Sept. 8, 1959 J. C. SCHOPP 2,903,622

MULTI-BEAM CONVERGENCE SYSTEM

Filed April 24, 1957 2 Sheets-Sheet 1

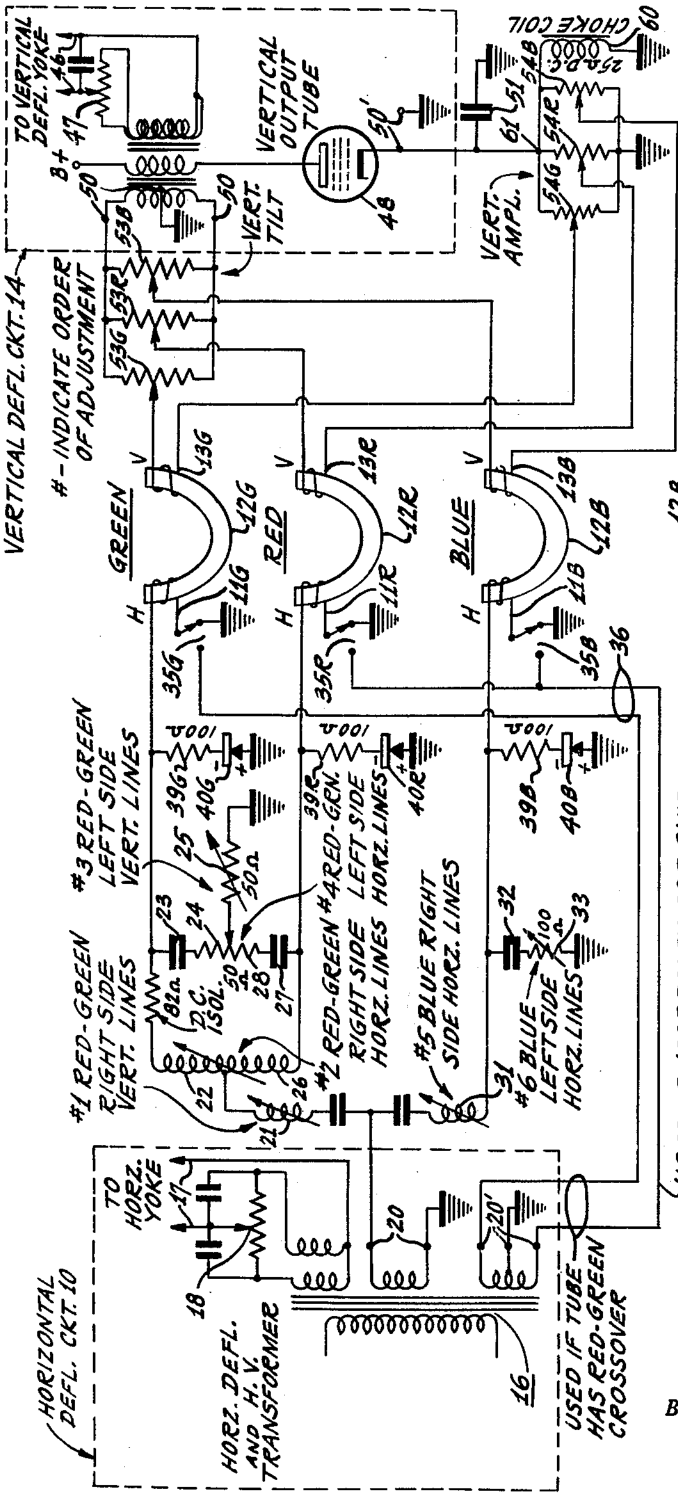

Fig. 1.

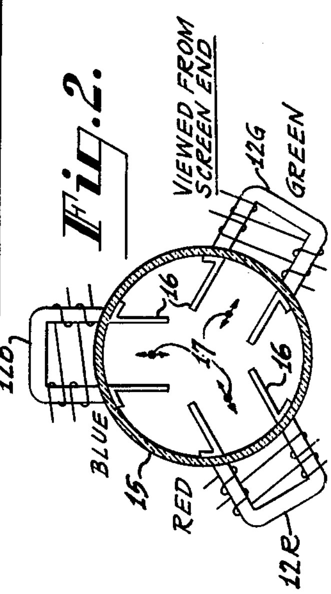

Fig. 2.

