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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Control Circuit for Electron Beam Convergence Apparatus

We, RCA CORPORATION, formerly Radio Corporation of America, a Corporation organized under the laws of the State of Delaware, United States of America, of 30, Rockefeller Plaza, City and State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to color image display systems and particularly to improvements of means for making a plurality of electron beams of a multiple beam display device converge at all scanned points on the target electrode of said device.

An illustrative example of such a multiple beam display device is a color picture tube. Color picture tubes of the shadow mask type normally have three electron guns positioned in the neck of the tube and a target electrode including an apertured shadow mask located between the electron guns and a luminescent screen of phosphor dots. The dots are arranged in groups of three in register with respective apertures of the mask. Static magnetic means are provided for making the three electron beams converge at the center of the scanned area of the target electrode. The three beams, after passing through the shadow mask, respectively strike three phosphor dots, each emitting a 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 picture tube target.

The more the three beams are deflected from the center of the target, unless corrective measures are taken, the greater may be the misconvergence of the beams when they reach the shadow mask. It is, therefore, customary to provide dynamic electromagnetic means for correcting the misconvergence of

the beams as a function of the angular deflection of the beams from the center of the picture tube target. For this purpose, current waveforms of generally parabolic shape are produced from energy derived from the horizontal and vertical deflection circuits and are employed in conjunction with three convergence electromagnets, to dynamically converge the three beams at all points of the entire scanned area of the picture tube target.

Convergence control of the electron beams customarily is effected before the beams are deflected to scan the picture screen. Such beam deflection is accomplished by an electromagnetic yoke and the beam convergence electromagnets are mounted immediately to the rear of this yoke. As a consequence, some of the magnetic fields produced by the deflection yoke extend rearwardly enough to encompass the convergence electromagnets and, thus, induce unwanted currents in the electromagnets. In the past, where all of the color picture tubes used electron beams which were being deflected for only about 70°, such induced currents, if any, did not appreciably affect the operation of the beam convergence apparatus.

Now, however, that electron beam deflection in color picture tubes is at wider angles such as 90°, the beam convergence is somewhat adversely affected by such unwanted induced currents. There appear to be several reasons for this. For one thing the deflection yoke needs to be driven harder in order to achieve the wider deflection angles, thus producing stronger magnetic fields. For another thing the difficulty of producing beam convergence increases as the maximum deflection angle increases.

The adverse effects of the external fields produced by the deflection yoke have been found to be particularly troublesome in the energizing circuit for the blue beam convergence magnet at the vertical deflection rate.

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The reasons for this appear to be the proximity of the convergence electromagnets to the deflection yoke and the vertical orientation of the blue convergence electromagnet. The red and green convergence electromagnets, while just as close to the deflection yoke, are oriented at about 120° angles to the vertical and, thus, do not have unwanted currents induced therein, at least to any significant degree.

- 5 The object of this invention, therefore, is to provide a circuit arrangement whereby to nullify, or at least minimize, the effect of unwanted currents induced in the electromagnetic beam convergence means from the beam deflection yoke associated with a multi-beam color television picture tube.

According to the invention there is included for this purpose means for deriving two pulse voltage waves of opposite pulse polarities each having cyclically occurring pulse portions with intervening varying voltage portions, and means for combining said voltage waves with the relationship of a portion of one of said waves selectively modified relatively to the remainder of that wave and to the other wave as to produce in said convergence means a resultant corrective current of waveform appropriate to counteracting the effect of said unwanted currents.

