May 7, 1968 C. M. HART 3,382,400

CONVERGENCE CIRCUIT

Filed Feb. 26, 1965 2 Sheets-Sheet 1

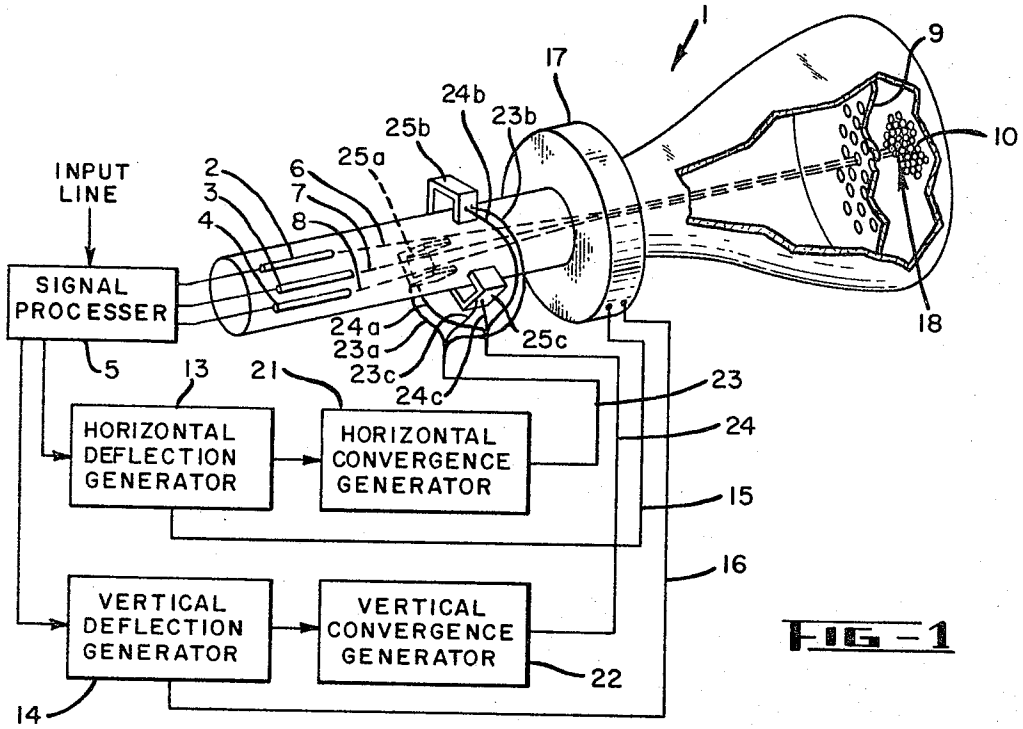


FIG-1

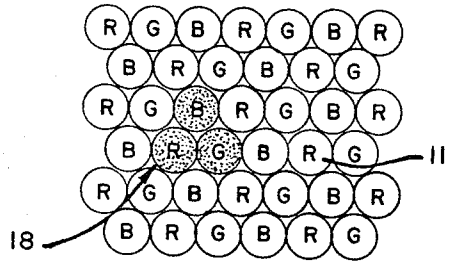


FIG-2

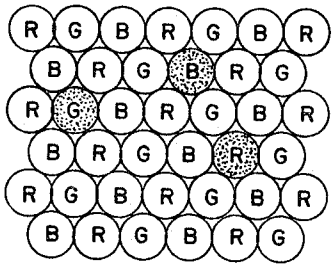


FIG-3

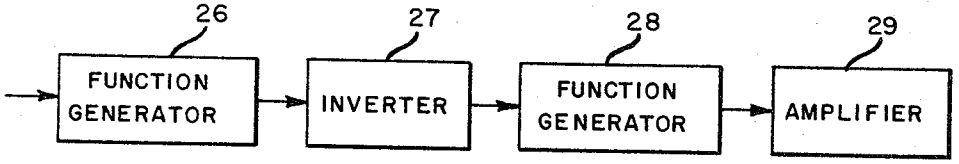


FIG-4

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CONVERGENCE CIRCUIT

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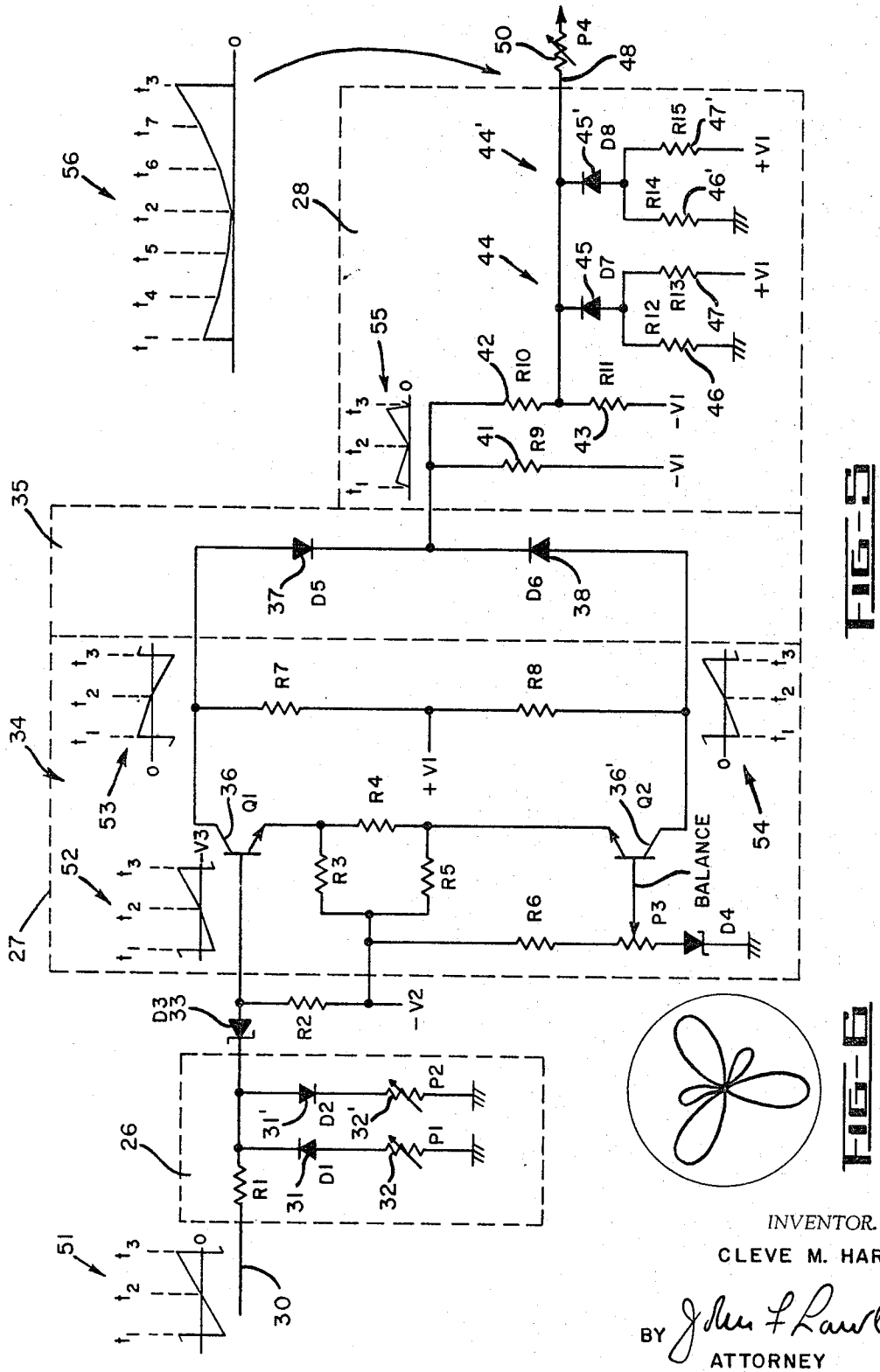


FIG-5

FIG-6

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CONVERGENCE CIRCUIT

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8 Claims. (Cl. 315—13)

This invention relates to information display and more particularly to a circuit for controlling convergence of electron beams in a multi-beam shadow mask color kinescope.

Present day air traffic control systems, radar systems and other type reconnaissance systems often provide a large amount of information in a short time. The human operator of such systems is frequently required to simultaneously observe a number of targets or analyze many signals. In general, he must process a large amount of information in a short time. One method of facilitating the processing of this information is to selectively display it in color. In an air traffic control system, aircraft assigned to a particular flight pattern may be indicated in one color on a color kinescope, aircraft being interrogated may be indicated in another color and aircraft not yet in an area requiring interrogation may be indicated in still another color.

