Oct. 7, 1958 O. H. SCHADE 2,855,542

BEAM CONVERGENCE APPARATUS FOR TRI-COLOR KINESCOPE

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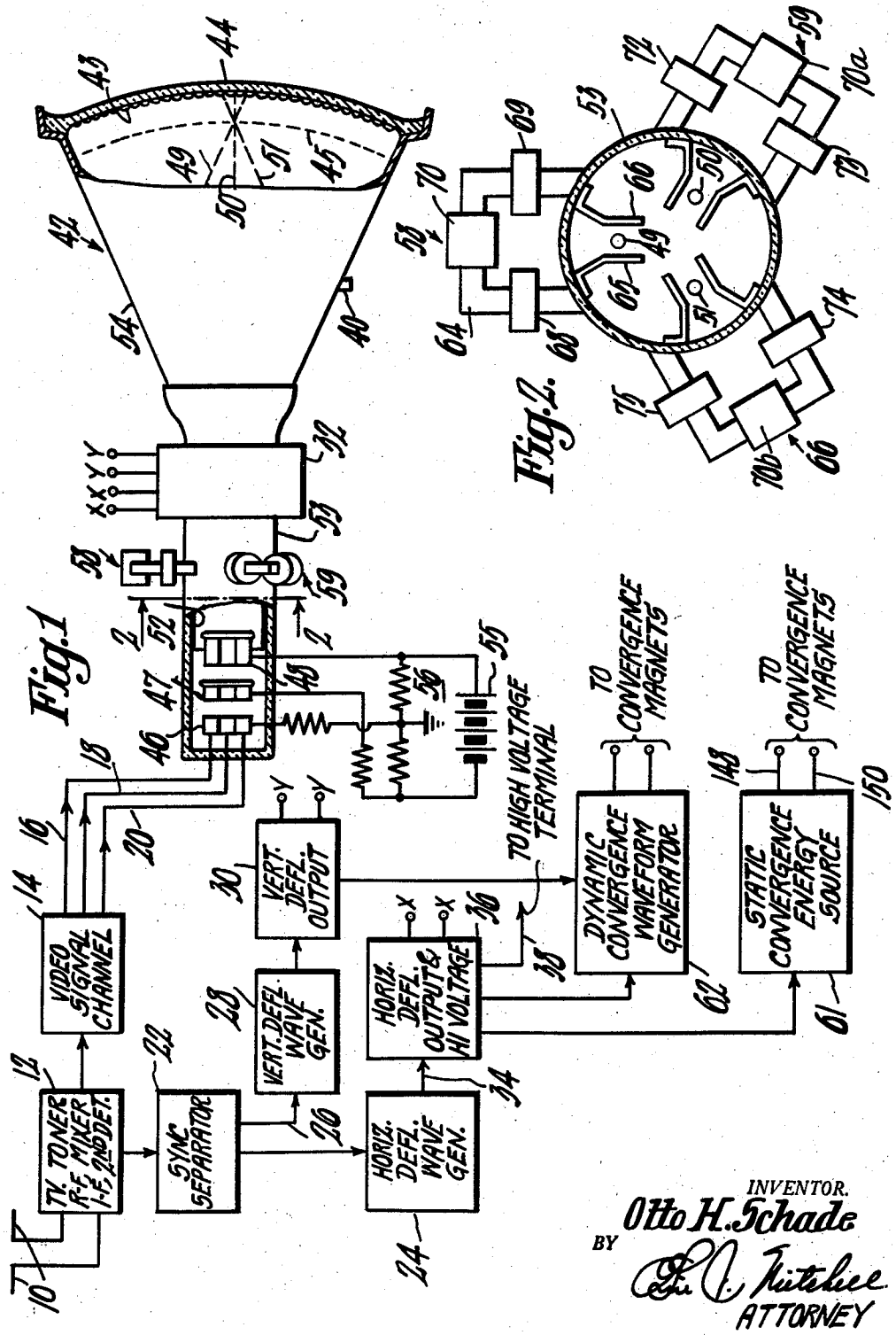



Fig. 1



Fig. 2.