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Fig. 3.

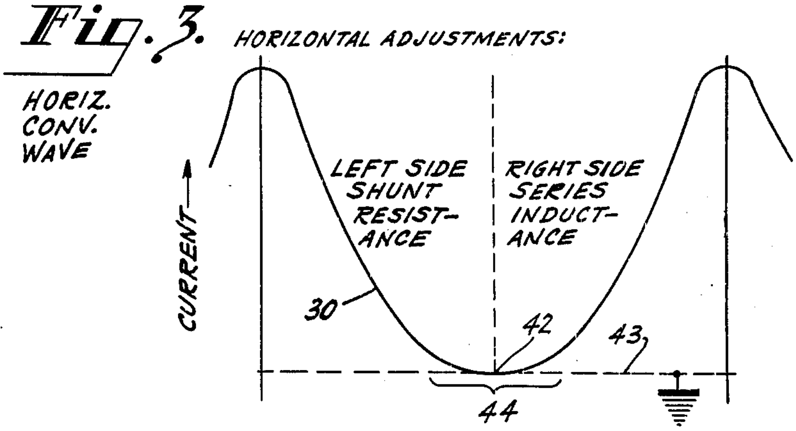
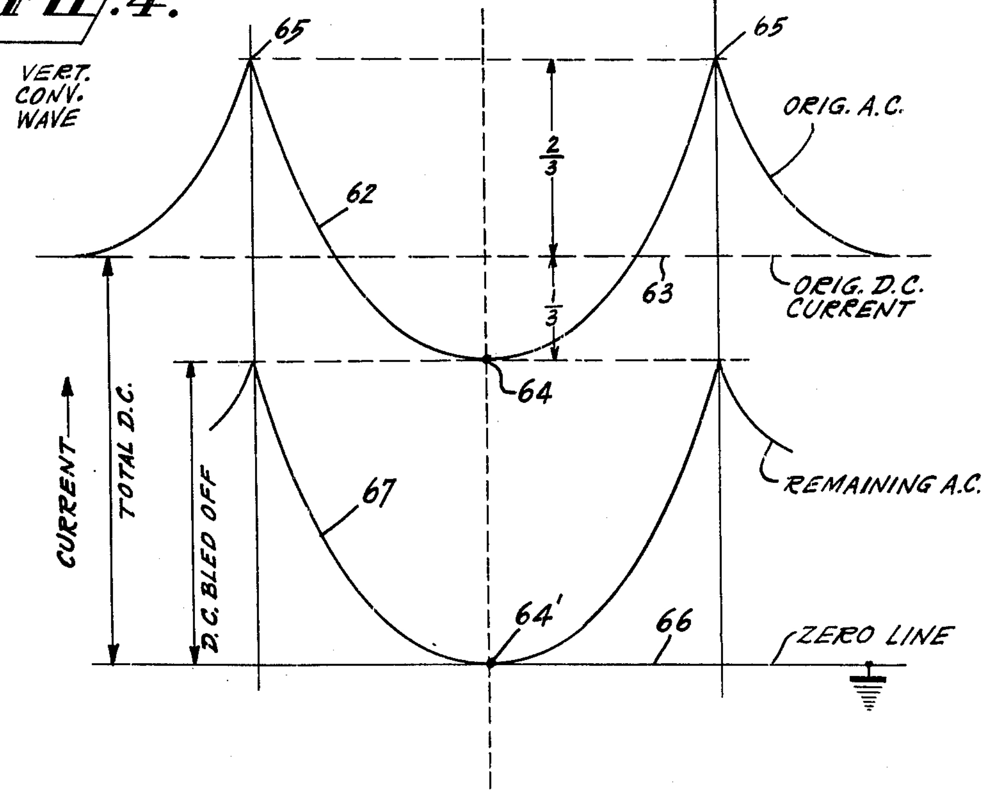


Fig. 4.



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MULTI-BEAM CONVERGENCE SYSTEM

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4 Claims. (Cl. 315—27)

This invention relates to color television receivers, and more particularly to means for making the three electron beams of a color kinescope converge at all scanned points on the kinescope screen.