In an electromagnetic reconnaissance direction-finding system, directional information may be represented by a polar display on a kinescope. The position of the indication on the kinescope, with respect to a reference point and reference plane, indicates the direction of the electromagnetic signal. The position of the indication wth respect to the reference point is a function of the magnitude of the signal. The frequency spectrum monitored by the system may be divided into a number of frequency bands and each frequency band indicated by a different color on the kinescope. Thus, the operator can quickly determine the frequency band and direction of received signals by the color of the indication on the kinescope. In the latter system, the electron beams of the color kinescope are moved about the face of the tube in a random manner.

Most present day color television receivers employ a color kinescope wherein three electron beams are focused through apertures in a shadow mask onto a screen comprised of a plurality of separate phosphor dots. The dots are arranged in triads. Each triad consists of a red, a blue and a green phosphor dot. Each dot in each triad emits either red, green or blue light when an electron beam is incident on it. In order to obtain a clear display, special circuitry is provided to insure that the electron beams are incident on phosphor dots of a single triad. A different convergence circuit and electromagnet is associated with each color. Each convergence circuit develops a convergence signal that is applied to the associated electromagnet. Convergence circuits associated with displays having periodic or raster type scans, such as in television receivers, are complex and contain frequency sensitive circuits such as tuned circuits, the resonant frequency of which is related to the scan rate. Such circuits do not generate proper convergence signals in applications where the electron beams move about the face of the tube in a random manner.

An object of this invention is the provision of convergence circuitry for a color kinescope wherein the electron beams are moved about the face of the tube in a random manner.

Another object is the provision of convergence circuitry for a color kinescope employing frequency insensitive circuits.

Another object is the provision of circuitry for color kinescopes for generating convergence signals that are independent of the rate the electron beams sweep across the face of the tube.

Another object is the provision of convergence circuitry that may be made as an integrated circuit.

In accordance with this invention, a convergence signal is generated by a convergence circuit employing frequency insensitive circuits. Selected portions of a deflection signal are attenuated. Selected portions of the deflection and attenuated signals are inverted and again attenuated to properly shape the input deflection signal. The gain of the output of the convergence circuit may be adjusted or the output applied directly to the convergence electromagnet of the kinescope.

This invention and these and other if its objects will be more fully understood from the following description of a preferred embodiment thereof, reference being had to the accompanying drawings in which:

FIGURE 1 is a perspective view of a color kinescope partially cut away together with control circuitry embodying this invention;

FIGURE 2 is a fragmentary view of a phosphor screen illustrating convergence of electron beams;

FIGURE 3 is a fragmentary view of a phosphor screen illustrating misconvergence of electron beams:

FIGURE 4 is a block diagram of a convergence circuit embodying this invention;

FIGURE 5 is a circuit diagram of the embodiment of FIGURE 4; and

FIGURE 6 is a representation of an actual polar display formed by a color display system employing this invention.

Referring now to the representation of FIGURE 1, the control circuitry comprises convergence generators **21** and **22** that incorporate this invention. The shadow mask kinescope **1** comprises electron beam sources **2**, **3** and **4** energized by a signal processor **5**. Electron beam sources **2**, **3** and **4** produce electron beams **6**, **7** and **8** associated with blue, green and red primary colors, respectively. An apertured shadow mask **9** is disposed near a screen **10** of triads of phosphor dots at the end of kinescope **1** opposite from the electron beam sources.

The arrangement of phosphor dots on screen **10** is illustrated in FIGURES 2 and 3. The phosphor dots are arranged in the same order (red, green and blue) in each row. Reference to the red phosphor dot **11** in FIGURE 2 reveals that each phosphor dot is surrounded only by phosphor dots of the other two primary colors. Each triad is comprised of a red, a green and a blue phosphor dot.

The point of incidence of the electron beams on screen **10** is controlled by signals produced by horizontal deflection generator **13** and vertical deflection generator **14**, which are also energized by signal processor **5**. The deflection signals from generators **13** and **14** are applied on lines **15** and **16**, respectively, to the deflection yoke **17** of the shadow mask kinescope.