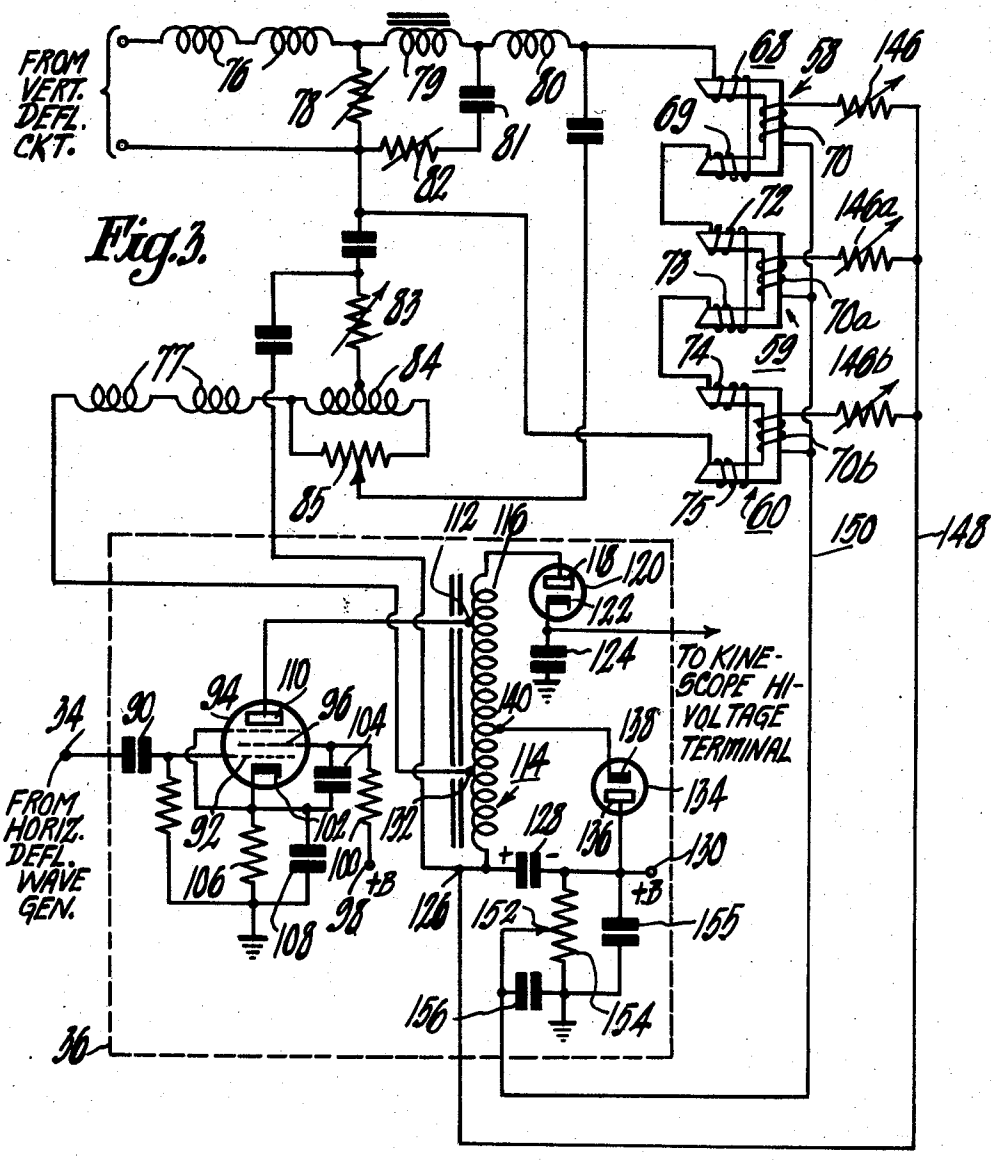
INVENTOR.
Otto H. Schade
BY
ATTORNEY

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Fig. 3.




INVENTOR.
Otto H. Schade
BY
Otto V. Mitchell
ATTORNEY

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Fig. 4.

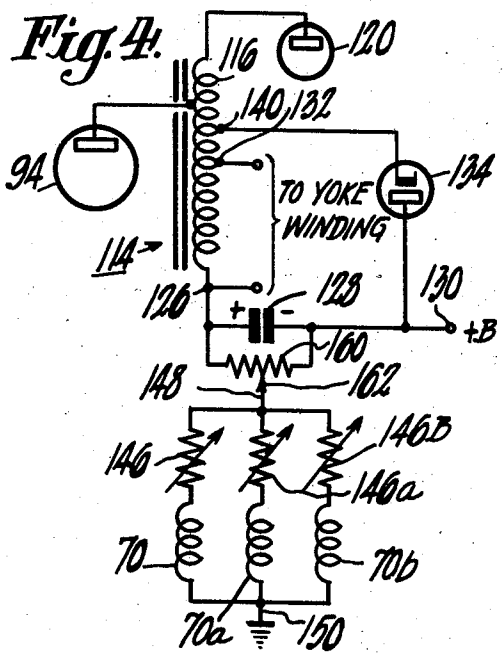



Fig. 6

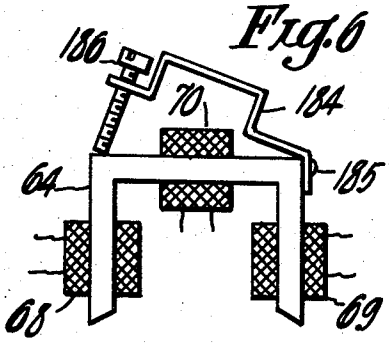



Fig. 7.

