Aug. 30, 1955 R. W. SONNENFELDT 2,716,718

DYNAMIC ELECTRON BEAM CONTROL SYSTEMS

Filed April 29, 1953 2 Sheets-Sheet 1

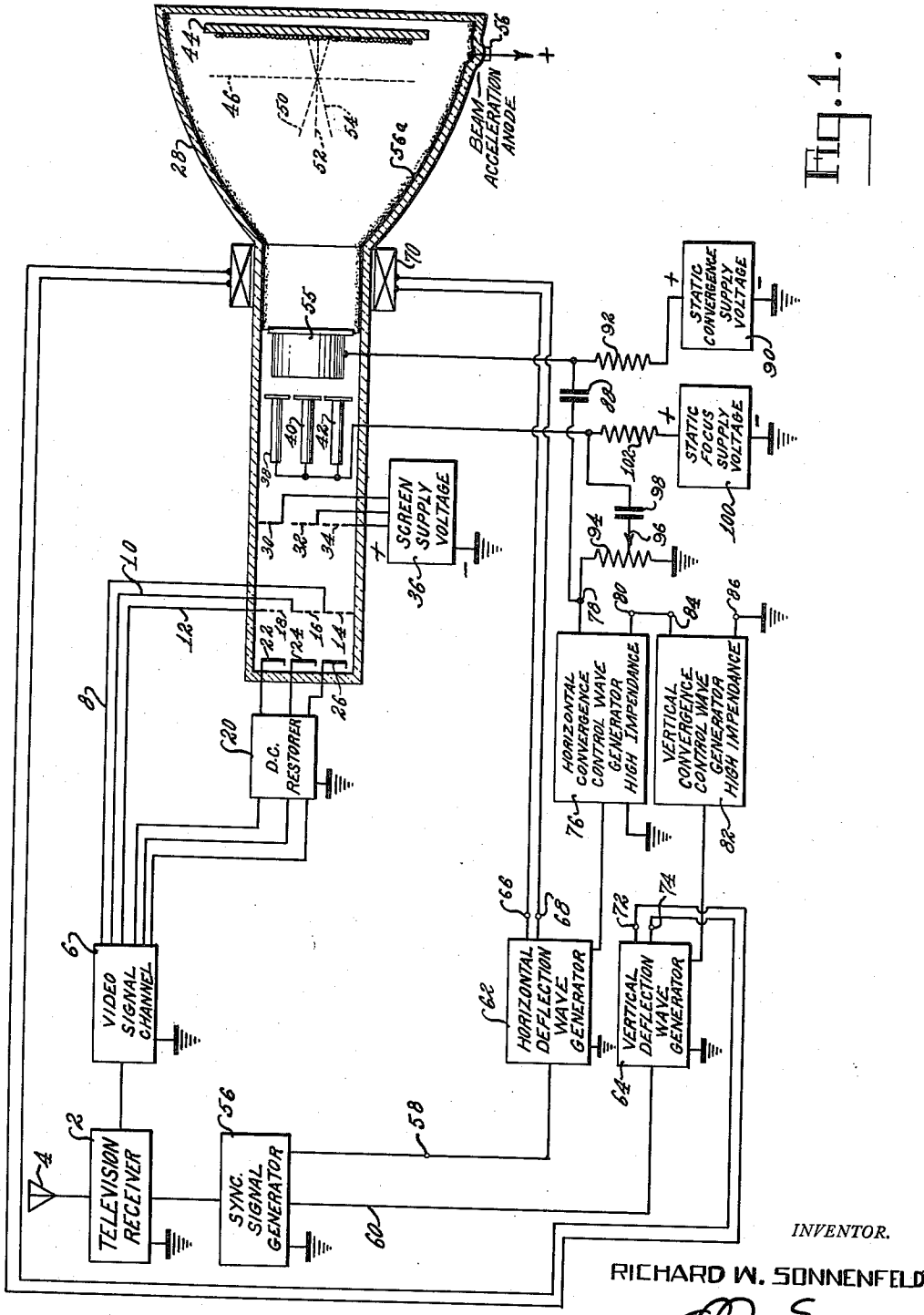


Fig. 1.

