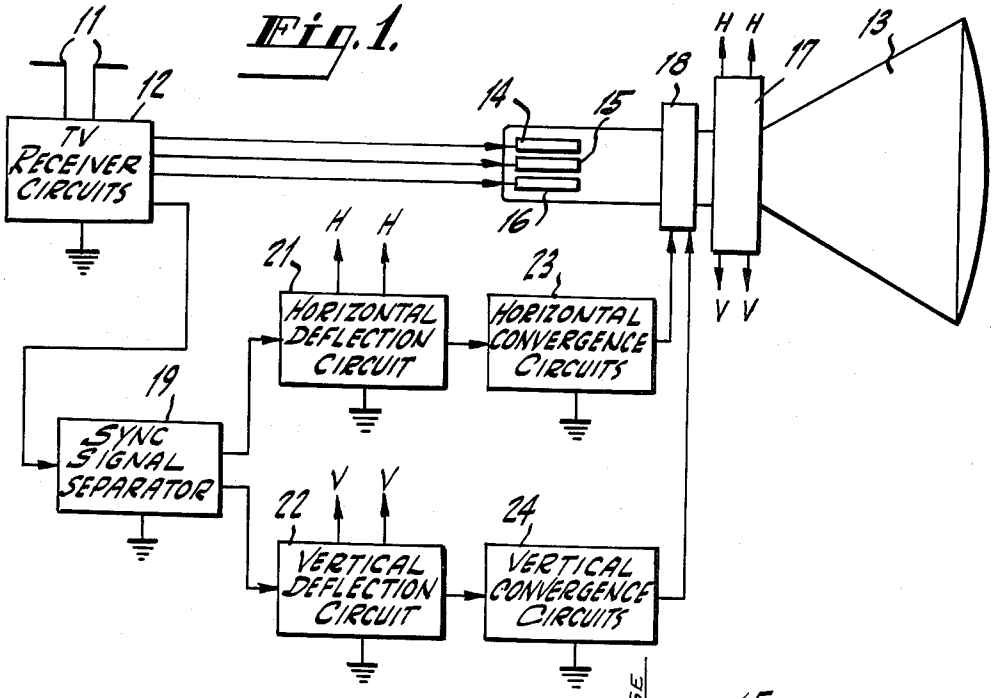
June 28, 1966 E. LEMKE 3,258,643

ELECTRON BEAM CONVERGENCE APPARATUS

Filed Aug. 5, 1963 2 Sheets-Sheet 1

Fig. 1.



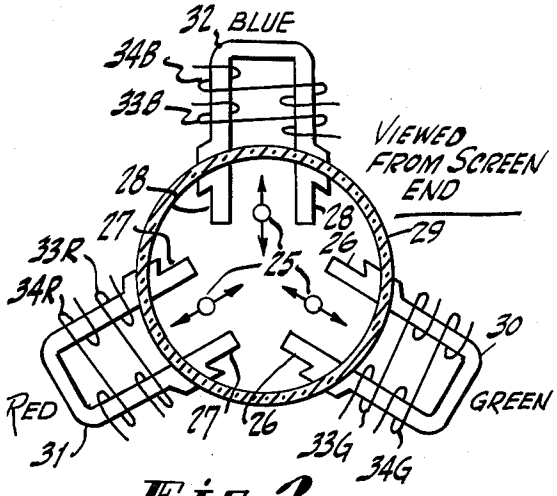


Fig. 2.

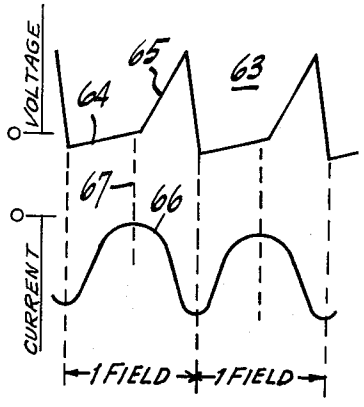


Fig. 4.