Color kinescopes of the shadow mask type normally include three electron guns positioned in the neck of the kinescope. Means are provided for making the three electron beams converge and pass through the same aperture at the center of the shadow mask plate. The three beams after passing through the shadow mask strike three phosphor dots each emitting light of a different color. All three beams are deflected by a common horizontal and vertical deflection system so that the beams systematically scan the kinescope target. The more the three beams are deflected from the center of the target, the greater is the separation or misconvergence of the beams when they reach the shadow mask. It is therefore customary to provide a dynamic focusing system for correcting the misconvergence as a funtion of the amount of deflection of the beams from the center of the kinescope target. For this purpose, current waveforms of generally parabolic shape are derived from the horizontal and vertical deflection circuits and are employed, in conjunction with three convergence electromagnets, to dynamically converge the three beams so that they pass through the same aperture in the shadow mask over the entire scanned area of the kinescope target.

Dynamic convergence circuits require careful adjustment in order to provide dynamic convergence waveforms having the proper amplitude and wave shape to achieve convergence at all scanned points on the kinescope target. In prior art arrangements, an adjustment made to achieve convergence at one part of the kinescope target has affected or disturbed the previously existing degree of convergence at another part of the kinescope target. The interaction between the convergence controls has made the adjustment difficult and laborious.

It is therefore a general object of this invention to provide an improved convergence system wherein the adjustment of convergence at one portion of the kinescope target does not adversely effect the previously made adjustment of convergence at another portion of the kinescope target.

It is a more specific object of this invention to provide an improved dynamic convergence system wherein adjustments made to achieve convergence at the edges of the kinescope target does not disturb the previously established convergence at the center of the target.

It is another object to provide improved means for generating generally parabolic current waveforms especially suited for convergence purposes.

It is a further object to provide an improved convergence system which is relatively stable over long periods of time.

One system in accordance with the teachings of the invention includes three electromagnets positioned with respect to the three beams in the kinescope to provide

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radial deflection of the respective beams. Voltage pulses from the horizontal deflection circuit are applied through three series circuits each of which includes a variable inductor, a capacitor and a variable resistor. A horizontal convergence coil of each of the convergence magnets is connected across the capacitor and resistor of the corresponding series circuit. By this arrangement, generally parabolic currents are made to flow in the convergence magnet coils. The parabolic currents have a minimum amplitude at the center portion of each horizontal scan, that is, at the points along the vertical line passing through the center of the kinescope target or screen. The parabolic current waves have maximum amplitude during the blanking or retrace intervals. A resistor and a rectifier are connected in series from each convergence coil to a point of reference potential. The value of the resistor and the polarity of the rectifier are selected so that the center of the generally parabolic waveform is clamped to a reference or zero value, and the generally parabolic waveform has a modified waveship which results in the desired convergence at all points on the screen.

A second vertical convergence coil on each of the convergence magnets is connected at one end to a tap on a balancing or differential potentiometer connected across opposite polarity voltage pulse terminals of the vertical deflection circuit, and is connected at the other end to a tap on a potentiometer connected across single ended generally sawtooth voltage output terminals of the vertical deflection circuit. The voltage pulses applied to one end of each vertical convergence coil are integrated by the convergence electromagnet to provide a sawtooth or tilt current in the coil. The sawtooth voltage wave applied to the other end of each vertical convergence coil is integrated by the convergence electromagnet to provide a generally parabolic current in the coil. The currents flowing from the single ended terminals include a direct current component. A choke coil having a predetermined direct current resistance value is connected from one of the single output terminals to a point of reference potential to bleed off an amount of direct current such that the parabolic current waves in the convergence coils have the direct current and alternating current components so related that the currents through the convergence coils always have the same magnitudes irrespective of the particular shapes and peak-to-peak amplitudes of the waves.