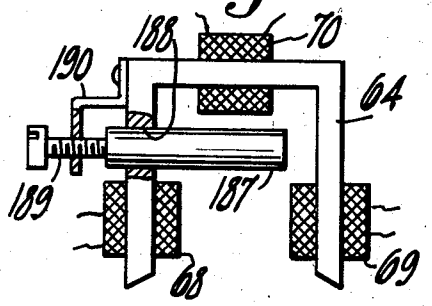



Fig. 5.

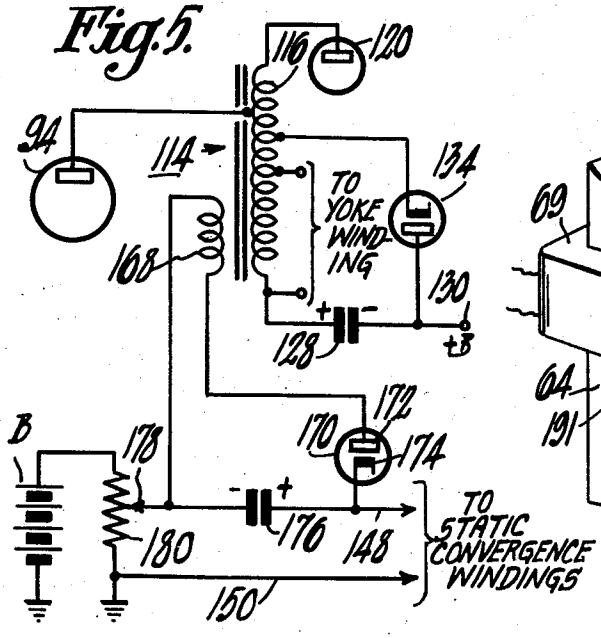
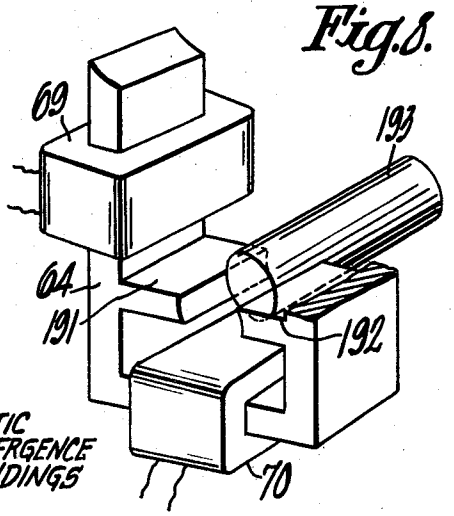



Fig. 8.




INVENTOR.
Otto H. Schade
BY
Otis V. Mitchell
ATTORNEY

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# BEAM CONVERGENCE APPARATUS FOR TRI-COLOR KINESCOPE

Otto H. Schade, West Caldwell, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application April 29, 1955, Serial No. 504,901

9 Claims. (Cl. 315—13)

The present invention relates to electron beam controlling systems and, particularly, to systems in which several electron beams are deflected by a common deflection apparatus.

One environment in which the present invention may be successfully employed is that involving a color kinescope of the type described in an article entitled "A Three Gun Shadow Mask Color Kinescope," by H. B. Law, published in the Proceedings of the IRE, volume 39, No. 10, October 1951. Such a tube has a luminescent screen as part of a target electrode structure in which different phosphor areas produce differently colored light when excited by electron beam components impinging upon it from different angles, the angle of impingement determining the particular color of the light produced by the phosphor areas. The invention also pertains, for example, to a kinescope of the type described in an article entitled "A One Gun Shadow Mask Color Kinescope" by R. R. Law, published in the Proceedings of the I. R. E., volume 39, No. 10, October 1951.

It is necessary for the satisfactory operation of such kinescopes to effect substantial convergence of the different electron beam components at all points of the raster scanned thereby at the target electrode. In general, this convergence may be effected by means of apparatus such as that disclosed in an article entitled, "Deflection and Convergence in Color Kinescopes" by A. W. Friend, published in the same issue of the "Proceedings of the I. R. E." cited above. Such beam convergence apparatus includes an electron-optical system by which to control the beam convergence angles. The electron-optical system is variably energized as a function of the radial angle of beam deflection.

Another type of apparatus for controlling the convergence of a plurality of electron beam components and with which the present invention is more particularly concerned comprises, in general, means for producing a plurality of electron beam components which traverse pre-deflection paths that are spaced respectively about the longitudinal axis of the tube and individual electro-magnetic means located respectively adjacent to the pre-deflection beam paths and of such character as to be energizable directly from the beam deflection circuitry in a manner to effect the desired beam convergence. In this fashion, the beam convergence angle may be varied in a manner suitable to maintain the desired beam convergence at all points in the scanned raster. It has been customary to provide, in connection with the type of apparatus alluded to, a convergence control for the several beam components in the nature of a direct current (i. e. static) convergence in order to effect proper convergence of the several beam components at the center of the screen. That is to say, in addition to the electromagnetic means described above which are provided for dynamic convergence of the beam components, it has also been found desirable to compensate in a static fashion for misalignment of the electron beam components which may result from manufacturing variations and the like.



