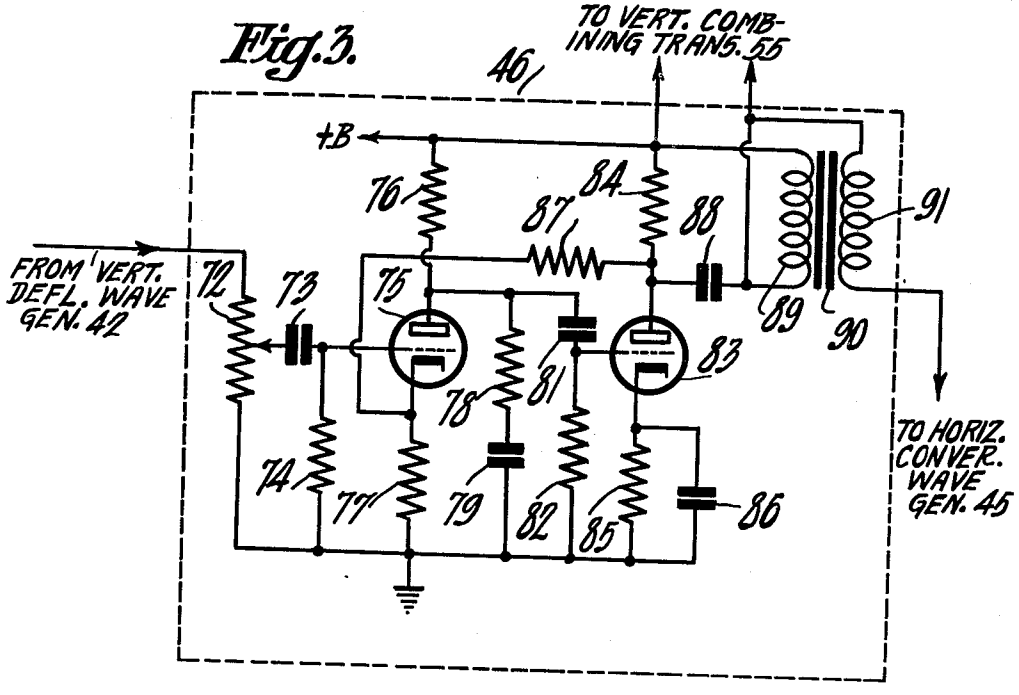


Fig. 3.



INVENTOR
Loren R. Kirkwood
BY
Kim O. Mitchell
ATTORNEY

Patented Aug. 24, 1954

2,687,493

UNITED STATES PATENT OFFICE

2,687,493

DYNAMIC ELECTRON BEAM CONTROL SYSTEM

Loren R. Kirkwood, Oaklyn, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application November 30, 1950, Serial No. 198,313

7 Claims. (Cl. 315—13)

1

This invention relates to systems for controlling the electron beams of cathode ray tubes. It pertains particularly to the dynamic control of a plurality of electron beam components used in a cathode ray tube so as to maintain good focusing of the respective beam components and also to effect convergence of said components at all points of a raster scanned in a predetermined plane.

The present trend in television kinescopes is toward the use of flatter luminescent screens which also are of greater areas than heretofore used. Also, the tendency is to shorten the tubes as much as possible. All of these factors makes the problem of deflecting an electron beam or a plurality of electron beam components a more difficult one than previously. Accordingly, new techniques are required.

A representative example of a cathode ray tube of the character referred to is a multi-color kinescope forming the subject matter of U. S. Patent No. 2,595,548 granted May 6, 1952, to A. C. Schroeder and titled "Picture Reproducing Apparatus." The luminescent screen of this tube consists of a multiplicity of phosphor areas of sub-elemental dimensions. Different ones of the phosphor areas are capable of producing light of the component image colors when excited by electron beam energy. In this tube, the different light-producing phosphor screen areas are excited respectively by a plurality of electron beams approaching the screen from different angles through an apertured masking electrode. Color selection is secured by the angle at which the electron beams approach the screen.