These and other objects and aspects of the invention will be apparent to those skilled in the art from the following more detailed description taken in conjunction with the appended drawings wherein:

Figure 1 is a circuit diagram of a convergence system constructed according to the teachings of this invention;

Figure 2 is a transverse sectional view of the neck of a color kinescope showing the convergence magnets for converging the three electron beams in the tube;

Figure 3 is a horizontal convergence current waveform which will be referred to in describing the operation of the invention; and

Figure 4 is a vertical convergence current waveform which will be referred to in describing the operation of the invention.

Referring now in greater detail to the drawings, Figure 1 shows a circuit diagram of a convergence system wherein horizontal deflection voltages are obtained from a horizontal deflection circuit **10**, are translated into parabolic current waveforms in energizing coils **11G**, **11R** and **11B** of convergence magnets **12G**, **12R** and **12B**, and wherein pulse and sawtooth voltage waves derived from a vertical deflection circuit **14** are translated to parabolic current waveforms in coils **13G**, **13R** and

13B on the convergence magnets 12. The convergence magnets 12 may be positioned with respect to the neck 15 of the color kinescope as shown in Figure 2. The convergence magnets 12 cooperate with internal pole pieces 16 to provide magnetic fields operative to deflect the electron beams 17 in radial directions.

The convergence system of Figure 1 is useful in color television receivers such as the receiver shown in block diagram form in Figure 1 in the article "Color Television Receiver Design—A Review of Current Practice" appearing at page 297 in the March 1956 issue of the Proceedings of the IRE. The block diagram in the publication includes blocks labeled horizontal deflection, vertical deflection, and convergence and centering circuits, which correspond in function with the circuit diagram constituting Figure 1 of this application.

Referring to Figure 1, the horizontal deflection circuit 10 includes horizontal and high voltage transformer 16 having output leads 17 for connection to the horizontal deflection yoke associated with the kinescope. Potentiometer 18 provides horizontal centering control. The transformer 16 also includes output terminals 20 and 20′ for convergence purposes. The terminals 20 provide a voltage pulse wave, with respect to ground, having the horizontal scanning frequency or repetition rate of about 15,750 cycles per second. The output terminals 20′ provide two opposite polarity voltage pulse waves with respect to ground.

Three horizontal convergence circuits are connected from output terminals 20 to respective ones of the convergence energizing coils 11G, 11R and 11B of the green, red and blue convergence magnets 12G, 12R and 12B. Each convergence circuit includes a variable inductor, a capacitor, and a variable resistor all connected in series, and a connection of the corresponding energizing coil in shunt with or across the capacitor and variable resistor. The green convergence circuit includes series inductors 21 and 22, capacitor 23, and resistors 24 and 25. The red convergence circuit includes inductors 21 and 26, capacitor 27 and resistors 28 and 25. The inductors and resistors in the green and red convergence circuits are arranged in a balanced or differential manner to facilitate a convergence adjusting procedure whereby the green and red beams are simultaneously deflected towards each other to determine a convergence point to which the blue beam is subsequently deflected. The blue convergence circuit also connected to output terminals 20 includes inductor 31, a capacitor 32 and a resistor 33. Generally speaking, the variable inductors control the amplitude of the current waveform (30 in Figure 3) flowing in the convergence coils 11, and the variable resistors control the phase or tilt or waveshape of the current waveforms in convergence coils 11.

The three horizontal convergence circuits include switches 35 for selectively connecting one side of the respective convergence coils 11 to ground, or through leads 36 to output terminals 20′ in the horizontal deflection circuit 10. The switches 35G and 35R permit the coils 11G and 11R to be connected to opposite polarity deflection voltage waves at terminals 20′. This is done if the kinescope being used is characterized in tending to reproduce a horizontal line on the screen of the kinescope as green and red lines having opposite tilts so that they cross at the center of the screen. The switch 35B can be used to connect one side of the convergence coil 11B to terminals 20′ providing an opposite polarity voltage pulse wave from that supplied at terminals 20. This is done if the color kinescope is characterized in representing the blue portion of a horizontal line with a tilt which cannot be corrected by adjustment of variable resistor 33.