INVENTOR.

RICHARD W. SONNENFELDT

BY

ATTORNEY

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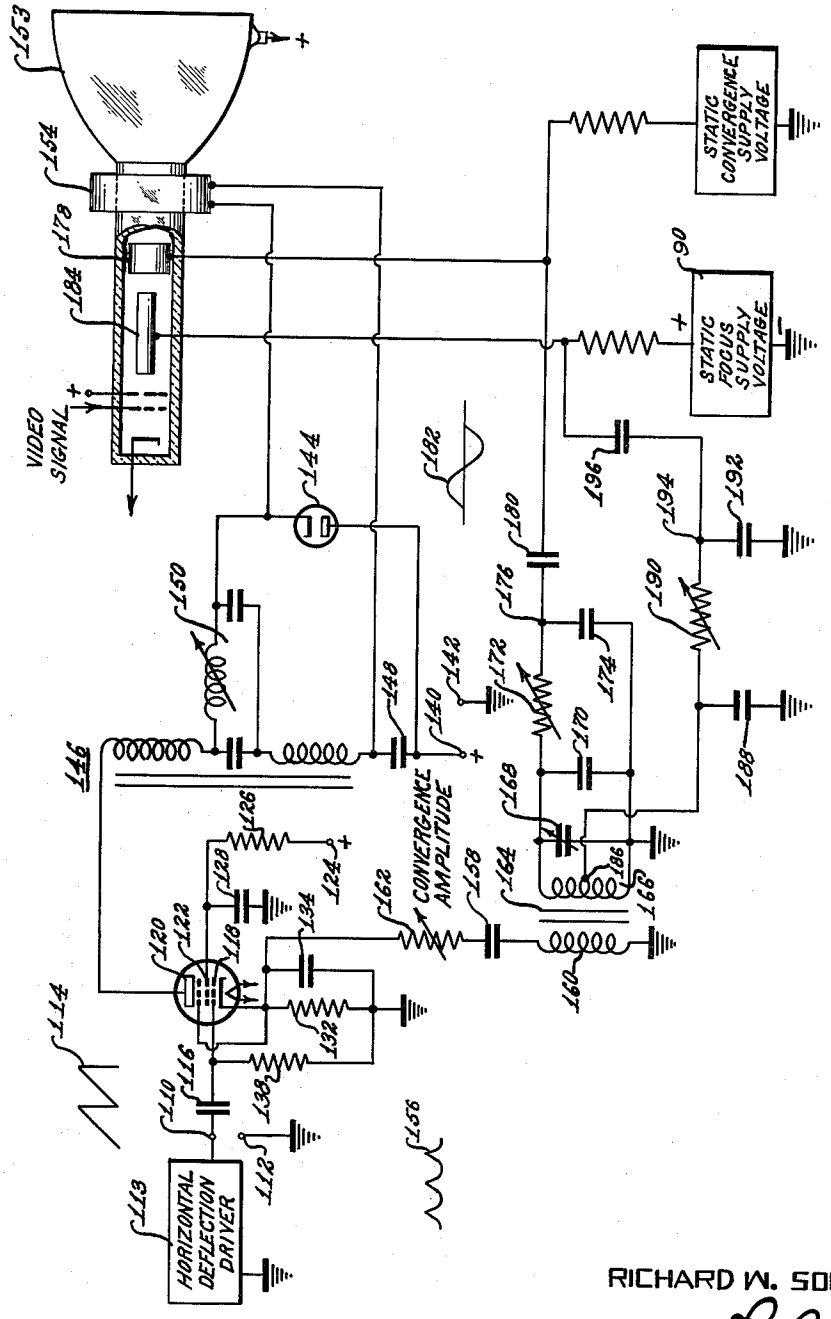


Fig. 2.

INVENTOR.