- 30 For a better understanding of the invention, reference now will be made to the following detailed description taken in connection with the accompanying drawings, in which:

35 FIGURE 1 is a block diagram of a color television receiver in which the present invention may be embodied;

FIGURE 2 is a fragmentary sectional view of the neck portion of a color picture tube, showing the relationship of the convergence electromagnets and the electron beams controlled thereby;

FIGURE 3 is a schematic circuit diagram of apparatus embodying the invention for controlling the convergence electromagnets at the vertical deflection frequency;

FIGURE 4 is a schematic circuit diagram of that portion of FIGURE 3 embodying the invention;

FIGURE 5 is a schematic circuit diagram similar to that of FIGURE 4 but in a more suitable form for explanatory purposes;

FIGURES 6 and 7 are representative waveforms of the respective sawtooth voltage waves derived from the two sources of FIGURE 5;

FIGURES 8 and 9 illustrate the waveforms respectively of the voltage waves derived from the sawtooth wave sources of FIGURE 5 and applied to the convergence electromagnet with values indicated at significant points thereof resulting from the inclusion of apparatus embodying the invention in the circuit;

FIGURE 10 illustrates the resultant voltage

65 waveform applied to the convergence electromagnet;

FIGURE 11 illustrates a typical waveform of the undesired current induced in the convergence electromagnet from the deflection yoke;

FIGURE 12 illustrates the waveform of the compensating current produced in the electromagnet resulting from the application to the electromagnet of the voltage waveform of FIGURE 10; and

FIGURE 13 is a fragmentary portion of the circuit diagram of FIGURE 3 showing another embodiment of the invention.

Reference first is made to FIGURE 1 for a general description of a color television receiver embodying the present invention. Radiated signals received by the antenna 11 are processed in the TV receiver circuit 12 in a known manner to produce (1) video signals representing three component colors of an image to be reproduced and (2) synchronizing signals for controlling beam deflection and for other purposes such as the production of suitable signals by which to effect convergence of the three electron beams at the target electrode of the image-reproducing color picture tube.

The color television receiver also includes a three-beam color picture tube 13 serving as a color image-reproducing device such as a shadow mask color picture tube of the RCA type 19EY22 or 21FJP22 or 25AP22A for example. The red, green and blue representative signals received from the receiver circuits 12 are impressed respectively upon electron guns 14, 15 and 16 of the tri-color picture tube 13. The three electron beams produced by these guns are deflected together over the target screen of the picture tube under the control of a deflection yoke 17. Also, the beams are maintained in convergence with each other by means of a suitably energized beam convergence yoke 18 mounted immediately to the rear of the deflection yoke 17, and of which an illustrative form will be described subsequently.

Also derived from the receiver circuits 12 are horizontal and vertical synchronizing signals which are impressed upon a synchronizing signal separator 19. The horizontal synchronizing signals are impressed upon the horizontal deflection circuit 21 and the vertical synchronizing signals are impressed upon the vertical deflection circuit 22. The horizontal and vertical deflection circuits are connected to the deflection yoke 17 as indicated by the reference characters H—H and V—V. All of the apparatus of FIGURE 1 described up to this point may be of a conventional character.

Signals derived from the horizontal deflection circuit 21 at the horizontal deflection rate are impressed upon horizontal convergence circuits 23, the output of which is

connected to the electromagnets of the convergence yoke 18. Signals at the vertical deflection rate derived from the vertical deflection circuit 22 are impressed upon the vertical convergence circuits 24 for the production of suitable waves which also are impressed upon the electromagnets of the convergence yoke 18. Details of such vertical convergence circuits by which suitable convergence waves are produced will be described subsequently. The horizontal convergence circuits are not part of the present invention and may be of a known type such as disclosed in United States Patent No. 2,903,622 granted September 8, 1959 to J. C. Schopp (U.K. Patent 883692).

Reference now is made to FIGURE 2 for a description of the physical relationship of the convergence electromagnets and the electron beams controlled respectively thereby as presently embodied in known commercial color television receivers.