Another representative example of a cathode ray tube with which the present invention is useful forms the subject matter of a copending U. S. application of Russell R. Law, Serial No. 165,552, filed June 1, 1950, and titled "Color Television." In general, the Law tube is similar to the Schroeder tube. The chief difference is that the Law tube employs a single electron gun by which to produce the plurality of electron beam components, whereas, in the Schroeder tube, an electron gun is provided to produce each beam. This is accomplished by imparting a spinning type of movement to the beam so that it is made to rotate about the central, or longitudinal, axis of the tube. In its rotation about the tube axis, the beam occupies, in successive intervals, substantially the same positions as the different electron beams of the Schroeder tube.

The expression "electron beam components," as used in this specification and claims, is intended to cover the type of phosphor exciting electronic energy produced by a single or a plurality of electron guns. This energy may be continuous or pulsating as required without departing from the scope of the invention.

2

The successful operation of multi-color kinescopes of the type referred to requires that the plurality of electron beam components be made to converge substantially in the plane of the masking electrode at all points in the scanned raster. In view of the fact that the different points of the target electrode are at different distances from the point or region of the electron beam deflection, it is necessary to provide a field-producing means which is variably energized to produce a dynamic convergence control. One such electron beam control system forms the subject matter of a copending U. S. application of Albert W. Friend, Serial No. 164,444, filed May 26, 1950, and titled "Electron Beam Controlling System." In the Friend case, an electron-optical system is variably energized as functions of both the horizontal and vertical beam deflections. It can be demonstrated that, without dynamic convergence control, the electron beam components converge at different points as they are deflected to scan a raster. The locus of these convergence points is approximately parabolic in form. Accordingly, as disclosed in the Friend application referred to, the electron-optical system is variably energized as parabolic functions of both the horizontal and vertical beam deflections.

Parabolic wave forms are somewhat difficult to produce in practice without resorting to costly systems and apparatus. It has been found that a sinusoidal wave form approximates a parabolic wave with sufficient accuracy to enable the energization of the dynamic convergence control system by energy having a sinusoidal wave form. One system in which this expedient is employed is described in a copending U. S. application of Gordon E. Kelly and Robert D. Flood, Serial No. 198,314, filed November 30, 1950, and titled "Electron Beam Convergence System."

In the Kelly and Flood application the convergence control system of the kinescope is energized by a wave having a sinusoidal form at the horizontal beam deflection frequency and also by a wave having a substantially parabolic form at the vertical deflection frequency. A parabolic wave derived from the horizontal deflection generator is converted to a sinusoidal wave for energizing the convergence system. At the same time a sawtooth wave, derived from the vertical deflection generator, is converted to a parabolic wave

for additionally energizing the convergence system.

It also is desirable to exercise some dynamic control of the focusing of the respective electron beam components as they are deflected to scan a raster in a cathode ray tube of the character described. The electron beam components tend to become defocused for substantially the same reasons as the electron beam components tend not to converge in the same plane. Even in cathode ray tubes having a single electron beam, there is a tendency for the beam to become defocused when large deflection angles are used. Accordingly, there is need for providing a dynamic focusing control of one or more of the electron beams of a cathode ray tube.

It, therefore, is an object of the present invention to provide an improved electron beam control system by which to maintain uniformity of performance by a plurality of electron beam components substantially at all points in the plane of a target electrode.

An additional object of the invention is to provide an improved electron beam control system by which dynamic control of the beam focusing is effected, whereby to maintain uniform focusing of the beam at all points in a raster scanned in the plane of a target electrode.

Another object of the invention is to provide an improved electron beam control system for a multi-color kinescope in which convergence of a plurality of electron beam components is effected by a dynamically operated system and also in which dynamic control of the focusing of the electron beam components is concurrently effected.