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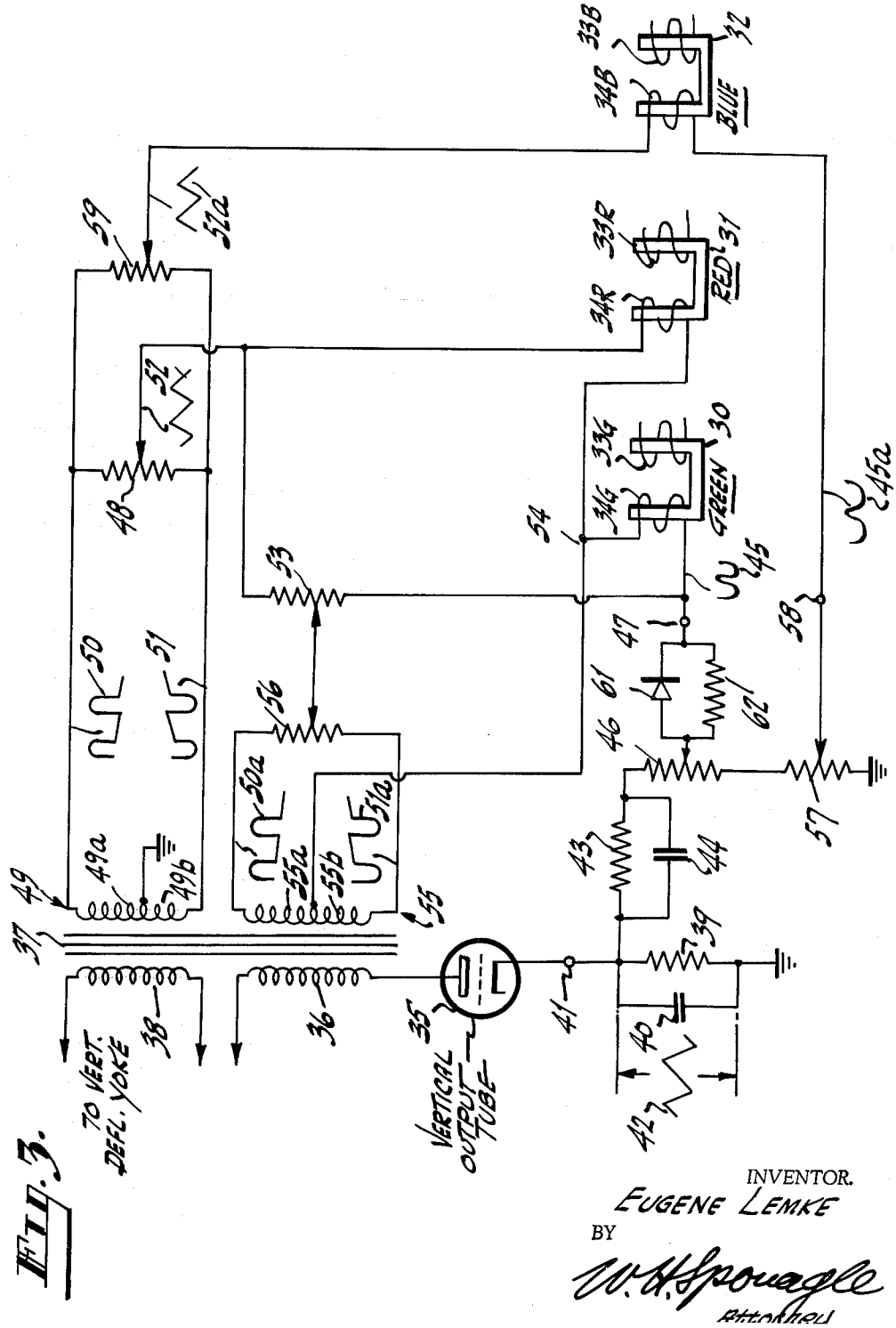

FIG. 3.

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ELECTRON BEAM CONVERGENCE APPARATUS

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This invention relates to color image display systems and particularly to 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 kinescope. Color kinescopes of the shadow mask type normally have three electron guns positioned in the neck of the kinescope 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 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, 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 kinescope 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 dynamicatly converge the three beams at all points of the entire scanned area of the kinescope target.

The waveforms employed must have proper shapes and amplitudes in order to achieve good convergence of the three beams at all points of the kinescope target. The waveform requirements may be estimated by observing the unconverged rasters of the three beams. It has been observed that color picture tube systems operating with relatively large angles of deflection, as for example 70° or more, require more correction at the outer edges of the scanned area when the undeflected beams are statically converged at the center of the picture area. Because of this requirement, the dynamic waveform must have greater amplitude and precision in order to effect satisfactory convergence throughout the scanned picture area. Not only are the wave shaping requirements more severe in more recent systems having greater angles of beam deflection, but also considerably more deflecting force (i.e., wave amplitude) is needed to suitably effect the desired beam convergence.