At any one time, the three electron beams **6**, **7** and **8** preferably pass through the same aperture of mask **9**, each beam being incident on a different associated phosphor dot of the same triad as represented by the shaded dots at **18** in FIGURES 1 and 2. When the electron beams are misconverged they are incident on phosphor dots of different triads as represented by the shaded dots in FIGURE 3.

Convergence of the electron beams onto the phosphor dots of a single triad is controlled by signals generated by horizontal convergence generator **21** and vertical convergence generator **22**. The horizontal and vertical convergence generators operate on the output of the associated deflection generator to provide convergence signals applied on lines **23***a*, **23***b* and **23***c* and **24***a*, **24***b*

and 24c to convergence electromagnets 25a, 25b and 25c, respectively. Each convergence electromagnet is associated with a particular primary color and has a horizontal deflection winding and a vertical deflection winding (not shown) connected to the output of the associated convergence generator. Each convergence generator comprises three physically identical convergence circuits. Each convergence circuit is associated with a different primary color and has an output connected to the associated winding of the associated convergence electromagnet. This invention is directed to the provision of the improved convergence circuit illustrated in FIGURES 4 and 5.

Referring now to the embodiment of this invention in FIGURE 4, each convergence circuit comprises a function generator 26, an inverter 27, a function generator 28 and an amplifier 29. Function generator 26 operates on the deflection signal generated by the associated deflection generator to attenuate selected portions thereof. Portions of the output of generator 26 are inverted by inverter 27. Function generator 28 operates on the output of inverter 27 to attenuate selected portions of the modified deflection signal. The output of function generator 28 may be amplified or applied directly to the associated winding of an associated convergence electromagnet 25.

Referring now to the embodiment of this invention shown in FIGURE 5, function generator 26 comprises diode 31 and potentiometer 32 connected between input line 30 and a reference potential. A second diode 31' and potentiometer 32' are also connected between the input line and the reference potential. The anode of diode 31' and the cathode of diode 31 are connected to the input line. The output of function generator 26 is coupled through a Zener diode 33 to inverter 27 which comprises difference amplifier 34 and full wave rectifier 35. Zener diode 33 is connected to the base of transistor 36 of the difference amplifier. Diode 33 provides a negative DC level shift at the input of the amplifier so the amplifier output can swing below the reference level. Rectifier 35 comprises diodes 37 and 38 connected between the collector electrodes of transistors 36 and 36'. The output of rectifier 35, and inverter 27, is coupled from the junction of diodes 37 and 38.

Function generator 28 comprises a resistor 41 connected between the output of rectifier 35 and a negative supply potential $-V_1$. Resistor 41 is shunted by a first voltage divider comprising resistors 42 and 43. A plurality of diode circuits 44 are connected to the junction of resistors 42 and 43. Each diode circuit comprises a diode 45 and a second voltage divider comprised of resistors 46 and 47. Resistors 46 and 47 are connected between the reference potential and a positive supply potential $+V_1$. The anode of diode 45 is connected to the junction of resistors 46 and 47. The cathode of diode 45 is connected to the junction of resistors 42 and 43. The magnitude of the output of function generator 28 on line 48 is controlled by a variable attenuator 50. It will be noted that neither inverter 27 nor function generator 26 or 28 contain frequency sensitive elements such as tuned circuits.

In order to facilitate understanding this invention, the operation of a convergence circuit incorporating the invention is described in relation to obtaining the parabolic wave signals employed to converge the electron beams in a color television receiver.

The deflection signal applied on line 30 to function generator 26 is the linear ramp signal indicated at 51 in FIGURE 5. In a television receiver, the negative and positive half cycles of the ramp signal may correspond to the right and left side or top and bottom of the kinescope screen. During the negative half cycle between times t_1 and t_2, diode 31 is forward biased and conducts. Conduction of diode 31 reduces the slope of the ramp signal between times t_1 and t_2 by shunting a portion of the signal to ground. Diode 31 is reverse biased and cut off during the positive half cycle of the ramp signal between times t_2 and t_3. Conversely, diode 31' is forward biased and conducts during the positive half cycle of the ramp signal between times t_2 and t_3. Diode 31' is reverse biased and cut off during the negative half cycle of the ramp signal from time t_1 to t_2. The slope of the output of function generator 26 between times t_1 and t_2 is varied by adjustment of potentiometer 32, whereas the slope between times t_2 and t_3 is controlled by potentiometer 32'. In the particular example described here, potentiometer 32' is adjusted to provide a very high impedance so the slope of the ramp signal between times t_2 and t_3 is unchanged as indicated in the waveform at 52.