Still another object of the invention is to provide an improved electron beam control system in which the energization of the beam-convergence system is controlled at least in part by sinusoidal wave energy and in which substantially the same type of energy is employed to concurrently control the focus of the electron beam components.

A further object of the invention is to provide an improved generator of electrical waves of complex form in which relatively inexpensive components are used.

The present invention is embodied in apparatus used in conjunction with an electron-optical system for effecting convergence of a plurality of electron beam components and of maintaining said beam components in focus substantially at all points in the plane of a target electrode of the type employed in multi-color kinescopes. The cathode ray tube is provided with a beam convergence field-producing means located adjacent to the paths of all of the electron beam components. The beam-convergence field-producing means is energized as functions of the vertical and horizontal beam deflections. At least one of these functions is sinusoidal. At the same time, the electron beam-focusing system of the tube also is energized in a substantially similar manner.

More specifically, in accordance with an illustrative embodiment of the invention in a color kinescope wherein the electron beam components are derived, respectively, from different electron guns, the beam convergence field-producing means includes an anode of the kinescope. Also, there is provided in the region between the different electron guns and the convergence anode, focusing electrodes for each of the electron beams. The convergence anode is

energized at horizontal beam deflection frequency by sinusoidal wave energy. This energy is produced in a circuit which is tuned to the horizontal deflection frequency and which is excited by a parabolic wave derived from the horizontal deflection wave generator. The convergence anode also is energized at vertical beam deflection frequency by a parabolic wave. This wave is produced by amplifying and suitably shaping a parabolic wave derived from the vertical deflection wave generator.

In accordance with one feature of the invention the means by which the parabolic wave energy at vertical deflection frequency is produced includes a facility for compensating in advance for the distortion of the low frequency components of the parabolic waves which may be produced in an inductive output circuit by such means as a transformer.

Also, in accordance with another aspect of the present invention, the wave energy which is produced at horizontal and vertical deflection frequencies for energizing the convergence anode of the kinescope is employed to vary the potential impressed upon the focusing electrodes associated with the different electron guns. By this means the focusing of the different electron beams is varied in accordance with the deflection of the beams so as to maintain them substantially in focus at all points of the scanned raster.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in accordance with the accompanying drawings.

In the drawings:

Figure 1 is a block diagram of a television receiver embodying the present invention;

Figure 2 is a fragmentary schematic diagram of an illustrative form of a horizontal convergence control wave generator; and,

Figure 3 is another fragmentary schematic diagram of an illustrative embodiment of a vertical convergence control wave generator.

Reference first will be made to Figure 1 of the drawings for a description of the general form of a color television receiver in which the present invention may be embodied. The receiver includes an antenna 11 to which is coupled, in a conventional manner, a television receiver 12. It will be understood that the receiver 12 may include such conventional apparatus as one or more carrier wave amplifiers, a frequency converter and a carrier wave demodulator, or signal detector. Accordingly, by such means it will be understood that there may be derived from the receiver 12 the video and synchronizing signals. A video signal channel 13 is coupled to the receiver 12 for amplifying and deriving from the video signals the different component image color-representative signals. A synchronizing signal separator 14 also is coupled to the receiver 12 for the usual separation of the synchronizing signals from the video signals and also for the separation of the horizontal and vertical synchronizing signals from one another. The video signal channel 13 is coupled to the electron beam controlling apparatus of an image-reproducing device such as a multi-color kinescope 15.

It will be assumed that the kinescope 15 is of the general type disclosed in the Schroeder pat-

ent previously referred to. It will be understood that the kinescope alternatively may be of other types such as that shown in the Law application referred to. The kinescope has a luminescent screen 16 which consists of a substantially flat transparent plate which is mounted in back of, and somewhat spaced from, the end wall 17 of the tube. The luminescent portion of the screen, which is on the side of the transparent plate remote from the end wall 17, comprises a multiplicity of groups of phosphor elements. Each of the elements is of sub-elemental image dimensions so that each group of such elements has an elemental image dimesion. For example, one such group of phosphor elements, or dots, consists of red, green and blue light-producing dots 18, 19 and 20, respectively. The groups of phosphor dots may be arranged in any desired pattern such as clusters of circular, triangular or hexangular configurations, or even in linear strips extending from one side of the screen to the other.