In each horizontal convergence circuit, a clamping circuit including a resistor 39 and a rectifier 40 is connected in shunt with the corresponding horizontal convergence coil 11. Since the bottom sides of coils 11 are connected by switches 35 directly to ground or through leads 36 and terminals 20′ to ground, each clamping circuit including the resistor 39 and rectifier 40 is connected from the corresponding coil 11 to a point of reference potential. By this means the parabolic current wave 30 in Figure 3 is clamped so that the center portion, or minimum current point, 42 of the parabolic current wave is held at a reference or zero value 43. The value of the resistors 39 is selected to avoid a clipping action by the rectifiers 40, but rather to clamp the middle portion 42 at a reference value, and also to improve the shape of the wave 30 by somewhat flattening the curvature in the region 44. The rectifiers 40 may be selenium rectifiers or any other suitable type of rectifier such as a crystal diode or a vacuum tube diode. Selenium rectifiers or diodes are preferred because of cost consideration, and because of their current carrying ability.

The action of the resistor 39 and rectifier 40 in each horizontal convergence circuit in clamping the center of the corresponding convergence current waveform to zero greatly simplifies the convergence adjustment procedure. As illustrated in Figure 3, convergence at the right side of the screen is controlled by adjusting the series inductors 21, 22, 26 and 31. Convergence at the left side of the screen is controlled by adjusting the shunt resistors 24, 25, 28 and 33. An adjustment of convergence at one side of the screen does not disturb the convergence at the other side of the screen. This is in marked contrast with prior art arrangements wherein both adjustments affect the convergence at both sides of the screen.

A procedure for adjusting horizontal convergence will now be described. A signal generator is connected to the color television receiver to provide spaced horizontal and vertical lines on the face of the kinescope. Static convergence means, such as adjustable permanent magnets, are moved until all three beams converge at the center of the kinescope screen. It will then normally be found that the three beams are increasingly misconverged in accordance with distance from the center of the screen. The controls are then adjusted in the following order:

(1) The inductor 21 is adjusted until the red and green vertical test pattern lines at the right edge of the screen coincide. This will result in also bringing closer together the vertical test pattern lines on the left side of the screen.

(2) The balancing or differential inductor 22, 26 is adjusted to bring red and green horizontal test pattern lines on the right side of the screen into coincidence.

(3) The variable resistor 25 is adjusted to bring the red and green vertical test pattern lines on the left side of the screen into coincidence.

(4) The balancing or differential resistor 24, 28 is adjusted to bring the red and green horizontal test pattern lines on the left side of the screen into coincidence.

(5) The variable inductor 31 is adjusted to bring the blue horizontal test pattern lines on the right side of the screen into coincidence with the converged red-green line.

(6) The variable resistor 33 is adjusted to bring the blue horizontal test pattern lines on the left side of the screen into coincidence with the red-green line.

(7) If convergence is then not perfect, the procedure can be repeated once again in the same order.

The convergence adjusting procedure is relatively simple and straight-forward compared with the procedure necessary with prior art convergence systems. Each adjustment operates relatively independently of the other adjustments. None of the adjustments effect the convergence previously established by static means at the center of the screen. These highly advantageous results are achieved because of the arrangement according to this invention including the clamping means 39, 40 in each of the three convergence circuits. The clamping means 39, 40 holds the trough or minimum amplitude portion 42 of each convergence waveform 30 at a fixed reference potential. This portion of the convergence waveform 30 corresponds in time with the center on the kinescope screen of each horizontal scan.

It is also necessary to correct the misconvergence which comes about because of the vertical scanning of the three electron beams. The vertical scanning, according to broadcast television standards in the United States, is at the rate of about 60 cycles per second. Vertical scanning is performed by a vertical deflection circuit 14 having output leads 46 for a connection to a vertical deflection yoke on the kinescope. The vertical centering is accomplished by a potentiometer 47. A vertical deflection circuit 14 includes a vertical output tube 48 having output terminals 50 for convergence purposes and providing out-of-phase or opposite polarity voltage pulse waves with respect to ground. The vertical output tube 48 also has output terminals 50′ for convergence purposes and providing a sawtooth voltage wave at the vertical frequency. Three potentiometers 53 are connected across the opposite polarity output terminals 50 of the vertical deflection circuit 14. The taps on the potentiometers 53 are connected to one side of respective vertical convergence coils 13 on the convergence magnets 12. Three potentiometers 54 are effectively connected across the output terminals 50′ of the vertical deflection circuit 14. Taps on the potentiometers 54 are connected to the other side of respective ones of the vertical convergence coils 13. Thus, one end of each vertical convergence coil 13G, 13R and 13B is connected to a voltage pulse wave from terminals 50, which results in a sawtooth current through the convergence coil. The other end of each vertical convergence coil is connected to a sawtooth voltage wave at terminals 50′, which results in a generally parabolic current wave through the convergence coil. Capacitor 51 is provided to by-pass undesired horizontal scanning frequency signals.