As will be pointed out more fully hereinafter, the deflection of an electron beam per unit of magnetic field intensity varies inversely as a function of the potential gradient within which the beam is operating. That is to say, if the intensity of an electromagnetic deflection field is maintained constant, but the voltage of the electron beam being deflected decreases, the beam will be deflected a greater amount. It has, therefore, been found necessary to employ rather elaborate arrangements for regulating the high voltage applied to the target or final anode of the kinescope whose beams are being converged, for otherwise misconvergence of the electron beams will result from differing deflection per unit of magnetic field intensity with differing high voltage. In the interest of efficiency, most present day television horizontal deflection circuits include means such as a power amplifier tube for driving a sawtooth current waveform through some form of transformer which couples the sawtooth energy to the raster scanning deflection coils. Through the agency of a voltage step-up winding, the flyback pulses produced in the circuit inductances during the scanning retrace intervals are applied to a rectifier tube and filtered to afford a high unidirectional potential suitable for application to the final anode of the kinescope. Where the high voltage must thus be regulated, as through the agency of an absorption type voltage regulator which maintains a constant power load on the high voltage source, there is imposed a continuous peak power load on the deflection system which increases the power demands upon the scanning tube and the low voltage B+ supply.

It is an object of the present invention to provide means for obviating or, at least, minimizing regulation of a high voltage power supply for a kinescope, insofar as the dependency of deflection upon high voltage provision is concerned.

Another and more specific object of the invention is the provision of novel static beam convergence means which, by their nature, eliminate the necessity for apparatus for regulating the high voltage supply which energizes the target electrode of a kinescope.

Stated otherwise, it is an object of the present invention to provide means for maintaining beam convergence independent of high voltage changes.

In general, the present invention, as employed in conjunction with the beam convergence apparatus of a tricolor kinescope, comprises electromagnetic windings for effecting static beam convergence and means for energizing such windings in part by rectified deflection energy and in such manner as to provide an established relation between high voltage and the static convergence field strength. As will be appreciated, the present invention permits substantial simplification of high voltage and deflection circuitry.

Additional objects and advantages of the present invention will become apparent to those skilled in the art from a study of the following detailed description of the accompanying drawing, in which:

Figure 1 illustrates, by way of block diagram, a color television receiver embodying the principles of the present invention;

Figure 2 is a vertical sectional view taken along line 2—2 of Figure 1;

Figure 3 is a schematic diagram of circuitry for performing certain of the functions indicated in Figure 1 in accordance with the invention;

Figures 4 and 5 illustrate schematically additional forms of the invention; and

Figures 6, 7 and 8 illustrate further forms of the invention.

As used herein, it will be understood that the term "beam components" denotes either a plurality of individual electron beams emanating respectively from a plurality of electron guns or from a single electron gun provided with suitable apparatus for forming several individual beams and, in addition, those components of a single electron beam to which is imparted a spinning motion so as to trace a substantially conic locus at different positions thereof.

Reference now will be made to Figure 1 for the general description of an illustrative color television receiver embodying an electron beam convergence system in accordance with the present invention. Composite color television signals which may, for example, be of the type set forth in the standards promulgated by the Federal Communications Commission on December 17, 1953 are intercepted by an antenna **10** and applied to the input terminals of a television tuner section **12** which may be understood as including radio frequency amplification stages, a mixer or converter, intermediate frequency amplifier stages and the second or video detector. The detected composite color television signal is, in turn, applied to a video signal processing channel **14** which performs the function of deriving therefrom video signals representative, respectively, of the component colors of an image (e. g. red, green and blue). Such color video signals are available at the leads **16**, **18** and **20**. Circuitry for performing the functions of blocks **12** and **14** may be found, for example, in the book entitled, "Practical Color Television for the Service Industry," revised edition, April 1954, second edition, first printing, published by the RCA Service Co., Inc., a Radio Corporation of America subsidiary.

The video signals detected within the receiver portion **12** are or may be suitably clipped to provide horizontal and vertical synchronizing pulses for application to the sync separator circuit **22**. The horizontal sync pulses then appearing at the output terminal of the sync separator circuit are applied for synchronization of the horizontal deflection signal generator or oscillator **24**, while the vertical synchronizing pulses are applied via the lead **26** to the vertical deflection signal generator **28**. The output of the vertical deflection generator **28** is conventionally connected for driving the vertical deflection output amplifier **30** which, in turn, drives a suitable sawtooth current of television field frequency through the terminals Y—Y and the vertical deflection winding forming a part of the conventional electromagnetic deflection yoke **32**. The output sawtooth wave of television line frequency provided by the horizontal deflection generator **24** is applied via a lead **34** to a horizontal deflection output and high voltage stage indicated by the block **36** and to be described in greater detail hereinafter. The horizontal deflection output stage applies, via the terminals X—X, sawtooth current wave-forms of line frequency to the deflection yoke **32** and also furnishes, in a manner to be described, a high positive operating voltage which is applied via the lead **38** to the high voltage or ultor terminal **40** of the kinescope **42**.