RICHARD W. SONNENFELDT

BY Otis J. Mitchell

ATTORNEY

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DYNAMIC ELECTRON BEAM CONTROL SYSTEMS

Richard W. Sonnenfeldt, Haddonfield, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application April 29, 1953, Serial No. 351,777

10 Claims. (Cl. 315—22)

This invention relates to systems for controlling the electron beams of cathode ray tubes and in more particularity, although not necessarily exclusively, to improved means for permitting the dynamic control of a plurality of electron beam components as employed in cathode ray tubes so as to maintain good focusing of the respective beam components and also to effect convergence of said components at all points of a raster scanned in a predetermined plane.

The present trend in television kinescopes is toward the use of flatter luminescent screens of increasingly greater areas. Also, the tendency is to shorten the tubes as much as possible to permit their employment in home instrument cabinets of smaller size. These factors make the problem of deflecting an electron beam or a plurality of electron beam components within a cathode ray tube a more difficult one. Deflection problems become even more complex when the size of the kinescope is increased along with the provision of specialized tube geometries aimed at enhancing the electron beam focus over the wide angles of deflection required in shorter tubes of large screen area.

A representative example of a cathode ray tube of the character referred to is a multi-color kinescope forming the subject matter of a United States patent of Alfred N. Goldsmith, No. 2,630,542, issued March 3, 1953, entitled "Multi-Color Television." The luminescent screen of this tube consists of a multiplicity of phosphor areas of sub-elemental dimensions. Different sub-elemental areas are respectively capable of producing a color of light corresponding to a different one of three component image colors, when excited by electron beam energy. In this tube the different light producing phosphor screen areas are excited respectively by a plurality of electron beams approaching the screen from different angles through an apertured masking electrode. Color selection is secured by controlling the angle at which the electron beams approach the screen.

Another representative example of a cathode ray tube with which the present invention may usefully be employed forms the subject matter of a copending U. S. patent application of Russell R. Law, Serial No. 130,195, filed November 30, 1949, now abandoned, and entitled "Color Television Reproducing Tubes." In general, the Law tube is similar to the Goldsmith tube. The chief difference is that the Law tube employs a single electron gun by which to produce the plurality of electron beam components whereas, in the Goldsmith tube, an electron gun is provided to produce each beam. This is accomplished by imparting a spinning type of movement to the beam so that it is made to rotate about the central or longitudinal axis of the tube. In its rotation about the tube axis, the beam occupies at insuccessive intervals, substantially the same positions as the different electron beams of the Goldsmith tube.

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

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

It has also been found that in wide angle cathode ray beam deflection systems the electron beam components tend to become defocused for the same reasons that a plurality of discrete electron beams tend to diverge when an attempt was made to converge them on a single point in the target plane. The electron beam convergence problem and the electron beam focusing problem in wide angle deflection systems are respectively discussed in U. S. patent application by Lorne R. Kirkwood, entitled "Dynamic Electron Beam Control Systems," filed November 30, 1950, Serial 198,313, now Patent No. 2,687,493. A complete color television receiving system using a parabolic waveform for both beam convergence and beam focus correction in a multigun color kinescope, is described in an article entitled "Compatible color TV receiver," by Kenneth E. Farr, appearing in the January 1953 issue of "Electronics," page 98. In the Kirkwood case and the "Electronics" article, it is pointed out that the electrical waveform required for electron beam convergence correction as well as focus correction are substantially the same. Accordingly, throughout the specification the terms "correction signal" or "correction waveform" will be meant to include the use of an electrical signal parabolic form to improve the dynamic beam convergence and/or dynamic beam focus in a cathode ray beam system.

The obtaining of truly parabolic waveforms of suitable amplitude for the correction of dynamic beam convergence and focus, without resorting to costly circuitry and apparatus, has presented itself as a major problem. Ideally, the beam convergence and beam focus correction waveform should be obtained directly from the cathode ray beam deflection circuits associated with the cathode ray tube in which beam convergence and beam focus correction is to be carried out. This is true since practice has shown that the amplitude of correction waveform required for convergence and focus correction in any given system is directly related to the amplitude of the beam deflection. Thus, if the correction waveform can be directly derived from those deflection circuits producing the basic beam deflection in the cathode ray beam device, aging of elements in the deflection circuits as well as long time changes in the values of circuit parameters can be met by complementary and corresponding changes in the amplitude of correction waveform.