This figure is a transverse sectional view of the neck portion of a color picture tube as it appears when viewed from the luminescent screen end of the tube. The three electron beams 25 pass respectively between pairs of pole pieces 26, 27 and 28 located internally of the neck 29 of the picture tube 13. These pole pieces extend inwardly from the ends of substantially U-shaped cores of green, red and blue convergence electromagnets 30, 31 and 32 respectively mounted externally around the neck of the picture tube. The convergence electromagnets are provided with horizontal frequency energizing windings designated 33G, 33R and 33B and with vertical frequency energizing windings designated 34G, 34R, and 34B respectively for the green red and blue electromagnets 30, 31 and 32. Energization of the electromagnet windings produces a magnetic field between the corresponding pole pieces which moves the corresponding electron beam radially. There also may be included as part of the convergence electromagnet structure some means for effecting a static convergence of the electron beams 25. The static convergence means may be permanent magnets associated with the respective convergence electromagnets or may comprise windings on the respective electromagnets for energization by direct current of the proper amplitude and polarity to effect the desired static convergence of the electron beams. Such static convergence means is known and, since a description of it is not needed for an understanding of this invention, it is not shown.

It should be noted that only the blue electromagnet 32 has an orientation (considering its effect on the associated beam) corresponding to one of the directions of electron beam deflection by the main deflection circuits. Specifically in this instance, such orientation is vertical and, as a consequence, the energizing

winding 34B is susceptible of having unwanted currents induced therein from the vertical coils of the nearby deflection yoke 17. The green and red electromagnets 30 and 31, being at about 120° angles to the vertical, thus are not aligned with either the vertical or horizontal beam deflection directions. Hence the energizing windings of the green and red electro magnets are substantially free from having unwanted currents induced therein from the deflection yoke coils.

Reference now is made to FIGURE 3 of the drawings. There is shown a vertical deflection output tube 35 having in its anode circuit a primary winding 36 of an output transformer 37. One of the secondary windings 38 of this transformer is coupled as indicated in the usual manner to the vertical windings of a deflection yoke (not shown) for deflecting the three electron beams of the color picture tube to scan the luminescent screen of the picture tube vertically at the rate of approximately 60 fields per second when operating to U.S. standards. It is to be understood that horizontal windings of the yoke also will be energized to deflect the beams to scan the screen horizontally at the rate of approximately 15,750 lines per second (again when operating to U.S. standards) in the usual manner. The cathode circuit of the vertical output tube 35 includes a resistor 39 and a capacitor 40, connected between terminal 41 and ground and across which cathode circuit there is developed a voltage wave 42 at the vertical deflection frequency. The wave 42 has both sawtooth and parabolic components and is of a particular character such that, when it is applied to the inductive energizing windings of the convergence electromagnets, it produces a generally parabolic current in these windings.

The cathode terminal 41 of the vertical output tube 35 is coupled by means including a series capacitor 43 and a resistive-capacitive wave-shaping shunt circuit 44 to the vertical frequency winding 34G, 34R and 34B respectively of the green, red and blue convergence electromagnets 30, 31 and 32, respectively. The shunt circuit 44 serves to steepen the sides of the voltage wave 42 to produce a voltage wave 45. The impression of the voltage wave 45 upon the convergence apparatus causes an integration of this wave such that the green and red convergence electromagnet windings 34G and 34R traversed by a substantially parabolic convergence current.

The amplitude of the parabolic current for the green and red convergence electromagnet windings 34G and 34R respectively is controlled by a master amplitude control potentiometer 46, the movable contact of which is connected to terminal 47 to which also are connected in series the green and red electromagnet windings.

The vertical windings 34G and 34R of the

green and red convergence electromagnets 30 and 31 respectively are connected in series to the movable contact of a master tilt control potentiometer 48, the resistive element of which is connected across the terminals of another secondary winding 49 of the vertical deflection output transformer 37. A tap of this winding is grounded through a resistor 49c to provide a return path for the currents flowing in the circuits including the windings of the convergence electromagnets. These currents develop a voltage wave 45a across the resistor 49c for the purpose of enabling a polarity reversal of energizing current for the blue electromagnet winding 34B. Pulse voltage waves 50 and 51 of opposite polarity are developed respectively in the coils 49a and 49b of the transformer winding and are available at the terminals of the winding. The impression of such pulses upon the convergence apparatus causes an integration of the pulses such that the convergence windings 34G and 34R are traversed by a substantially sawtooth current wave 52, the amplitude and polarity of which are determined by the adjustment of the master tilt control potentiometer 48. The sawtooth current wave 52 is added to the generally parabolic current wave in the usual manner to tilt or phase the parabolic wave to effect substantial beam convergence at most points of the scanned raster.