A choke coil 60 is also connected across the output terminals 50′ of the vertical deflection circuit 14. The choke coil 60 is selected to have a high impedance to alternating current signals, and to have a direct current resistance of a predetermined value. Of course, the value of resistance presented may be entirely included in the choke coil, or may be partially provided by a separate resistive element. The value of direct current resistance is selected so that the direct current from vertical tube 48 divides through the resistors 54 and the choke coil 60 in the proportion of substantially ⅔ through the choke coil and ⅓ through the resistors 54 in the particular embodiment of the invention illustrated, although other proportions may be employed in other embodiments without departing from the invention. The current flowing through the convergence coils 13 to ground may be as represented by the parabolic waveform 62 in Figure 4. The direct current component of this waveform is represented by the line 63, which is ⅓ of the distance above the trough 64 of the distance between the trough 64 and the crests 65. This proportion applies to parabolic waveforms used for convergence purposes. The areas of the waveform 62 above and below the direct current component line 63 are equal. The direct current component is represented by the distance between the line 63 and the zero current line 66. The direct current resistance of the choke coil 60 is selected so that approximately ⅔ of the direct current flows through the choke coil 60 and the balance flows through resistors 54. The waveform 67 then represents the current through the convergence coils 13. It can be seen that the troughs or minimum current points 64′ of the waveform 67 coincide with zero current through the resistors 54. Therefore, zero current exists in resistors 54 at the middle of vertical scan.

In the adjustment of the vertical convergence circuits, the taps on the potentiometers 53 control the polarity and the magnitude of the waveform applied to the vertical convergence coils 13. This controls the tilts or skew of the upper portion of a vertical test pattern line relative to the bottom portion of the line as it appears on the screen of the kinescope. The taps on the potentiometers 54 control the amplitudes of the parabolas of the convergence current waveforms applied to the other ends of the vertical convergence coils 13. Adjustment of the vertical tilt potentiometers 53 and the vertical amplitude potentiometers 54 does not effect the convergence initially established by static means for the center of the kinescope. The vertical convergence adjustments are therefore very straight-forward and simple compared with prior art arrangements wherein the controls or adjustments affected each other. This extremely desirable result is accomplished according to this invention by employing the choke coil 60 having a direct current resistance of such value as to bleed off that proportion of the direct current at point 61 which brings the minimum current point of the parabolic waveform to zero or reference value. The parabolic vertical convergence waveform has the direct current and alternating current components so related that the point corresponding with the center of the kinescope screen is maintained at zero or a fixed reference value irrespective of the particular shape and peak-to-peak amplitude of the waveform. The system including the choke coil 60 also serves to maintain the vertical convergence at its adjusted condition over long periods of time. This is because most of the direct current, which may drift with tube aging, is bled off.

In both the horizontal convergence circuits and the vertical convergence circuits, the electromagnetic characteristics of the convergence magnets with their associated coils contributes in the process of translating the waveforms derived respectively from the horizontal and vertical deflection circuits to the desired substantially parabolic form.

It is apparent that according to this invention there is provided a convergence system for use in color television receivers which greatly facilitates the obtaining and maintaining of perfect convergence at all points on the kinescope screen, and that this is accomplished by means for maintaining the central portion of each convergence waveform to a fixed or a reference value irrespective of the particular shapes and peak-to-peak amplitudes of the convergence waves employed.