The kinescope **42** may be of the same general type as that disclosed in the H. B. Law paper referred to earlier. It will be understood, however, that the kinescope may be of other types such as that shown in the R. R. Law paper. In either case, the kinescope **42** has a luminescent screen **43** provided with a multiplicity of small phosphor areas arranged in groups and capable, respectively, when excited by an electron beam, of producing light in the different component colors in which the image is to be reproduced. The luminescent screen may, as shown, be deposited directly upon the rear surface of the glass face plate **44** of the kinescope. In back of and spaced from the screen **43** is an apertured masking electrode **45** which has an aperture for and in alignment with each group of phosphor areas of the screen.

In the particular tube illustrated, the kinescope also has a plurality of electron guns, equal in number to the number of component colors in which the image is to be reproduced. Each of these guns may be conventional, consisting of a cathode, a control grid electrode and a focusing electrode. Since the three guns are identical, the different parts thereof will be referred to collectively as the cathodes **46**, the control grids **47** and the focusing electrodes **48**. The three electron guns produce schematically represented electron beams **49**, **50** and **51** by which to energize, respectively, the blue, red and green phosphor areas of the screen **43**. When these electron beams are properly converged at the masking electrode **45**, they pass through the apertures thereof from different directions and impinge upon different phosphor areas of the various groups so as to produce blue, red and green light. It is to be noted that the size of the phosphor areas, the angles between the beams and the spacing of the mask **45** from the screen **43** as compared with the length of the tube are exaggerated for better illustration of the operation of the kinescope.

The electron-optical apparatus of the kinescope **42** also includes a beam accelerating electrode consisting, in the present instance, of a conductive wall coating **52** formed on the inner surface of the tubular glass neck **53** of the kinescope and extending from the region adjacent to the outer end of the focusing electrodes **48** to the conical section **54** of the tube which, in this case, is metallic. Suitable electrical connection (not shown) is made at the junction of the wall coating with the metal cone **54**. The target electrode structure including the masking electrode **45** and the luminescent screen **43** which, for this purpose, may be metalized, is electrically connected to the metal cone **54** by suitable means (not shown). Metallization of a luminescent screen of the character described may be effected in the manner disclosed in a paper by D. W. Epstein and L. Pensak entitled, "Improved Cathode Ray Tubes With Metal-Backed Luminescent Screens," published in the RCA Review, vol. VII, March 1946.

The described electrode structure of the kinescope may be energized in a conventional manner as illustrated in which the source of energy for the cathodes, control grids and focusing electrodes is represented diagrammatically by a battery **55** across the terminals of which there is connected a voltage divider **56**. The cathodes **46** are connected to the grounded point of the voltage divider and the control grids **47** are connected to a point which is somewhat negative relative to ground. Similarly, the focusing electrodes **48** are connected to a point on the voltage divider which may conventionally be at a higher positive potential relative to the grounded cathodes. The beam accelerating anode, including the wall coating **52** and the metal cone **54**, is provided with its high, positive operating potential via the terminal **40** which is connected to the lead **38** from the high voltage portion of the horizontal deflection output stage **36** and which will be described more fully.

The electron beams **49**, **50** and **51** are suitably modulated in intensity under the control of the several component color-representative video signals from the leads **16**, **18** and **20**. While the source of signals has been illustrated as comprising a color television receiver, it will be understood that the video signal source may be a color television camera, in the event that the kinescope **42** is employed as a monitor, for example. Also, it will be understood that the illustrated connection of the video signal source to the electron guns of the kinescope is merely diagrammatic and that these connections may or may not be made directly to the cathodes. Instead, they may be made to the grids **47** or to both the cathodes and control grids.

The beam convergence system, in accordance with the present invention, also includes a plurality of electromagnetic field-producing elements such as the magnets **58** and **59** mounted around the neck **53** of the kinescope

adjacent to the pre-deflection paths of the electron beam components. It is to be understood that the precise location of these magnets is not necessarily indicated in the drawing. Instead, as will appear in greater detail, it is to be understood that each of these magnets is located relative to one of the electron beam components so as to influence its associated beam component to the substantial exclusion of the others. Furhermore, it is to be understood that these magnets are of a character which, when suitably energized, produce respective fields which are transverse to the associated beam paths.

Figure 2 shows more clearly the relative positions of the convergence magnets such as **58** and **59** and, additionally, **60**, relative to one another and to the electron beams with which they are respectively associated. Inasmuch as all of these magnets are substantially identical, only one of them will be described in detail.