A differential amplitude control potentiometer 53 has its resistance element connected across the series arrangement of the windings 34G and 34R of the green and red convergence electromagnets 30 and 31 respectively. The junction point 54 between the green and red windings 34G and 34R is connected to a tap of still another secondary winding 55 of the vertical deflection output transformer 37. Pulse voltage waves 50a and 51a of opposite polarity are developed respectively in the coils 55a and 55b of this secondary winding and are available at the terminals of the winding. The terminals of this secondary winding 55 are connected to the terminals of the resistive component of a differential tilt control potentiometer 56. The movable contacts of the two differential potentiometers 53 and 56 are electrically connected together. The adjustment of the movable contact of the differential amplitude control potentiometer 53 varies distribution of the parabolic current through the respective windings 34G and 34R of the green and red convergence electromagnets 30 and 31. The adjustment of the movable contact of the differential tilt control potentiometer 56 determines the distribution between the windings 34G and 34R of the green and red convergence electromagnets 30 and 31 of the sawtooth current wave 52 by controlling the combination with this wave of another sawtooth current wave resulting from the integration of voltage pulses 50a, 51a by the convergence apparatus.

The vertical frequency winding 34B of the blue convergence electromagnet 32 is energized by a substantially parabolic current wave 45b, the amplitude and polarity of which is adjusted by a clue control potentiometer 57 connected to terminal 58 in common with the winding 34B. This parabolic current wave can be tilted or phased, to a limited but adequate extent as will be explained later, by means of a sawtooth component 52a, the amplitude and polarity of which are determined by the adjustment of a blue shape control potentiometer 59, the resistive element of which is connected across the terminals of the deflection transformer secondary winding 49 by means of a circuit including a series-connected diode 61 which is shunted by a resistor 62. The diode-resistor combination 61-62 functions in a manner to be described to counteract any unwanted currents induced in the blue energizing winding 34B from the deflection yoke.

The green, red and blue convergence electromagnets 30, 31 and 32 also are provided with respective windings 33G, 33R and 33B as previously described and which are energized by suitably shaped waves at the horizontal deflection frequency. These windings may be energized by any suitable means.

In the operation of the described beam convergence apparatus, the inclusion of the terminating resistor 49c enables the energization of the blue electromagnet winding 34B by a current of either polarity and of variable magnitude as determined by the adjustment of the potentiometer 57. When the adjustment of the potentiometer is such that the wave 45b has a greater amplitude than the fixed amplitude of the wave 45a, current flows in one direction through the winding 34B. When the potentiometer adjustment is such that the respective amplitudes of the waves 45b and 45a are reversed, current flows in the opposite direction in the winding 34B.

The following description of the manner in which the present invention operates is taken in conjunction with FIGURES 4 to 12. In FIGURE 4 only that part of the circuit of FIGURE 3 pertinent to an understanding of the invention has been redrawn. Because the impedance of the blue electromagnet winding 34B of FIGURE 3 is materially greater than the value of any of the resistors in the energizing circuit it is assumed for analytical purposes, to be an open circuit as indicated between terminals 63 and 64. Also, the values and positions in the circuit of resistor 49c and of potentiometer 57 of FIGURE 3 are such that they may be neglected for analytical purposes and, hence, are not shown in FIGURE 4. The voltages e_{51} and e_{52} correspond respectively to the pulse voltage waves 51 and 50 of FIGURE 3. The resistance R_1 corresponds to the resistor 62 of FIGURE 3 and the resistances R_2 and R_3

correspond to the two parts of the potentiometer 59 on opposite sides of the movable contact. The voltage e_o indicated across terminals 63 and 64 represents the pulse voltage impressed upon the electromagnet winding resulting from a combination of the voltages e_{s1} and e_{s2} as determined by the adjustment of the potentiometer 59 and as modified by the diode 61 and the resistor 62.