The kinescope 15 also is provided with an apertured masking electrode 21 for use in conjunction with the luminescent screen 16. This masking electrode is mounted in back of, and in spaced relation to, the luminescent screen. It also is provided with apertures conforming in shape substantially to the configuration of the groups of phosphor dots. For example, in the case of substantially circular groups of phosphor dots the masking electrode apertures, such as 22, will be substantially circular. There is one aperture provided in this electrode for each group of phosphor dots on the screen 16. The apertures of the masking electrode 21 also are suitably arranged with respect to the associated groups of phosphor dots so that proper selective excitation of these areas may be effected to produce the desired component colors of the image.

The kinescope 15 also is provided with electron guns 23, 24 and 25 for exciting respectively the red, green and blue phosphor areas of the screen 16. Also, as part of the electron-optical system of the tube, there are provided with, or as parts of, the electron guns second anodes 26, 27 and 28. These anodes serve to focus the electron beams produced respectively by the guns 23, 24 and 25 into the region of the target area which includes the screen 16. It will be understood that such electron-optical apparatus is conventional in substantially any cathode ray tube.

In the present case, the kinescope 15 includes an additional electrode 29 having a substantially cylindrical form and used to effect convergence of the electron beams substantially in the plane of the masking electrode 21. Such convergence is indicated graphically in this figure. For example, in order to excite the red, green and blue light-producing phosphor dots 18, 19 and 20, respectively, the electron beams indicated at 31, 32 and 33 converge in the aperture 22 of the masking electrode 21 substantially as shown. It is seen that, as the electron beams travel beyond the masking electrode, they impinge upon the proper phosphor dots of the screen 16.

The electron beam focusing effected by the anodes 26, 27 and 28 is accomplished by impressing upon these electrodes a potential of the order of 3,000 volts of positive polarity relative to the cathodes of the respectively associated electron guns 23, 24 and 25. The convergence anode 29 functions in conjunction with the focusing anodes to produce a field by which to effect the desired convergence of the electron beams. This field is produced by impressing upon the convergence anode 29 a potential of the order of 6,000 volts of positive polarity relative to that of the focusing anodes.

These potentials are impressed upon the electrodes of the kinescope 15 in a conventional manner from a suitable power supply which is indicated diagrammatically herein as a battery 34. A voltage divider 35 is provided for the derivation of the different potentials to be impressed upon the electrode system of the kinescope. The negative terminal of the power supply is grounded as shown and it is assumed that the cathodes of the electron guns 23, 24 and 25 are operated substantially at ground potential. Accordingly, it is seen that the focusing electrodes 26, 27 and 28 are connected to a relatively low positive voltage point 36 on the voltage divider through a circuit to be described presently. In a similar manner, the convergence anode 29 is connected to a more positive point 37 on the voltage divider by a circuit which includes a relatively high impedance resistor 38.

The kinescope 15 also is provided with a deflecting system which, in the present case, is represented as an electromagnetic yoke 39. The deflection yoke is mounted in the usual manner around the outside of the neck portion of the kinescope in a region adjacent to the conical section thereof. It also is energized in a conventional manner which will be referred to presently.

The synchronizing signal separator 14 is coupled to horizontal and vertical deflection wave generators 41 and 42, respectively. These generators may be entirely conventional. Accordingly, it will be understood that the horizontal deflection wave generator 41 produces in its output circuit, a substantially sawtooth wave, such as 43 at line scanning frequency. Similarly, the vertical deflection generator 42 produces in its output circuit a substantially sawtooth wave 44 at field scanning frequency. The deflection generators 41 and 42 are coupled to the yoke 39 as indicated for impression thereon the horizontal and vertical beam-deflecting waves 43 and 44.