It has been found that a sinusoid approximates a parabolic curve with sufficient accuracy to enable the energization of a cathode ray dynamic convergence control system by energy having a waveform sinusoidal in nature. One system in which this fact is applied is described in a co-pending U. S. patent application of Gordon S. Kelly et al., Serial No. 198,314, filed November 30, 1950, "Electron Beam Control System." In the Kelly disclosure, the convergence control system of the kinescope is energized by a wave of sinusoidal form and recurrent at the horizontal beam deflection frequency as well as by a substantially parabolic waveform at the vertical deflection frequency. In the Kelly case a low amplitude parabolic wave is derived from the horizontal deflection circuit and converted into a high amplitude sinusoidal signal. At the same time a sawtooth waveform of vertical deflection frequency is converted into a parabolic wave for additional energization of the convergence system. In the Kelly application the conversion of the parabolic wave derived from the horizontal deflection system into a sinusoidal waveform of high amplitude involves circuitry having a marked degree of complexity and construction cost.

It is therefore an object of the present invention to provide an improved and simplified electron beam control system by which it is possible to maintain uniformity of performance in beam deflection within a cathode ray tube.

It is a further object of the present invention to provide an improved signal generating circuit for developing high amplitude sinusoidal signals at a minimum of circuit complexity and expense.

It is also an object of the present invention to provide an improved and simplified means for deriving high amplitude signal energy for horizontal deflection cathode ray beam convergence and focus control from standard forms of cathode ray beam deflection circuits.

It is further an object of the present invention to provide an improved means for deriving a high amplitude sinusoidal deflection signal from a horizontal electromagnetic cathode ray beam deflection circuit of the type used in home instrument television receivers.

In the realization of the above objects and features of advantage, the present invention in one of its more specific embodiments, contemplates the development of a sinusoidal waveform through the use of a series tuned resonant circuit coupled with the cathode circuit of a deflection signal electron tube amplifier. The series resonant circuit includes the primary winding of a voltage step-up transformer whose secondary winding is connected to a phase shifting network, output signal from which is in turn applied to electromagnetic dynamic convergence control means of a cathode ray tube. Additional and independent phase shifting means may be connected from a tap along the secondary winding to provide a lower amplitude deflection voltage suitable for dynamic focus control in the same cathode ray tube.

A more complete understanding of the present invention as well as other objects and features of advantage will be gleaned from the reading of the following specification, especially when taken in connection with the accompanying drawings, in which:

Figure 1 is a combination block and schematic representation of one form of cathode ray beam system of the color kinescope variety with which the present invention may advantageously be employed.

Figure 2 is a combination and schematic representation of one form of horizontal deflection circuit embodying the present invention whereby to make available a sinusoidal and deflection waveform for use in a cathode ray beam deflection system.

Turning now to Figure 1 there is shown a block form and basic element of a dot multiplex type color television system to which the present invention may be advantageously applied. The underlying principle of operation of the dot sequential color television is treated at some length in an article entitled "Analysis of dot sequential color television," appearing in the October 1951 issue of the Proceedings of the Institute of Radio Engineers, page 1280.

In the arrangement of Figure 1 a television signal receiving means is indicated by block **2**. The television receiver amplifies signals detected by the antenna **4**, demodulates these signals and provides a video signal to the video signal channel means indicated by block **6**. Suitable color demodulation means are provided in the video signal channel **6** so that three separate component color signals are made available on the output buses **8**, **10** and **12** respectively connected with gun control electrodes **14**, **16** and **18**. Average brightness information for each color channel is developed by the D. C. restorer circuit **20**. The restorer circuit **20** is a three channel device which permits separate brightness information to be applied to the separate electron gun cathodes **22**, **24** and **26**.