The output of function generator 26 (indicated at 52) is amplified by difference amplifier 34. The outputs of the difference amplifier are indicated at 53 and 54. The output at 53 is 180 degrees out-of-phase with the input at 52. Conversely, the output at 54 is in-phase with the input at 52 and is 180 degrees out-of-phase with the output at 53.

The output 53 of amplifier 34 causes diode 37 to conduct between times t_1 and t_2 to pass the positive half-cycle of the signal represented at 53. Diode 37 is cut off between times t_2 and t_3. Conversely, the output 54 of amplifier 34 causes diode 38 to conduct between times t_2 and t_3 to pass the positive half-cycle of the signal represented at 54. Diode 38 is cut off between times t_1 and t_2. The output of rectifier 35 illustrated at 55 is the same as the output of function generator 26 (waveform 52) except that the signal between times t_1 and t_2 is inverted.

The resistances of resistors 46 and 47 the selected to provide a predetermined bias potential at the junction of the resistors to forward bias the associated diode 45. Each diode (45, 45' . . .) is biased to conduct when the output of the rectifier is a different potential. For example, bias potentials of +2.0 volts and +1.0 volt might be impresed on the anodes of diodes 45 and 45', respectively, by the associated resistors 46, 47 and 46', 47', respectively. In this example, diode 45 conducts and shunts a portion of the signal on line 48 to ground when the signal potential on the cathode is less than +2.0 volts. Similarly, diode 45' conducts when this potential is less than +1.0 volt and shunts more of the signal on line 48 to ground. Each diode continues to conduct until the cathode potential is more positive than the signal potential at which the diode initially started to conduct.

The output of function generator 28 is illustrated at 56. It is larger than the other waveforms in order to better illustrate the operation of function generator 28.

The output of inverter 27 (waveform 55) at time t_1 is more positive than the bias on the anodes of diodes 45 and 45' and the diodes are cut off. At time t_4 (see waveform 56) the output of the inverter has decreased in magnitude sufficiently to cause diode 45 to conduct to shunt a portion of the inverted signal to ground. Diode 45', however, is still reverse biased and cut off. Conduction of diode 45 causes the slope of the signal on line 48 to decrease at time t_4.

At time t_5 (see waveform 56) the output of the inverter has decreased in magnitude sufficiently to also cause diode 45' to conduct to shunt more of the inverted signal to ground. Conduction of both diodes 45 and 45' causes a further decrease in the slope of the signal on line 48.

At time t_6 (see waveform 56) the output of the inverter has increased in magnitude sufficiently to reverse bias and cut off diode 45'. This causes the slope of the signal on line 48 to increase since the signal is no longer shunted to ground through diode 45'. Similarly, at time t_7 the output of the inverter has increased in magnitude sufficiently to also reverse bias and cut off diode 45. This causes a further increase in the slope of the signal on line 48 since neither diode 45 nor 45' shunts the signal on line 48 to ground. Thus, the signal on line 48 and the output of inverter 27 have the same slope after time t_7. The signal on line 48 is a very close approximation of a parabola. The fidelity of this signal on line 48 may be

improved by adding more diode circuits in shunt with diode circuits **44** and **44'**. The magnitude of the convergence signal on line **48**, waveform **56**, is controlled by potentiometer **50**. The convergence signal on line **48** may also be amplified or applied directly to an associated winding of an associated convergence electromagnet.

In most instances, the same convergence signal will not converge all the electron beams. A slightly different signal is required to converge each electron beam. For a particular shadow-mask tube, for example, the rate of change of the slope of the convergence signal required for horizontal convergence of the electron beam associated with the red phosphor dots on the left side of the screen varies more rapidly than the slope of the convergence signal required for horizontal convergence of the electron beam associated with the green phosphor dots on the left side of the screen. Selective shaping to obtain the necessary convergence signal is achieved by selection of resistors **46** and **47** for biasing diodes **45**, by adjustment of potentiometers **32** and **32'**, and by adjustment of potentiometer **50** or the gain of amplifier **29**.