The image-reproducting system, in accordance with the present invention, also includes horizontal and vertical convergence control wave generators 45 and 46 respectively. Details of illustrative embodiments of these generators will be described more fully hereinafter. The input circuits of the convergence control wave generators 45 and 46 are coupled to predetermined ones of the internal circuits of the horizontal and vertical deflection wave generators 41 and 42 respectively. In this way, there are impressed upon the input circuits of the horizontal and vertical convergence control wave generators 45 and 46, parabolic waves 47 and 48, respectively, at line and field scanning frequencies. The horizontal generator 45 functions to convert the wave 47 into a substantially sinusoidal wave 49. The vertical generator 46 amplifies and suitably shapes the parabolic wave 48 to produce an output parabolic wave 51.

The output circuits of the horizontal and vertical convergence control wave generators 45 and 46 are coupled effectively in series as indicated. The combined control waves produced in this manner are impressed by means of a coupling capacitor 52 upon the convergence anode 29. A by-pass capacitor 53 is connected from the junction point between the horizontal and vertical generators 45 and 46 to ground. This capacitor

has a low impedance for the horizontal waves and a high impedance for the vertical waves.

It is seen that the energization of the convergence electrode 29 in the manner described impresses upon this electrode a constant positive potential upon which is superimposed a varying potential comprising the combination of the sinusoidal and parabolic waves 49 and 51, respectively, at horizontal and vertical beam deflection frequencies. A field, to which the electron beams are subjected, is thereby produced which varies in such a manner that convergence of the three beams 31, 32 and 33 occurs substantially in the plane of the masking electrode 21 at all points in a raster scanned in this plane by deflecting the beams.

It has been found, as explained in detail in the copending application of Kelly and Flood referred to, that a sinusoidal energization of the convergence electrode 29 at the horizontal scanning frequency is a sufficiently close approximation of the theoretically ideal parabolic energization of this electrode to produce the desired results. In effecting the sinusoidal energization of this electrode, advantage is taken of the fact that an appreciable portion (about 18 per cent) of the horizontal scanning period is utilized for blanking time during which beam retrace occurs. Accordingly, substantial economies may be effected by not having to provide apparatus for producing parabolic waves at the line scanning frequency.

Also, in accordance with another feature of this invention, the individual electron beam-focusing electrodes 26, 27 and 28 have impressed thereon potentials varying at the horizontal and vertical scanning frequencies. These varying potentials are in addition to the constant potential derived from the voltage divider 35. The apparatus for effecting this dynamic control of the electrodes includes horizontal and vertical combining transformers 54 and 55. The primary winding 56 of the horizontal transformer 54 is coupled to a point in the output circuit of the horizontal convergence control generator 45. Similarly, the primary winding 57 of the vertical winding 55 is connected to a point in the output circuit of the vertical convergence control wave generator 46. Illustrative connections of the character described will be referred to presently. The secondary winding 58 of the horizontal transformer 54 and the secondary winding 59 of the primary transformer 55 are connected effectively in series between the voltage divider point 36 and the focusing anodes 26, 27 and 28. A capacitor 61 is shunted across the secondary winding 59 of the vertical transformer. By this means, the effective impedance of the winding 59 at the horizontal scanning frequency is reduced. Thus, there is obviated the effect of a voltage divider with the distributed shunt capacitance of the focus electrodes 26, 27 and 28.

A substantially sinusoidal wave, similar to the wave 49, is developed in the secondary circuit of the horizontal combining transformer 54. Similarly, a substantially parabolic wave similar to the wave 51 is developed in the secondary winding 59 of the vertical combining transformer 55. By means of the described interconnection of the secondary circuits of the combining transformers 54 and 55, the sinusoidal variation of the focusing anode voltage is effected at line scanning frequency. At the same time, the potential of the focusing anodes also is varied parabolically at the field scanning frequency. By such means, the individual electron beams such as indicated at 31, 32 and 33 are maintained substantially in focus at all points of the luminescent screen 16.