As described in an article entitled "A three gun shadow mask color kinescope," by H. B. Law, appearing in October 1951 issue of the Proceedings of the I. R. E., pages 1186–1194, the color television picture reproducing kinescope **28**, referred to sometimes as a "Triniscope," includes three separate cathode ray beam gun structures. The gun control electrode and cathode of these gun structures have been described hereinabove. Also shown within the envelope **28** are the respective gun screen electrodes **30**, **32** and **34**. The gun screen electrodes are connected in a conventional fashion to a source of positive power supply potential indicated by the block **36**. Focus control electrodes are indicated at **38**, **40** and **42** for focusing the respective electron beams onto the multicolor phosphor dot target **44**. A shadow mask for producing selective energization of predetermined color dots by the respective electron beams is indicated at **46**. For purposes of illustration the direction of approach to the target of the three electron beams produced by the three electron beam guns, is indicated by the dotted lines **50**, **52** and **54**. Thus, as described in the above article "A three gun shadow mask color kinescope" the three beams produced by the respective electron guns passing through a given aperture in the shadow mask **46**, will excite respective deposits of phosphor on the target **44**. The phosphor deposits on the target **44** are arranged in tangential relationship so that any group of three deposits served by a given aperture in the shadow mask **46** will, when simultaneously excited by properly balanced beam energy, act to produce a resultant white light. A beam convergence electrode **55** is provided for insuring the coincidence of the three beams upon any given aperture in the shadow mask **46** for any angle of beam deflection. This convergence control results from an electrostatic lens effect produced by maintaining the ultor or beam accelerating anode **56** with the conductive coating **56***a* at a higher positive potential than the focus electrode **55**.

The method by which the beam convergence electrode serves to improve coincidence of the three electron rays produced by the three separate electron beam guns is discussed in an article "Deflection and convergence in color kinescopes" by Albert W. Friend, appearing in the Proceedings of the I. R. E. for October 1951, pages 1249–1263. In this article it is pointed out that in order to accomplish a satisfactory degree of beam convergence over very wide angles of deflection, the waveform of voltage applied to the beam convergence electrode **55** should be substantially parabolic in shape, and synchronously related to the deflection signal of the system. As brought out in the above identified U. S. patent application "Dynamic Electron Beam Control Systems," filed November 30, 1950, Serial No. 198,313, by Loren R. Kirkwood, the dynamic beam convergence signal applied to the beam convergence electrode **55** may also be applied to the gun focus electrodes **38**, **40** and **42** to improve the uniformity of focus of each of the beams over the area of the

target 44. It is with the production or generation of the required parabolic waveform for use as a beam convergence electrode or for use as a beam convergence signal or gun focus control signal, that the present invention is concerned.

The general method of generating the required parabolic waveform and applying the resulting waveform as a correction signal to the beam convergence electrode and gun focus electrodes of a color triniscope, is illustrated in Figure 1. Demodulated video signal developed by the television receiver 2 is also applied to a sync signal separator 56. Circuits of this type are well known in the art and act in such a way as to separate the synchronizing component from the composite video signal as demodulated by the television receiver 2. Separated horizontal synchronizing signal may then appear on bus 58 while vertical synchronizing signal may appear on bus 60. These synchronizing signal buses are respectively connected with the input circuits of the horizontal and vertical deflection wave generators 62 and 64. The deflection wave generators 62 and 64 may be of conventional form. Horizontal deflection signal is developed across the output terminals 66 and 68 of the horizontal deflection wave generator. The output terminals 66 and 68 are connected with the horizontal deflection winding of the deflection yoke 70 surrounding the neck of the triniscope 28. Output terminals 72 and 74 for the vertical deflection wave generator 64 are correspondingly connected with the vertical deflection winding of the beam deflection yoke 70. Horizontal deflection wave energy is extracted from the horizontal deflection wave generator 62 and applied to a horizontal convergence control wave generator 76 which is designated as having a high impedance. The parabolic control wave for horizontal beam convergence and focus correction therefore will appear across the terminals 78 and 80 of the control wave generator 76. A corresponding control wave generator 82 is provided for excitation from the vertical deflection wave generator 64. The required parabolic control waveform developed by the vertical convergence and focus control wave generator will therefore appear across terminals 84 and 86 thereof. As shown in the drawing the parabolic control waveform output signals of the horizontal and vertical convergence and focus control wave generators are serially added with one another to provide a composite waveform which may be applied to the beam convergence electrode 55. As shown in the drawing the terminal 86 of the vertical convergence focus control wave generator is grounded while the terminal 78 of the horizontal convergence and focus control wave generator is capacitively coupled, via capacitor 88, to the beam convergence electrode 55. A high potential static convergence supply voltage is provided by the voltage producing means 90. One terminal of the supply voltage means 90 is grounded while the other terminal is connected through a high resistance 92 to the beam convergence electrode 55. Thus the composite parabolic convergence and focus control wave will be superimposed upon the static potential developed by the supply voltage means 90.