One method of adjusting the convergence circuits to converge the electron beams of the color kinescope is as follows. Horizontal deflection generator **13** is caused to generate a horizontal sweep on the kinescope. When the three electron beams are not properly converged, three lines (red, blue, green) occur which are not coincident. Potentiometers **32**, **32'** and **50** and the gain of amplifier **29** of each horizontal convergence circuit are adjusted to converge the three lines. Vertical deflection generator **14** is then caused to generate a vertical sweep on the kinescope. If the electron beams are not properly converged, three vertical lines occur which are not coincident. Potentiometers **32**, **32'** and **50** and the gain of amplifier **29** of each vertical convergence circuit are adjusted to converge the three lines. After the convergence circuits are adjusted to converge linear signals, the horizontal and vertical deflection generators are caused to generate a circle or similar waveform having a symmetrical geometric configuration on the outer portions of each quadrant of the kinescope. Potentiometers **32**, **32'** and **50** and the gain of amplifier **29** of all convergence circuits are again adjusted to converge the geometric configurations that occur when the electron beams are not properly converged. This process is repeated until the beams are satisfactorily converged.

By way of example, convergence circuits similar to the one illustrated in FIGURE 5 were employed to converge the electron beams in a color display system that provided the polar display shown in FIGURE 6. Components and values of elements employed in these convergence circuits are:

R_1	200Ω	P_2	(1)
R_2	4.3KΩ	P_3	1KΩ
R_3	3KΩ	P_4	(1)
R_4	300Ω	D_1	1N916
R_5	3KΩ	D_2	(1)
R_6	3.3KΩ	D_3	1N73
R_7	1.5KΩ	D_4	1N755
R_8	1.5KΩ	D_5	1N270
R_9	33KΩ	D_6	1N270
R_{10}	15KΩ	D_7	1N270
R_{11}	150KΩ	D_8	1N270
R_{12}	22KΩ	Q_1	2N697
R_{13}	82KΩ	Q_2	2N697
R_{14}	5.1KΩ	$+V_1$	10 v.
R_{15}	43KΩ	$-V_1$	10 v.
P_1	1KΩ	$-V_2$	30 v.

[1] The signal on line 48 was applied to a variable gain amplifier rather than employing these components.

Although this invention is shown and described in relation to a preferred embodiment thereof, variations and modifications will be apparent to those skilled in the art. The scope and breadth of this invention is, therefore, to be determined from the following claims rather than from the above detailed description of a preferred embodiment thereof.

What is claimed is:

1. In a color display including a multi-beam kinescope and means for providing deflection signals for deflecting the beams, a convergence circuit for developing a signal for controlling convergence of a beam, said convergence circuit comprising

a first function generator having an input and passing a deflection signal and having an output, said first function generator comprising

first and second potentiometers having first terminals connected to a reference potential and having second terminals,

a first diode having a first electrode connected to said input and having a second electrode connected to the second terminal of said first potentiometer,

a second diode having a first electrode connected to the second terminal of said second potentiometer and having a second electrode connected to said input,

said first and second diodes conducting to bypass a portion of the deflection signal when the value of the deflection signal is less than and exceeds a predetermined threshold value, respectively, and

an inverter comprising

a difference amplifier responsive to the output of said first function generator for generating a first output in phase with the output of said first function generator and a second output 180 degrees out-of-phase with the output of said first function generator, and

a full-wave rectifier responsive to the outputs of said difference amplifier and passing said in-phase signal when it passes in one direction a prescribed value and passing said out-of-phase signal when it passes in the opposite direction said prescribed value, and

a second function generator having an input passing the output of said rectifier and having an output, said second function generator comprising

a first supply potential,

a first voltage divider having a first terminal connected to the output of said rectifier and having a second terminal connected to said first supply potential and having a tap,

a second supply potential, and

a diode bypass circuit comprising

a second voltage divider having a first terminal connected to the reference potential and having a second terminal connected to said second supply potential and having a tap, and

a third diode having a first electrode connected to said tap of said first voltage divider and having a second electrode connected to said tap of said second voltage divider,

said third diode conducting to bypass a portion of the output of said rectifier when the rectifier output causes said third diode to conduct.