What is claimed is:

1. In a color television receiver including a three-gun color kinescope provided with a deflection circuit, a convergence system comprising, three beam convergence electromagnets having energizing coils, convergence waveform generating circuits coupled from said deflection circuit to the coils of said electromagnets to provide currents in said coils having direct current and alternating current components and generally parabolic waveshapes with crests occurring during the blanking intervals and troughs occurring at the middle of scan, and inductive and resistive means connected in circuit with said convergence waveform generating circuits, said means being proportioned to so relate the direct current and alternating current components of the parabolic current waves that, at the troughs of said waves, the currents through the coils of said electromagnets always have the same magnitudes irrespective of the particular shapes and peak-to-peak amplitudes of said waves whereby said convergence waveform generating circuits can be adjusted to provide dynamic convergence at the edges of the kinescope screen without changing the convergence at the center of the screen.

2. In a color television receiver including a three-gun color kinescope provided with a vertical deflection circuit, a convergence system comprising, three beam convergence electromagnets having energizing coils, conver-

gence waveform generating circuits coupled from said vertical deflection circuit to the coils of said electromagnets to provide currents in said coils having direct current and alternating current components and generally parabolic waveshapes with crests occurring during the blanking intervals and troughs occurring at the middle of scan, and inductive and resistive means connected in circuit with said convergence waveform generating circuits, said means being proportioned to so relate the direct current and alternating current components of the parabolic convergence waves that, at the troughs of said waves, the currents through the coils of said electromagnets always have the same magnitudes irrespective of the particular shapes and peak-to-peak amplitudes of said waves whereby said convergence waveform generating circuits can be adjusted to provide dynamic convergence at the edges of the kinescope screen without changing the convergence at the center of the screen.

3. In a color television receiver, a three-gun color kinescope, a horizontal deflection circuit having terminals providing voltage pulses at horizontal scanning frequency, three series circuits each including inductive, capacitive and resistive elements connected across said vertical terminals, green, red and blue beam convergence magnets each having horizontal energizing coils connected across the capacitive and resistive elements of respective ones of said series circuits, whereby generally parabolic waveform currents flow in said convergence coils and have a central portion of minimum amplitude at the middle of horizontal scan, clamping circuits each including a rectifier and resistor connected in series from respective ones of said convergence coils to a point of reference potential, a vertical deflection circuit having a first pair of terminals providing opposite polarity voltage pulses at the vertical scanning frequency, and a second pair of terminals including a reference potential terminal providing a given polarity sawtooth voltage wave at the vertical scanning frequency, vertical energizing coils on each of said convergence magnets, resistor means connecting one side of each of said vertical energizing coils to said first pair of terminals and connecting the other side of each of said vertical energizing coils to said second pair of terminals, whereby generally parabolic currents flow in said vertical energizing coils and have a central portion of minimum amplitude at the middle of vertical scan, and a choke coil connected across said second pair of terminals, said choke coil having a high impedance to vertical scanning frequencies and having a direct current resistance of such value that the central portions of the parabolic current waves in said vertical energizing coils have the same magnitudes irrespective of the particular shapes and peak-to-peak amplitudes of said waves.

4. In a color television receiver, a three-gun color kinescope, a vertical deflection circuit having a first pair of terminals providing opposite polarity voltage pulses at the vertical scanning frequency, and a second pair of terminals including a reference potential terminal providing a given polarity sawtooth voltage wave at the vertical scanning frequency, vertical energizing coils on each of said convergence magnets, resistor means connecting one side of each of said vertical energizing coils to said first pair of terminals and connecting the other side of each of said vertical energizing coils to said second pair of terminals, whereby currents flow through said vertical energizing coils having direct current and alternating current components and generally parabolic waveshapes with central portions of minimum amplitude at the middle of vertical scan, and a choke coil connected across said second pair of terminals, said choke coil having a high impedance to vertical scanning frequencies and having a direct current resistance of such value to so relate the direct current and alternating current components of the parabolic current waves that, at the central portions of the parabolic waves applied to said vertical energizing coils, the currents through said coils have the same magnitudes irrespective of the particular shapes and peak-to-peak amplitudes of said waves.

References Cited in the file of this patent

UNITED STATES PATENTS

2,707,248	Goodrich	Apr. 26, 1955
2,742,589	Goodrich	Apr. 17, 1956
2,880,362	Parmet	Mar. 31, 1959