In order to provide dynamic focus correction of the electron beams produced by the electron ray guns within the triniscope 28, a voltage dividing means 94 is connected across the terminal 78 to ground. A variable tap 96 on the resistance element 94 permits any voltage level of composite horizontal and vertical convergence and focus control wave to be obtained. This reduced amplitude version of the composite control wave is coupled via capacitor 98 to the gun focus electrodes 38, 40 and 42, as described in the above Kirkwood patent application. Static focus supply voltage is supplied by the voltage supply means 100 having one terminal grounded and its positive terminal connected through a relatively high value resistor 102 to the gun focus electrodes.

It is noted that since the vertical convergence and focus control waveform generator is productive of a lower frequency parabolic voltage than the horizontal convergence focus control wave generator, it has one of its terminals connected with ground potential as shown at terminal 86. This prevents the possible attenuation of the higher frequency components of the high impedance horizontal convergence and focus control waveform generator from being dissipated in the circuit capacitances of the vertical convergence focus control waveform generator as would be the case were the horizontal control waveform generator placed at ground potential instead of the vertical generator.

The above description of the arrangement of Figure 1 has been in an attempt to establish a better understanding of the nature of certain problems in electron beam control solved by the practice of the present invention. As pointed out at the beginning of this specification the present invention concerns itself more directly with improved means for accomplishing the generation of a horizontal convergence and focus control waveform and hence is directed to a general form of improved circuitry which in essence combines the functions of blocks 62 and 76 in Figure 1. That is it incorporates in a single circuit a horizontal deflection waveform generator action as well as a horizontal convergence and focus control waveform generator action.

One embodiment of the present invention is shown in Figure 2. In Figure 2 it will be assumed that a saw tooth deflection waveform of suitable linearity for cathode ray beam deflection purposes is available across terminals 110 and 112. A source of such a signal is indicated at 113. The sawtooth waveform 114 appearing across these terminals is capacitively coupled via capacitor 116 to the control electrode 118 of a pentode type vacuum amplifier 120. It will be appreciated that the merits of the present invention are in no way limited to the particular form of vacuum tube employed. Where a pentode amplifier is used, a screen biasing potential may be applied to the screen electrode 122 from a source of positive potential power supply 124 through a dropping resistor 126. A conventional screen electrode bypass capacitor 128 is connected from the screen electrode 122 to circuit ground. Anode power supply requirements for the vacuum tube 120 are supplied from a power supply having a positive terminal 140 and a negative terminal 142, the latter being established at circuit ground. The diode 144 is connected with the auto transformer 146 through B boost capacitor 148 and linearity control network 150 in accordance with well known practice. Diode 144 through its unilateral conduction characteristics effectively captures stored magnetic energy in the auto transformer 146 at the end of deflection cycle and charges the B boost capacitor 148 therewith. This results in an effectively higher anode power supply potential for the tube 120 than is available at terminal 140. The horizontal deflection winding of the deflection yoke 154 is connnected from the cathode of the diode 144 to the upper terminal of capacitor 148. Vertical deflection coil connections to the deflection yoke 154 are not shown. Details of the operation of the above described B boost deflection circuit which results in a sawtooth current flow through the horizontal deflection winding of the deflection yoke 154, are discussed in considerable detail in the U. S. Patent to Edwin L. Clark, No. 2,536,835, issued January 2, 1951, entitled "High-Efficiency Cathode-Ray Beam Deflection System."