Since focusing of an electron beam is related to the distance traveled by the beam from the region of the focusing field to the focal plane, it is seen that these distances vary widely in a tube of the character described, where relatively wide angles of deflection are employed and the target electrode is substantially planar in form. Accordingly, it is seen that a suitable variation of the strength of the focusing field in accordance with the distances to be traveled by the electron beams as they are deflected to scan a raster serves to maintain these beams substantially in focus at all points of the target electrode plane. Also, the effectiveness of the focusing lenses depends to some extent upon the potential difference between the focus anodes 26, 27 and 28 and the convergence anode 29. It is desirable, therefore, to maintain this potential difference substantially constant.

Referring now to Figure 2 of the drawings, there is disclosed an illustrative embodiment of a horizontal convergence control wave generator in accordance with the present invention. The input circuit of the generator 45 is derived as explained from a conventional horizontal deflection wave generator 41. The input energy also is parabolic in wave form and is conveniently derived from the cathode circuit of the output tube of a conventional horizontal deflection wave generator. It is customary to provide in a cathode circuit in apparatus of this character, a network which has the capability of integrating the current traversing it of a sawtooth form so as to produce a voltage having a substantially parabolic form. Such a network usually consists of a partially by-passed cathode-connected resistor.

Such a circuit is coupled by means of a capacitor 62 and a resistor 63 to the control grid of an electron tube 64. In the present case this tube is shown as a pentode such as an RCA type 5763. The screen grid of this tube has a positive potential impressed thereon and the suppressor grid is connected to ground in a conventional manner. A resistor 65, which is by-passed for alternating currents by a capacitor 66 connects the cathode of the tube to ground. The anode of the tube 64 is connected to a source of space current indicated at +B through an inductive device such as a coil 67.

The anode of the tube also is coupled by a capacitor 68 to the primary winding 69 of an output transformer 70. The transformer also is provided with a secondary winding 71 which is connected to the convergence anode 29 and also to the vertical convergence control wave generator 46 in the manner previously described. The terminals of the primary winding 69 also are coupled to the primary winding of the horizontal combining transformer 54 as previously described.

The coil 67, in conjunction with the capacitor 68 and the primary transformer winding 69, comprises a circuit which is parallel tuned for resonance at the horizontal beam deflection frequency. The coil also may be used to phase the voltage developed in the secondary winding 71. This parallel tuned circuit is excited by the energy of parabolic wave form derived from the tube 64. By reason of the described way in which this circuit is tuned, it is seen that it produces a substantially sinusoidal wave at the horizontal deflection frequency.

An illustrative form of a vertical convergence control wave generator 46 is shown in Figure 3

to which reference now will be made. There is impressed upon the input circuit of this generator, a parabolic wave at field scanning frequency which may be conveniently derived from the cathode circuit of the ouput tube of a conventional vertical deflection wave generator. As in the case of the horizontal deflection wave generator previously described, the output tube of the vertical generator usually includes an integrating network which functions to produce a parabolic wave from a substantially sawtooth current wave.

Such a parabolic wave is impressed upon an input resistor 72, a selectable point of which is coupled by a capacitor 73 and a resistor 74 to the control grid of an electron tube 75. As illustrated, this tube is a triode. It will be understood, however, that it may comprise one-half of a dual triode, such as an RCA 12AU7. Space current for the tube is derived from a suitable power supply indicated at +B which is connected to the anode of the tube through a resistor 76. The cathode of the tube also is connected to ground through an unby-passed resistor 77.

The output circuit of the tube includes a series arrangement of a resistor 78 and a capacitor 79 forming an integrating circuit. This circuit is part of the apparatus provided for shaping the vertical parabolic wave for use in energizing the convergence anode 29 in the desired manner. The functioning of this circuit will be referred to in a more detailed manner presently.