2. In a color display including a multi-beam kinescope and means for providing deflection signals for deflecting the beams, a convergence circuit for developing a signal for controlling convergence of a beam, said convergence circuit comprising

a difference amplifier responsive to a deflection signal for generating a first output in phase with the deflection signal and a second output 180 degrees out-of-phase wtih the deflection signal,

a potentiometer having a first terminal connected to a reference potential and having a second terminal,

a first diode having a first electrode connected to said second terminal of said potentiometer and having a second electrode connected to the input to said difference amplifier,

said first diode conducting to bypass a portion of the deflection signal when the deflection signal has predetermined values,

a full-wave rectifier responsive to the outputs of said difference amplifier for passing said in-phase signal when it passes in one direction a prescribed value and passing said out-of-phase signal when it passes in the opposite direction said prescribed value,

first and second supply potentials,

a first voltage divider having a first terminal connected to the output of said rectifier and having a second terminal connected to said first supply potential and having a tap,

a second voltage divider having a first terminal connected to the reference potential and having a second terminal connected to said second supply potential and having a tap, and

a second diode having a first electrode connected to said tap of said first voltage divider and having a second electrode connected to said tap of said second voltage divider,

said second diode conducting to bypass a portion of the output of said rectifier when the rectifier output causes said second diode to conduct.

3. In a color display including a multi-beam kinescope and means for providing deflection signals for deflecting the beams, a convergence circuit for developing a signal for controlling convergence of a beam, said convergence circuit comprising

a difference amplifier responsive to a deflection signal for producing a first output in phase with the deflection signal and a second output 180 degrees out-of-phase with the deflection signal,

a potentiometer having a first terminal connected to a reference potential and having a second terminal,

a first diode having a first electrode connected to the second terminal of said potentiometer and having a second electrode connected to the input to said difference amplifier,

said first diode conducting to bypass a portion of the deflection signal when the deflection signal has predetermined values,

a full-wave rectifier responsive to the outputs of said difference amplifier for passing said in-phase signal when it passes a prescribed value in one direction and passing said out-of-phase signal when it passes the prescribed value in the opposite direction,

a second diode having first and second electrodes,

means for connecting the first electrode of said second diode to the output of said rectifier, and

bias means connected to the second electrode of said second diode,

said second diode conducting to bypass a portion of the output of said rectifier when the rectifier output causes said second diode to conduct.

4. In a color display including a multi-beam kinescope and means for providing deflection signals for deflecting the beams, a convergence circuit for developing a signal for controlling convergence of a beam, said convergence circuit comprising

a difference amplifier having an input responsive to a deflection signal for producing a first output in phase with the deflection signal and a second output 180 degrees out-of-phase with the deflection signal,

rectifier means responsive to the outputs of said difference amplifier for reproducing the deflection signal with selected portions thereof inverted,

a second diode having first and second electrodes,

means for connecting the first electrode of said second diode to the output of said rectifier means, and

bias means connected to the second electrode of said second diode,

said second diode conducting to bypass a portion of the output of said rectifier means when the rectifier output causes said second diode to conduct.

5. In a color display including a multi-beam kinescope and means providing deflection signals for deflecting the beams, a convergence circuit for developing a signal for controlling convergence of a beam, said convergence circuit comprising

first means for attenuating a deflection signal when the deflection signal has predetermined values,

means for inverting the output of said first attenuating means when the value of the attenuated signal passes in one direction a predetermined threshold value, and for providing the attenuated signal at an output when its value passes in the opposite direction the predetermined threshold value, and

second means for attenuating selected portions of the output of said inverting means.

6. In a color display including a multi-beam kinescope and means providing deflection signals for deflecting the beams, a convergence circuit for developing a signal for controlling convergence of a beam, said convergence circuit comprising

means for inverting a deflection signal when the deflection signal has predetermined values, and

means connected to the input of said inverting means for selectively bypassing a portion of the deflection signal.

7. In a color display including a multi-beam kinescope and means providing deflection signals for deflecting the beams, a convergence circuit for developing a signal for controlling convergence of a beam, said convergence circuit comprising

means for inverting a deflection signal when the deflection signal has predetermined values, and

means responsive to the output of said inverting means for selectively varying the slope of a portion of the output thereof.

8. The convergence circuit according to claim 7 wherein said last named means comprises

means for selectively bypassing a portion of the output of said inverter means.

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