Recent trends in the design of color television receivers have been to employ dynamic beam convergence circuits which include no active elements. Such circuits perform essentially the function of providing suitably shaped waves for application to the convergence electromagnets. The energy for these electromagnets consequently must come entirely from the horizontal and vertical deflection circuits. As the angle of beam deflection increases, more energy is required to effect the deflection. Similarly, still more energy must be supplied to effect the desired convergence of the beams. Such requirements have placed severe burdens upon the deflecting circuits.

Therefore, it is an object of the invention to provide an improved high efficiency circuit by which to effect convergence of a plurality of electron beams of a color kinescope throughout a raster produced by relatively wide angle deflection of said beams.

The present invention reduces the energy demands placed upon the deflection circuits by providing improved wave shaping accomplised by the use of inactive circuit elements in the convergence circuits. At each of the horizontal and vertical deflection frequencies the substantially parabolic convergence current waves through the electromagnet windings are produced by deriving substantially sawtooth voltage waves from the respective deflection circuits. The improved wave shaping is achieved at the vertical deflection rate by clipping the substantially sawtooth voltage wave derived from the vertical deflection circuit during the first part of the deflection cycle and by suitably sloping the clipped portion of the wave. The vertical frequency convergence circuits include wave shaping networks including such clipping facilities so as to provide more symmetrical convergence parabolic current waves with steeper sides than heretofore has been achieved in order to provide better beam convergence at the top and bottom portions of the picture area for a kinescope operating with 70° (or more) beam deflection.

More specifically, the improved wave shaping of the present invention is achieved by means including a parallel arrangement of a clipping device and a resistor connected effectively in series between the vertical deflection circuit and the convergence electromagnet apparatus.

For a better understanding of the invention together with additional objects, features and advantages thereof, reference now will be made to the following detailed description taken in connection with the accompanying drawings, in which:

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 kinescope, 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; and

FIGURE 4 is a set of curves for reference in describing the operation 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 circuits **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 kinescope. The receiver circuits **12** may be of the type disclosed in "Color Television Service Data—1961 No. T6" furnished by RCA Sales Corporation, Indianapolis, Indiana.

The color television receiver also includes a three-beam color kinescope **13** serving as a color image-reproducing device such as a shadow mask color kinescope of the RCA type 21FBP22 or 21FJP22 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 kinescope **13**. The three electron beams produced by these guns are deflected together over the target screen of the kinescope 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**,

an illustrative form of which 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 horzontal 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 the same character as that disclosed in the service data previously referred to.

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 per se are not part of the present invention and may be of a known type such as disclosed in Patent No. 2,903,622, granted Sept. 8, 1959, to J. C. Schopp.

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 commercial color television receivers such as that disclosed in the referenced RCA service data. This figure is a transverse sectional view of the neck portion of a color kinescope as it appears when viewed from the luminescent screen end of the kinescope. The three electron beams 25 pass respectively between pairs of pole pieces 26, 27 and 28 located internally of the neck 29 of the kinescope 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 kinescope. 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.

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 kinescope to scan the luminescent screen of the kinescope vertically at the rate of approximately 60 fields per second. 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 in the usual manner. The cathode circuit of the vertical output tube 35 includes a resistor 39 which is bypassed by a capacitor 40, connected between terminal 41 and ground and across which cathode circuit there is developed a substantially sawtooth voltage wave 42 at the vertical deflection frequency.

The cathode of the vertical output tube 35 is coupled by means of a series resistor 43 which is shunted by a capacitor 44 to the vertical frequency windings 34G, 34R and 34B respectively of the green, red and blue convergence electromagnets 30, 31 and 32, respectively. By means of the resistor 43 and shunting capacitor 44, the A.C. and D.C. components of the sawtooth voltage wave 42 are proportioned in a predetermined ratio. The proportioning is such that the currents which are caused to flow through the vertical frequency windings of the convergence electromagnets always have substantially the same magnitudes at the time that the electron beams are tracing the horizontal lines of the raster at the center of the screen, irrespective of the particular shapes of the convergence currents and their peak-to-peak amplitudes.

The impression of the sawtooth voltage wave 42 upon the convergence apparatus causes an integration of this wave such that the green and red convergence electromagnet windings 34G and 34R are traversed by a substantially parabolic convergence current wave 45. The amplitude of the parabolic current wave 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 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. The center of this winding is grounded to provide a return path for the currents flowing in the windings of the convergence electromagnets. Pulse voltage waves 50 and 51 of opposite polarity are developed respectively in the coils 49*a* and 49*b* 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 45 in the usual manner to tilt or phase the parabolic wave to effect substantial beam convergence at most points of the scanned raster, except at those points in areas adjacent to the outer edges of the raster for which the beams are subjected to relatively wide angle deflection.