The anode of the tube 75 is coupled by a capacitor 81 and a resistor 82 to the control grid of another electron tube 83. This tube also is shown as a triode and may, for example, be the other half of the dual triode which includes the tube 75. Space current for this tube is provided by a circuit which includes a resistor 84 connected to the anode of the tube. The cathode of the tube is connected to ground by a resistor 85 which is by-passed for alternating currents by a capacitor 86.

The anode of the tube 83 is coupled by a resistor 87 to the cathode of the tube 75. By this means, there is provided a de-generative feed-back which improves the fidelity of the generator 46 to produce a wave having the desired shape.

The anode of the tube 83 also is coupled by a capacitor 88 to the primary winding 89 of an output transformer 90. This transformer also is provided with a secondary winding 91. It will be noted that the primary and secondary windings 89 and 91 of the output transformer are connected in the manner of an autotransformer. The output terminal of the secondary winding 91 is connected to the horizontal convergence control wave generator 45 in the manner described previously. Also, the terminals of the primary winding 89 are connected to the vertical combining transformer 55 as previously described. By means of these connections, a substantially parabolic wave at the vertical scanning frequency is impressed upon the convergence anode 29 and also upon the focusing electrodes 26, 27 and 28 of the kinescope 15 of Figure 1.

The electron tubes 75 and 83 and their associated circuits function primarily as an amplifier for the parabolic wave derived from the vertical deflection generator 42. The apparatus of the generator 46 also produces some beneficial shaping of the vertical parabolic wave. Inasmuch as the fundamental frequency of this wave is of the order of 60 cycles per second, it is seen that the operation of the output transformer 90 will effect some undesired differentiation of the parabolic wave unless it is especially wound to prevent it. Such a transformer would be a comparatively expensive component. Accordingly, a relatively inexpensive transformer is used and the circuits of the generator are designed to compensate for the differentiation. This is accomplished essentially by the operation of the integrating circuit including the resistor 78 and the capacitor 79. It also has been found that the wave shaping operation of the device may be improved to some extent by providing a comparatively small amount of degenerative feed-back from the output of the tube 83 to the cathode of the tube 75. As described, the circuit including the resistor 87 performs this function.

It, thus, may be seen from the foregoing disclosure of an illustrative embodiment of the invention that there is provided an improved electron beam control system by which a plurality of electron beam components may be dynamically controlled to maintain a substantial uniformity of operation at all points in the plane of a target electrode. This invention enables the simplification of the apparatus required to develop the necessary convergence control waves for use with a convergence anode of a multibeam kinescope. This apparatus is of such a character that over-all deformation of the control waves is effectively obviated.

Also, it is seen that this invention provides an improved system for effecting dynamic control, not only of the convergence of a plurality of electron beam components, but also of the focusing of the individual beam components. In this way, it is practical to deflect the electron beam components through greater angles than heretofore in order to scan rasters in the plane of a target electrode, which may be flatter and of greater area than heretofore, without substantial defocusing of the beam components.

The nature of the invention may be ascertained from the foregoing disclosure of an illustrative embodiment thereof. The scope of the invention may be determined from the following claims.

What is claimed is:

1. In a cathode ray tube image-reproducing system wherein a plurality of electron beams, which traverse paths before deflection that are spaced respectively about a longitudinal axis of the tube, are angularly deflected both horizontally and vertically to scan a raster in a predetermined plane, a dynamic beam-controlling system comprising, individual field-producing means disposed respectively adjacent to the paths of said electron beams and energizable to control the focusing of said individual beams, and means for energizing all of said field-producing means as functions of said vertical and horizontal beam deflections, at least one of said functions being substantially sinusoidal.