In the practice of the present invention, advantage is taken of the fact that there is produced, in the normal operation of the above described horizontal deflection circuit, a parabolic wave form across the cathode resistor 132 connected in the cathode circuit of the pentode 120. The parabolic waveform developed across resistor 132 may be illustrated by the curve 156. This signal is generally of insufficient amplitude for dynamic beam convergence or focus control of a cathode ray tube.

In accordance with the present invention, a series tuned circuit is imposed across the resistor **132**. This tuned circuit is made up of the capacitor **158** and inductor **160**. The values of capacitor **158** and inductor **160** are selected to form a series resonant circuit at the horizontal deflection rate, which according to present R. T. M. A. standards in the United States is 15,750 cycles per second. Variable resistor **162** connected in series with the tuned circuit controls the amount of energy applied thereto. The variable resistor **162** may also be thought of as a means for controlling the Q of the tuned circuit and hence the maximum current that will flow therethrough upon its excitation from the signal developed across the cathode resistor **132**.

In further accordance with the embodiment of the present invention, shown in Figure 2, the inductor **160** is made to act as the primary winding of a transformer means **164** whose secondary winding **166** is designed with a voltage step-up relationship with respect to the primary winding **160**. The secondary winding **166** is in turn shunted by the capacitors **168** and **170** in order to form a parallel resonant circuit which also may be tuned to the horizontal deflection frequency of the cathode ray beam deflection system. By such means a very high amplitude sinusoidal signal can be developed across the capacitor **170**. A phase shifting means comprising variable resistor **172** and condenser **174** is connected across the capacitor **170**. In this way the relative phase of the signal appearing at terminal **176** may be varied with respect to the retrace interval of the deflection cycle. This facility permits optimum dynamic convergence correction to be achieved upon application of the signal appearing at terminal **176** to the convergence electrode **178** via capacitor **180**. As shown in Figure 1, the sinusoidal convergence signal **182** appearing at terminal **176** is superimposed upon the static convergence electrode supply voltage developed by the voltage supply means **90**.

In further accordance with the present invention, dynamic focus control may be accomplished by applying a reduced amplitude version of the correction sinusoid to the focus electrode **184**. In accordance with the arrangement of Figure 2, this is accomplished by tapping the secondary winding **166** at some point such as **186**. The sinusoidal wave form appearing thereat is then conveyed to an individual variable phase shifting network comprising capacitor **188**, resistor **190** and capacitor **192**. The value of capacitor **188** will, of course, be taken into consideration in determining the resonant frequency of the secondary winding **166** along with other circuit capacitances. The phase shifted lower amplitude correction waveform appearing at terminal **194** of capacitor **192** may then be applied through coupling capacitor **196** to the convergence electrode **184**. Static focus electrode supply voltage is developed by the voltage supply means **90**.

It is, therefore, seen that in accordance with the present invention very little additional circuit complexity and construction cost is necessary to derive from a standard cathode ray beam deflection circuit, a high amplitude signal suitable for dynamic beam convergence and focus correction. For purposes of simplicity, the kinescope **153** of Figure 2 has been illustrated as being of the single electron gun type. It will be appreciated however upon reference to Figure 1 and the description thereof, that the circuitry of Figure 2 is equally applicable to a multi-gun kinescope such as **28** in Figure 1.

It will be further recognized that the advantageous arrangement provided by the present invention can be applied to both the horizontal and vertical deflection circuits of a television system, provided operating frequencies and operating waveforms are suitable for the excitation of the series tuned circuit described above.

What is claimed is:

1. In a cathode ray beam deflection system the combination of: a source of cathode ray beam deflection signal; a signal amplifying means having an input circuit and an output circuit; signal coupling means from said source of deflection signal to said amplifier input circuit; primary cathode ray beam control means coupled with said amplifier output circuit for deflecting electron beam components in accordance with said deflection signal; means coupled with said signal amplifier for developing a derivative signal in accordance with said deflection signal; a series resonant tuned circuit connected in shunt with said last named means, said series resonant circuit being tuned to the fundamental of said deflection signal; voltage step up means magnetically coupled to said series resonant circuit, said voltage step up means including a winding having a predetermined inductance value; capacitance means connected in shunt with said winding to form a parallel resonant circuit whose frequency of resonance is substantially in the range of the fundamental of said deflection signal; secondary cathode ray beam control means; and signal coupling means connected from said voltage step up winding to said secondary beam control means.