Before describing the details of the convergence system, however, a brief description will be given of the general manner in which the apparatus functions to produce the desired result. The convergence magnets **58**, **59** and **60** are energized by unidirectional energy from the static convergence energy source **61** so as to effect an initial convergence of the electron beam components substantially at the apertured masking electrode **45**. In order to do this, the unidirectional energization of the magnets is affected in such a way that the magnets may be individually energized in different magnitudes. It is to be understood that, in effecting the initial beam convergence, the beams may be in any desired one of their different deflected positions. For example, they may be initially converged at the center of the raster to be scanned or, alternatively, they may be initially converged at one corner of the raster. The convergence magnets **58**, **59** and **60** are also dynamically energized by control wave energy derived from a generator **62** so as to effect a periodic variation of the magnitude of the transverse fields produced respectively thereby. These field strength variations are in accordance with a predetermined function of the beam deflection. Variations in the strength of the fields produced by the convergence magnets effect corresponding variations in the paths of the electron beam components relative to the longitudinal axis of the tube. Hence, suitable variations are made in the convergence angles between the various beam components so as to produce the desired convergence of the beam components at the masking electrode **45**.

The convergence magnet **58** which is associated, by way of illustration, with the "blue" electron beam **49** is provided with a core comprising a generally U-shaped pole piece which is so mounted as to form a continuous U-shaped magnetic path in close association with the tube neck **53**. In accordance with a specific embodiment of the present invention, the convergence magnets are associated with a tri-color kinescope having internal pole pieces. That is, and as is illustrated, a pair of radially and inwardly extending internal pole pieces is provided for each of the magnets **58**, **59** and **60**. The magnet **58**, for example, is provided with a pair of internal pole pieces **65** and **66** associated, respectively, with the legs of the external pole piece **64**. It will be understood that, by such means, the reluctance of the magnetic circuit is considerably decreased and that the flux distribution of the field produced between the internal pole pieces **65** and **66** is considerably improved. While the present invention is illustrated herein in conjunction with a kinescope having internal pole pieces, it will be understood that its principles are also applicable to other forms of kinescopes.

The external pole piece **64** of the convergence magnet **58** is provided with electromagnetic windings **68** and **69** for dynamic energization and the static convergence field which is produced in accordance with the present invention is accomplished through the agency of the electromagnetic winding **70**. Prior to describing the static convergence control of the invention, however, reference will be made to that portion of Figure 3 of the drawing which illustrates means for energizing the dynamic convergence windings of the apparatus. Since the apparatus for providing the dynamic convergence control of electron beam components does not per se constitute a part of the present invention, it will be understood that that portion of the circuitry in Figure 3 relating thereto and described herein in the interest of completeness of description is intended merely to serve as an example of suitable dynamic convergence circuitry.

In Figure 3, the energizing coils of the convergence magnets **58**, **59** and **60** include the electromagnetic, dynamic convergence windings **68**, **69**, **72**, **73** and **74**, **75** connected serially in pairs and wound about the external pole pieces of the magnets. That is to say, the windings **68** and **69** of the magnet **58** are connected in series with each other and to the corresponding windings of the magnets **59** and **60**. All of the dynamic windings are, moreover, connected in series with the vertical and horizontal electron beam scanning deflection circuits, substantially as indicated. As shown, the windings are coupled effectively in series with the vertical windings **76** of the deflection yoke **32** and also with the horizontal windings **77** of the yoke. Thus, the convergence magnets may be energized dynamically as a function of both vertical and horizontal beam deflection angles.

In the operation of the dynamic convergence magnet energizing portion of the apparatus of Figure 3, the vertical deflection current traversing the vertical yoke winding **76** produces a sawtooth voltage across the resistor **78** which, as indicated, may be made variable so as to control the amplitude of the convergence control wave.

Inductance means, such as an inductor **79** coupled to the resistor **78**, has the property of performing current-integrating action whereby a substantially parabolic current wave at vertical deflection frequency traverses the dynamic windings **68**, **69**, **72**, **73** and **74**, **75** of the convergence magnets **58**, **59** and **60**, respectively.

The resistive components of the integrating inductor **79** and another inductor **80**, or horizontal frequency choke coil, in series therewith, together with the resistive components of the dynamic convergence magnet windings produce a small sawtooth component in the substantially parabolic current wave traversing the circuit elements. As a result of this sawtooth component, the peaks of the parabolic wave are slightly advanced in phase or displaced slightly to the left on a time base running from left to right. The capacitor **81**, connected effectively across the resistor **78** and the integrating inductor **79**, has the effect of producing an opposite, or retarding, phase shift by which to move the peaks of the parabolic wave slightly to the right, relative to a time base. Accordingly, a variable resistor **82** in series with the capacitor **81** is provided so as to afford a symmetry control for the substantialy parabolic wave at vertical deflection frequency in order that the convergence apparatus may be suitably operated to effect the desired result with different deflection yokes.

In a somewhat similar manner, a sawtooth voltage at horizontal deflection frequency is developed across a resistor **83** which may be made variable so as to provide an amplitude control for the horizontal convergence wave. This voltage is also impressed upon the dynamic windings of the convergence magnets **58**, **59** and **60** by means including a center-tapped inductor **84**, at least a portion of which is connected in series with the horizontal yoke winding **77** and the resistor **83**. Inductance means, which in this case comprise the dynamic windings, function to integrate the sawtooth voltage wave to produce a substantially parabolic current wave for energization of the dynamic convergence windings of the magnets.