2. In a cathode ray tube image-reproducing system wherein a plurality of electron beams, which traverse paths before deflection that are spaced respectively about a longitudinal axis of the tube, are angularly deflected both horizontally and vertically to scan a raster at a target electrode, a dynamic beam-controlling system comprising, field-producing means disposed adjacent to the paths of said electron beams and energizable to control the focusing of said individual beams, field-producing means disposed adjacent to the paths of said electron beams and energizable to control the convergence of said

beams at all points in said raster, and means varying as a substantially sinusoidal function of said horizontal beam deflection for energizing all of said field-producing means.

3. In a cathode ray tube image-reproducing system wherein a plurality of electron beams, which traverse paths before deflection that are spaced respectively about a longitudinal axis of the tube, are angularly deflected both horizontally and vertically to scan a raster at a target electrode, a dynamic beam-controlling system comprising, field-producing means disposed respectively adjacent to the paths of said electron beams and energizable to control the focusing of said individual beams, field-producing means disposed adjacent to the paths of said electron beams and energizable to control the convergence of said beams at all points in said raster, means varying as a substantially parabolic function of one of said beam deflections for energizing all of said field-producing means, and means varying as a substantially sinusoidal function of the other of said beam deflections for additionally energizing all of said field-producing means.

4. In a cathode ray tube image-reproducing system wherein a plurality of electron beams, which traverse paths before deflection that are spaced respectively about a longitudinal axis of the tube, are angularly deflected both horizontally and vertically to scan a raster at a target electrode, a dynamic beam-controlling system comprising, field-producing means disposed respectively adjacent to the paths of said electron beams and energizable to control the focusing of said individual beams, field-producing means disposed adjacent to the paths of said electron beams and energizable to control the convergence of said beams at all points in said raster, means varying as a substantially parabolic function of said vertical beam deflection for energizing all of said field-producing means, and means varying as a substantially sinusoidal function of said horizontal beam deflection for additionally energizing all of said field-producing means.

5. In a cathode ray tube image-reproducing system wherein a plurality of electron beams which traverse paths before deflection that are spaced respectively about a longitudinal axis of the tube, are angularly deflected both horizontally and vertically to scan a raster in a predetermined plane, a dynamic beam-controlling system comprising, a focusing anode for each of said electron beams, a convergence anode disposed adjacent to the predeflection paths of all of said electron beams, a vertical control wave generator

including an output transformer having primary and secondary windings in which to develop a parabolic control wave at vertical deflection frequency, a horizontal control wave generator including an output transformer having primary and secondary windings in which to develop a sinusoidal wave at horizontal deflection frequency, means coupling said secondary windings to said convergence anode, and means coupling said primary windings to said focusing anodes.

6. A dynamic electron beam-controlling system as defined in claim 5 wherein, said means coupled to said focusing anodes includes horizontal and vertical frequency combining transformers, each having primary and secondary windings, the primary windings of said combining transformers being connected to the respective primary windings of the output transformers of said horizontal and vertical wave generators, and the secondary windings of said combining transformers being connected in series with one another between said focusing anodes and a source of substantially constant potential.

7. In a system for controlling the operation of a cathode ray image-reproducing tube, an electrical wave generator comprising, first and second electron tubes each having input and output circuits, an inductive output device for said generator coupled to said second tube output circuit, means impressing upon the input circuit of said first tube a wave having a substantially parabolic form and a predetermined frequency, means coupled to the output circuit of said first tube and serving to pre-emphasize the low frequency of said parabolic wave, whereby to compensate for de-emphasis of said components by said inductive output device, means coupling said first tube output circuit to said second tube input circuit, and means degeneratively coupling said second tube output circuit and said first tube input circuit.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,093,395	Ballard	Sept. 14, 1937
2,147,559	Schlesinger	Feb. 14, 1939
2,224,005	Vance	Dec. 3, 1940
2,300,452	Lewis	Nov. 3, 1942
2,449,524	Witherby et al.	Sept. 14, 1948
2,481,839	Goldsmith	Sept. 13, 1949

FOREIGN PATENTS

Number	Country	Date
866,065	France	Mar. 31, 1941