2. A system according to claim 1 wherein said signal coupling means connected from said voltage step up winding to said secondary beam control means includes a variable phase shifting network.

3. In a cathode ray beam deflection system the combination of: a source of cathode ray beam deflection signal; an amplifier having an input circuit and an output circuit, said amplifier including an electron discharge device having at least a cathode element; a circuit ground for said amplifier; impedance means coupled from said cathode to said circuit ground; signal coupling means connected from said deflection signal source to said amplifier input circuit; a primary cathode ray beam control means coupled with said electron tube amplifier output circuit for energization by signals delivered by said amplifier; a series resonant tuned circuit having resonant frequency in the range of the frequency of the fundamental component of said deflection signal; a voltage step up winding magnetically coupled to said series resonant circuit, said voltage step up winding having a predetermined inductance value; capacitance means connected in shunt with said voltage step up winding to form a parallel resonant circuit; secondary electron beam control means acting conjointly with said primary electron beam deflection means; and electrical signal coupling means connected from said voltage step up winding to said secondary electron beam control means.

4. In an electron beam deflection system, a deflection signal generating circuit comprising in combination: a circuit ground terminal; an input terminal reference with said circuit ground terminal designated to receive a periodically recurrent deflection signal; an electron tube amplifier having at least an anode, cathode and control electrode; an input circuit connected from said control electrode to said cathode; an output circuit connected between said anode and said cathode; an impedance means connected from said cathode to said circuit ground terminal; signal coupling means connected from said input terminal to said input circuit; primary electron beam influencing means connected with said output circuit; a series resonant circuit connected between said cathode and said circuit ground terminal; voltage step up winding means magnetically coupled to said series resonant circuit; and secondary electron beam influencing means designated to act conjointly with said primary electron beam influencing means; and signal coupling means connected from said voltage step up winding to said secondary electron beam influencing means.

5. Apparatus according to claim 4 wherein said signal coupling means connected from said voltage step up winding to said secondary electron beam influencing means includes an electrical phase shifting means.

6. Apparatus according to claim 4 wherein said series

resonant circuit is resonant to the fundamental recurrence frequency of said deflection signal.

7. Apparatus according to claim 6 wherein there is additionally provided capacitance means connected in shunt with said voltage step up winding means to form a parallel resonant circuit whose resonant frequency is substantially the same as the resonant frequency of said series resonant circuit.

8. In a cathode ray tube beam deflection system the combination of: a first, second and third terminal means respectively designated for connection to a cathode ray beam deflection yoke, a cathode ray tube beam focusing electrode, and a cathode ray tube beam convergence electrode; an input terminal designated to receive cathode ray beam deflection signal substantially sawtooth in waveform; a circuit ground terminal to which said input terminal is referenced; an electron discharge tube having at least an anode, cathode and control electrode; signal coupling means connected from said input terminal to said control electrode; signal coupling means connected from said anode to said first terminal means; a series resonant circuit connected from said cathode to said circuit ground terminals; a signal step up transformer having primary and secondary windings, said primary winding being included at least in part in said series resonant circuit; signal coupling means connected from one extremity of said secondary winding to circuit ground; signal coupling means connected from the other extremity of said secondary winding to said second terminal means; and signal coupling means connected from an intermediate tap on said secondary winding to said third terminal means.

9. Apparatus according to claim 8 wherein there is additionally provided a capacitor connected in shunt with said secondary winding to form a parallel resonant circuit, the value of said capacitor being so chosen relative to the inductance of said secondary winding as to produce a resonant frequency substantially equal to the resonant frequency of said series resonant circuit of which said primary winding forms a part.

10. Apparatus according to claim 9 wherein there is included a separate phase shifting means in each of said coupling means between said secondary winding and said second and third terminal means.

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