The deflection current in the horizontal winding **77** of the yoke **32** also produces a voltage pulse during flyback or retrace intervals. This voltage pulse is developed

across the left hand portion of the inductor **84**, as viewed in the drawing, and is impressed upon the dynamic windings of the convergence magnets by means including a potentiometer **85** connected across the inductor **84**. The inductance of the dynamic windings causes an integration of the voltage pulse to form of small sawtooth current component through the windings. The potentiometer **84** provides a facility for controlling the magnitude and polarity of the voltage pulses impressed upon the convergence magnet and thereby functions as a symmetry control for the substantially parabolic current wave of horizontal frequency by which the convergence magnets are exicited.

Although the illustrative circuitry of Figure 3 described thus far shows an arrangement in which the vertical and horizontal convergence waveforms flow through the same windings of the electromagnets, it should be understood that other arrangements in which the vertical and horizontal waveforms flow through separate windings may be satisfactorily employed. Additionally, while the windings **68** and **69** are shown as separate coils, serially connected, it should be understood that a single winding may be used in their stead. Various other types and combinations of windings and separate control circuits for the dynamic convergence of each of the three beams may also be substituted for that shown.

As mentioned briefly above, static control of the electron beam components in their pre-deflection paths is necessary in order to bring about proper convergence of the beams at the center of the target, for example. In the past, such static convergence control has been dependent upon rather accurate regulation of the high voltage applied to the final anode of the kinescope since, as has been pointed out, the action of the convergence apparatus which is in fact a deflection action depends for its effectiveness upon the potential of the final anode of the kinescope relative to the cathode thereof. Specifically, the deflection of an electron beam per unit of magnetic field intensity,

$$\frac{D}{B}$$

is given by the following relationship:

$$\frac{D}{B}=\frac{1L}{\sqrt{E_a}}\sqrt{\frac{e}{2m}}$$

where "D" is the distance which the beam is deflected, "B" is the magnetic field intensity, "1" is the axial length of the magnetic deflecting field, "L" is the distance from the center of deflection to the final anode or target, "$E_a$" is the potential of the final anode, "*e*" is the charge of the electron, and "*m*" is the mass of the electron. It will be seen, therefore, that the quantity

$$\frac{D}{B}$$

or the "magnetic deflection sensitivity" varies inversely with the square root of the final anode voltage. It follows that any undesirable variation in the final anode voltage will produce misconvergence, assuming that the magnetic field intensity remains constant. In order to prevent such misconvergence, prior art ararngements have, for example, relied upon complicated and costly circuitry for regulating the voltage applied to the final anode of the kinescope. Moreover, such regulating circuitry undesirably loads the deflection system with which the high voltage-producing arrangement is associated. In accordance with the present invention, therefore, means are provided for energizing the static convergence windings such as **70** partially by rectified deflection voltage and in such manner as to provide a ½ power relation between the final anode voltage and the strength of the static convergence field, thereby obivating the need for high voltage regulating circuits.

In order that the operation of the present invention



may be more fully understood, Figure 3 illustrates within the dotted line rectangle **36**, a generally conventional horizontal deflection output amplifier circuit including a typical flyback high voltage power supply. The output signal of the horizontal deflection generator **24** is coupled, via the lead **34** and a capacitor **90** to the control electrode **92** of the amplifier tube **94**. A grid leak resistor connects the electrode **92** to ground, as shown. Suitable biasing potential for the discharge tube screen electrode **96** is conventionally supplied from a source of positive potential indicated at terminal **98** ("+B") through a screen dropping resistor **100** which is, in turn, by-passed to the cathode **102** via a capacitor **104**. A self-biasing cathode resistor **106** whose value is chosen in accordance with the desired operating bias for the amplifier tube **94** is connected in the cathode circuit of the tube and is by-passed by a capacitor **108**. The anode **110** of the amplifier tube **94** is connected to a terminal **112** of an autotransformer **114** which includes an auxiliary step-up winding **116** connected to the anode **118** of the high voltage rectifying diode **120**. The cathode **122** of the rectifier diode is connected to ground through a filter capacitor **124**, so that high voltage for the final anode of the kinescope **42** may be applied to the high voltage terminal **40**. The lower terminus **126** of the autotransformer is connected through a "B-boost" capacitor **128** to a source of "+B" potential at the terminal **130**. It will further be seen that the horizontal deflection winding **77** of the raster scanning deflection yoke is connected in shunt with that portion of the autotransformer between the terminals **126** and **132**. A conventional damping device comprising, by way of illustration, the diode **134** is connected in damping relation with the yoke winding **77** through the B-boost capaictor **128**. Specifically, the anode **136** of the damper diode **134** is connected to the +B terminal **130**, while the cathode **138** of the damper tube is connected to a point **140** on the autotransformer.