FIGURE 5 is a rearrangement of the circuit of FIGURE 4 with the two parts of the transformer winding 49 represented by generators 65 and 66 producing the voltages e_{s1} and e_{s2} respectively.

FIGURE 6 illustrates the waveform of the voltage e_{s1} derived from the generator 65 as a positive-going sawtooth wave 67 with negative-going pulses 68. The instantaneous voltages at points 69, 70 and 71 of the wave are indicated respectively as $-E_o$, $+E_1$ and $-E_2$.

Similarly, FIGURE 7 shows the waveform of the voltage e_{s2} derived from the generator 66 as a negative-going sawtooth wave 72 with positive-going pulses 73, the instantaneous voltages at points 74, 75 and 76 being indicated respectively as $+E_o$, $+E_1$ and $-E_2$.

FIGURE 8 illustrates the waveform of the voltage component e_{o1} derived from the generator 65 of FIGURE 5 as applied to the electromagnet winding as represented by the terminals 63 and 64 of FIGURES 4 and 5. The values of the instantaneous voltages at points 69a, 70a and 71a are represented by the indicated divisions of the voltages E_o , E_1 and E_2 . These values are based upon the assumption that the diode 61 of FIGURES 3, 4 and 5 is ideal; that is, having no resistance in the forward direction and infinite resistance in the reverse direction.

FIGURE 9 is similar to FIGURE 8 and illustrates the waveform of the voltage component e_{o2} derived from the generator 66 of FIGURE 5 as applied to the electromagnet terminals 63 and 64 of FIGURES 4 and 5.

FIGURE 10 illustrates the waveforms of the composite voltage $e_o = e_{o1} + e_{o2}$ as applied to the electromagnet terminals 63 and 64 of FIGURES 4 and 5 when the potentiometer 59 of FIGURES 3, 4 and 5 is adjusted so that $R_3 E_1 = (R_1 + R_2) E_o$. It will be noted that each cycle of the waveform of the voltage e_o comprises a negative-going pulse 77 and a positive-going ramp portion 78 for approximately one-half of a cycle. Because of the inclusion of the diode 61 in the circuit as shown in FIGURES 3, 4 and 5, the voltage e_o does not have a positive value at any time during the cycle.

The impression of the voltage e_o as shown in FIGURE 10 upon the energizing winding 34B of the blue convergence electromagnet 32 of FIGURE 3 is effective to produce the flow in the winding of a current I_{b2} as shown in FIGURE 12. Such current is substantially

equal and opposite to the unwanted current I_{b1} as shown in FIGURE 11 which is induced in the winding 34B from the deflection yoke. As a result, the unwanted induced current I_{b1} is substantially cancelled from the electromagnet winding.

It has been found that, even though the ideal conditions assumed for the foregoing analysis may not in all cases be completely realized in practice, the use of the invention does effectively cancel the induced current, at least to the point that it does not adversely affect the performance of the convergence apparatus to any significant extent. Also, it should be noted that, in the foregoing analysis, the described adjustment of the potentiometer 59 of FIGURE 3 so that $R_3 E_1 = (R_1 + R_2) E_o$ is at a null point so far as the use of the sawtooth voltage waves 50 and 51 to shape or tilt the parabolic current wave in the electromagnet winding 34B is concerned.

Should it become necessary to readjust the potentiometer 59 from the null point in order to change the shape of the parabolic current wave through the blue electromagnet winding 34b, some slight change may be produced in the waveform of the voltage e_o of FIGURE 10. Such change would be such that the ramp portion 78 extends into the positive region and the pulse 77 extends more into the negative region. Such waveshape change alters the shape of the correcting current I_{b2} of FIGURE 12 so little that the inducer current I_{b1} of FIGURE 11 is still effectively cancelled. It has been found in practice, however, that very little, if any, reshaping of the parabolic current wave is necessary. Hence, the potentiometer 59 is susceptible of adjustment to perform both functions of shape control of the parabolic current wave and of effective cancellation, in conjunction with the circuit including the diode 61 and the resistor 62 of any unwanted currents induced in the blue electromagnetic winding 34b from the deflection yoke.