A differential amplitude control potentiometer 53 has its resistive 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 the center point of still another secondary winding 55 of the vertical deflection output transformer 37. Pulse voltage waves 50*a* and 51*a* of opposite polarity are developed respectively in the coils 55*a* and 55*b* 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 connected together. The adjustment of the movable contact of the differential amplitude control potentiometer 53 varies dis-

tribution of the parabolic current wave **45** 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 **50***a*, **51***a* by the convergence apparatus.

The vertical frequency **34B** of the blue convergence electromagnet **32** is energized by a substantially parabolic current wave **45***a*, the amplitude of which is adjusted by a blue amplitude control potentiometer **57** connected to terminal **58** in common with the winding **34B**. This parabolic wave is tilted or phased by means of a suitable sawtooth component **52***a*, the amplitude and polarity of which is 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**.

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 such as that shown in Patent No. 2,903,622, granted September 8, 1959, to J. C. Schopp.

In order to improve the shape of the convergence current wave by which the green and red convergence electromagnets **30** and **31** are energized when relatively large beam deflection angles are employed, there also is provided a parallel arrangement of a unilaterally conducting device such as a diode **61** and a resistor **62** which is connected between the movable contact of a master amplitude control potentiometer **46** and the terminal **47**. This parallel arrangement is thus effectively connected in series with the green and red electromagnet windings **34G** and **34R** respectively, the movable tap of potentiometer **48** being substantially at ground. Note the grounded center tap of secondary winding **49**.

The improved wave shaping effected by the diode **61** and resistor **62** may better be seen by additional reference to FIGURE 4. The substantially sawtooth voltage wave **42** appearing at the terminal **41**, and impressed across the potentiometer **46**, has its negative-going portion clipped by the diode **61** so as to form a modified sawtooth wave **63** for impression upon the electromagnet windings **34G** and **34R** at terminal **47**. This clipping action occurs during the first portion of the vertical scanning interval, the mid-point of the scanning interval being indicated by the broken line **67**. The desired slope of the clipped portion **64** of the wave **63** is determined by the value of the resistor **62**. The positive-going portion of the modified sawtooth voltage wave **63** is not materially altered by the described wave shaping circuit from its original shape in the wave **42**.

In the described wave-shaping circuit the diode **61** performs a clipping function and the resistor **62** bypasses some of the unclipped portion of the wave applied to the circuit. In performing its clipping function the diode presents a varying impedance to the applied waveform so that the clipped portion of the applied wave deviates somewhat from the desired shape. The shape of the original wave complements the shape deviation so that by bypassing a suitable magnitude of the unclipped wave around the diode the resultant is a wave developed at terminal **47** which has the desired shape of the portion **64** as shown in FIGURE 4.

As a result of the integration of the wave **63** by the convergence apparatus, the substantially parabolic current wave **66** traversing the green and red electromagnet windings **34G** and **34R** has a more symmetrical shape with steeper sides than it would have without the wave shaping

circuit of this invention. Such wave shaping thus, enables the achievement of substantial convergence of the red and green electron beams with the blue electron beam in the top and bottom portions of the raster scanned by these beams.

What is claimed is:

1. In a television color image display system including a multiple beam color image reproducing device and deflection means for deflecting said beams in a series of vertically spaced horizontal lines during successive beam trace periods to form a raster,

the combination for converging said beams at all points of said raster comprising;

a dynamic convergence electromagnet having an energizing winding;

a source of a sawtooth wave;

means coupling said source to said winding; and

wave-shaping means including a parallel arrangement of a diode and a resistor and comprising at least part of said coupling means, said wave-shaping means functioning to so modify said sawtooth wave that its impression upon said winding causes to flow through said winding a current wave having a substantially symmetrical parabolic form with relatively steep side portions occurring respectively at the start and finish of each of said trace periods.

2. In a television color image display system including a multiple beam color image reproducing device and deflection means for deflecting said beams at line and field rates during respective beam trace periods to form a raster,

the combination for converging said beams at all points of said raster comprising;

a dynamic convergence electromagnet having an energizing winding;

a source of a sawtooth wave at one of said deflection rates, said wave having A.C. and D.C. components;

means coupling said source to said winding to impress said sawtooth wave upon said winding; and

wave-shaping means including a parallel arrangement of a diode and a resistor connected effectively in series with said winding to so modify the A.C. component of said sawtooth wave during the first part of each of one of said trace periods that the impression of said modified sawtooth wave upon said winding causes to flow through said winding a current wave having a substantially symmetrical parabolic form with relatively steep side portions occurring respectively at the start and finish of each of said trace periods.