FIGURE 13 shows another embodiment of the invention in which a capacitor 79 is used in the convergence correcting circuit instead of the diode 61 of FIGURE 3. The value of the capacitor is such that it has a relatively low impedance for the pulse portions 68 and 73 of the respective voltages e_{s1} and e_{s2} of FIGURES 6 and 7 and it has a relatively high impedance for the sawtooth or ramp portions 67 and 72 of these voltages. Consequently, wave components similar to those of FIGURES 8 and 9 are produced, whereby a correcting wave closely resembling the wave of FIGURE 10 is developed to effect the desired cancellation of the unwanted induced current.

WHAT WE CLAIM IS:—

1. Color television display apparatus com-



correspond to the two parts of the potentiometer 59 on opposite sides of the movable contact. The voltage e_o indicated across terminals 63 and 64 represents the pulse voltage impressed upon the electromagnet winding resulting from a combination of the voltages e_{s1} and e_{s2} as determined by the adjustment of the potentiometer 59 and as modified by the diode 61 and the resistor 62.

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WHAT WE CLAIM IS:—

1. Color television display apparatus com-

prising a multiple-beam color image reproducing device having electromagnetic deflection means for rasterwise scanning of the beams and electromagnetic beam convergence means susceptible to induction of unwanted currents therein from said deflection means, said apparatus further comprising, for reducing the effects of said unwanted currents, means for deriving two pulse voltage waves of opposite pulse polarities each having cyclically occurring pulse portions with intervening vary voltage portions, and means for combining said voltage waves with the relationship of a portion of one of said waves selectively modified relatively to the remainder of that wave and to the other wave as to produce in said convergence means a resultant corrective current of waveform appropriate to counteracting the effect of said unwanted currents.

2. Apparatus as defined in claim 1 wherein said combining means includes connected in circuit with at least one of said pulse voltage wave sources a transfer device having a different effective impedance for the pulse portions of that voltage wave than for the intervening portions of that voltage wave, whereby to modify the pulse portions differently from the other portions prior to combination of the two voltage waves.

3. Apparatus as defined in claim 1 wherein the pulse portions of each voltage wave are of opposite polarity to at least part of each intervening portion of the same wave and the combining means includes connected in circuit with at least the source of that voltage wave a transfer device conductive for the pulse portions of the wave and substantially non-conductive for the opposite polarity parts of the wave.

4. Apparatus as defined in claim 2 wherein said combining means includes a transfer device conductive for negative portions of

said one pulse voltage wave and for positive portions of the other pulse voltage wave and a voltage divider comprising a plurality of resistive elements connected between said two pulse voltage wave sources with an intermediate point on said divider connected to the convergence means.

5. Apparatus as defined in claim 4 wherein one of said voltage divider elements is a resistor connected in shunt with said transfer device and others of said voltage divider elements comprise a potentiometer connected in series with said resistor and having its adjustable contact connected to said convergence means.

6. Apparatus as defined in claim 4 wherein: one of said voltage divider resistive elements is a resistor connected in shunt with said transfer device; and others of said voltage divider resistive elements comprise a potentiometer connected in series with said resistor and having its adjustable contact connected to said convergence means, and wherein with said pulse voltage waves combining to provide a sawtooth current in said convergence means, said potentiometer is adjustable to establish the amplitude and polarity of said sawtooth current.

7. Apparatus as defined in any of claims 2 to 6 wherein said transfer device is a diode.

8. Apparatus as defined in any of claims 2 to 6 wherein said transfer device is a capacitor.

9. Color television display apparatus having provision for electron beam convergence correction substantially as herein described with reference to FIGURES 3 to 13 of the accompanying drawings.

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* C L M S *