3. In a television color image display system including a three beam color image reproducing device and deflection means for deflecting said beams at line and field rates during respective beam trace periods to form a raster,

the combination for converging said beams at all points of said raster comprising;

three respective dynamic convergence electromagnets for said beams, each of said electromagnets having an energizing winding;

a source of a sawtooth wave at said field deflection rate;

means including an amplitude controlling potentiometer coupling said source to two of said windings to impress said sawtooth wave upon said two windings; and

wave-shaping means including a parallel arrangement of a diode and a resistor connected between said potentiometer and a series arrangement of said two windings to so modify said sawtooth wave durring the first part of each of said field rate trace periods that its impression upon said two windings causes to flow through said two windings a current wave having a substantially symmetrical parabolic form with relatively steep side portions occurring respectively

at the start and finish of each of said field rate trace periods.

4. In a television color image display system including a multiple beam color image reproducing device and deflection means for deflecting said beams at line and field rates during respective beam trace periods to form a raster,

the combination for converging said beams at all points of said raster comprising;

a dynamic convergence electromagnet having an energizing winding;

a source of a sawtooth wave at one of said deflection rates;

means coupling said source to said winding to impress said sawtooth wave upon said winding; and

means connected effectively in series with said winding for clipping said sawtooth wave during the first part of each of one of said trace periods so that the impression of said clipped sawtooth wave upon said winding causes to flow through said winding a current wave having a substantially symmetrical parabolic form with relatively steep side portions occurring respectively at the start and finish of each of said trace periods.

5. In a television color image display system including a multiple beam color image reproducing device and deflection means for deflecting said beams at line and field rates during respective beam trace periods to form a raster,

the combination for converging said beams at all points of said raster comprising;

a dynamic convergence electromagnet having an energizing winding;

a source of a sawtooth wave at one of said deflection rates;

means coupling said source to said winding to impress said sawtooth wave upon said winding; and

wave-shaping means including a diode connected in series with said winding for clipping said sawtooth wave during a portion of each of one of said trace periods and a resistor connected in series with said winding for controlling the slope of the clipped portions of said sawtooth wave, said wave-shaping means functioning to so modify said sawtooth wave that its impression upon said winding causes to flow through said winding a current wave having a substantially symmetrical parabolic form with relatively steep side portions occurring respectively at the start and finish of each of said trace periods.

6. In a television color image display system including a three beam color image reproducing device and deflection means for deflecting said beams at line and field rates during respective beam trace periods to form a raster,

the combination for converging said beams at all points of said raster comprising;

three respective dynamic convergence electromagnets for said beams, each of said electromagnets having an energizing winding;

a source of a sawtooth wave at said field deflection rate, said wave having A.C. and D.C. components;

means coupled to said source to effect a predetermined proportioning of said A.C. and D.C. components;

means including an amplitude controlling potentiometer coupling said proportioning means to two of said windings to impress said sawtooth wave upon said two windings; and

wave-shaping means including a parallel arrangement of a diode and a resistor connected between said potentiometer and a series arrangement of said two windings to so modify said sawtooth wave during the first part of each of said field rate trace periods that its impression upon said two windings causes to flow through said two windings a current wave having a substantially symmetrical parabolic form with relatively steep side portions occurring respectively at the start and finish of each of said field rate trace periods.

7. In a television color image display system including a three beam color image reproducing device and deflection means for deflecting said beams at line and field rates during respective beam trace periods to form a raster,

the combination for converging said beams at all points of said raster comprising;

three respective dynamic convergence electromagnets for said beams, each of said electromagnets having an energizing winding;

a source of a sawtooth wave at said field deflection rate, said wave having A.C. and D.C. components;

means including a parallel arrangement of a resistor and a capacitor having its input terminal connected to said source to produce at its output terminal a revised sawtooth wave having a predetermined ratio of A.C. and D.C. components;

means including an amplitude controlling potentiometer coupling said output terminal to two of said windings to impress said revised sawtooth wave upon said two windings; and

wave-shaping means including a parallel arrangement of a diode and a resistor connected between said potentiometer and a series arrangement of said two windings to so modify said revised sawtooth wave during the first part of each of said field rate trace periods that its impression upon said two windings causes to flow through said two windings a current wave having a substantially symmetrical parabolic form with relatively steep side portions occurring respectively at the start and finish of each of said field rate trace periods.

No references cited.

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