As thus far described, the apparatus of the drawing is in accordance with conventional practice and, since the operation of such scanning apparatus is well-known, it need not be described in detail here. A full analysis of such operation is given, for example, in an article by the present applicant entitled, "Magnetic Deflection Circuits," which appeared in the September, 1947, issue of RCA Review. Briefly, however, it is to be noted that the bias on the horizontal output tube **94** is so adjusted that, during operation, the driving sawtooth waveform which is provided by the horizontal deflection generator will produce anode-cathode conduction only during a period corresponding to a little more than half the deflection cycle. Accordingly, it may be assumed that the horizontal output tube **94** is rendered conductive by the sawtooth waveform on its control electrode during only the second half of the line scanning interval, during which interval anode-cathode current will pass from the positive power supply terminal **130** through the diode **134**, the transformer **114** and the tube **94**. Such current flow induces some deflection voltage and current in the transformer which causes a substantially linear rise in deflection current through the yoke winding **77**. At a time corresponding to the commencement of the retrace or flyback interval of the deflection cycle, the discharge tube **94** becomes non-conductive and the magnetic field in the autotransformer and yoke will then collapse, causing oscillation of the primary resonant circuit (i. e., yoke and its distributed capacitance) at its self-resonant frequency which is normally at least four or five times that of the deflection frequency.

After one-half cycle of free oscillation, the voltage appearing across the horizontal winding **77** will be of such polarity as to cause the diode **134** to conduct, thereby damping the oscillations and aperiodically discharging the energy magnetically stored in the yoke. The direction of the damping current through the diode **134** will be

in such direction as to charge the capacitor **128** such that its terminal adjacent to the point **126** is positive with respect to the terminal **130**. This current through the diode **134**, in accordance with well-known reaction scanning principles, provides the first portion of the current sawtooth through the winding **77**, which portion corresponds to the first portion of the trace interval. At the end of such interval, the horizontal discharge tube **94** will have been rendered conductive and, this time, by reason of the bias across the capacitor **128**, the diode will not immediately conduct, which will therefore cause most of the horizontal output tube anode current to flow through the autotransformer section between the terminals **126** and **140**. It will be recognized from the foregoing that the value of the high voltage produced at the lead **38** by the rectifier tube **120** will depend upon the amplitude of the flyback pulses produced in the autotransformer **114** during the retrace intervals of the deflection scanning cycle. Since, from the standpoint of static convergence, it is undesirable for such high voltage to vary or fluctuate, prior art arrangements have employed voltage regulating arrangements at the lead **38**, for example, to maintain a substantially constant load on the rectifier **120**. It will also be recognized, however, that the amplitude of the flyback pulses rectified to produce the final anode voltage is proportional to the deflection current through the transformer **114**, and, therefore, proportional to the amount of energy stored in the B-boost capacitor **128** by the damper diode **134** which serves, as will be understood, as a rectifier. The present invention exploits this proportionality in controlling the static convergence energy applied to the static convergence windings **70**, **70***a* and **70***b* and in a manner which will now be described.

Each of the static convergence windings **70**, **70***a* and **70***b* has in series with itself one of the variable resistors **146**, **146***a* and **146***b* and the several windings are connected in parallel, as shown in Figure 3. The junction of the variable resistors **146**, **146***a* and **146***b* is connected via a lead **148** to the terminal **126** which is, as shown in the drawing, connected to the positive terminal of the B-boost capacitor **128**. The junction of the windings **70**, **70***a* and **70***b* is, on the other hand, connected via a lead **150** to the adjustable slider tap **152** of a potentiometer **154** which is connected from the B+ terminal **130** to ground, as shown. The B+ terminal **130** and the slider tap **152** are, respectively, by-passed to ground by capacitors **155** and **156**.

In the interest of simplicity, it may be assumed initially in the following explanation of the operation of the circuit of Figure 3 that the voltage at the +B terminal **130** is equal to that developed across the B-boost capacitor **128** and that the slider tap **152** is at the lowermost end of the potentiometer **154** (i. e., at ground). It will, therefore, be appreciated that the voltage impressed across the leads **148** and **150** will be equal to the sum of the +B voltage and that across the B-boost capacitor and, since it has been assumed that such voltages are equal, the voltage impressed across the leads **148** and **150** will be equal to twice the B-boost voltage. Assuming now, by way of example, that the high voltage developed at the lead **138** decreases 10 percent, as by reason of an increased beam current load in the kinescope **42**, the boost voltage component will similarly decrease by substantially 10 percent. The total voltage across the leads **148** and **150** (and, therefore, across the parallel-connected static convergence windings) will, however, decrease only 5 percent, since the +B voltage at the terminal **130** remains constant. That is to say, it may be assumed that a battery of the voltage required for the +B terminal is connected between the terminal **130** and ground.

It will further be seen from the foregoing example, that, while the high voltage at the lead **38** has decreased from 100 percent of its normal value to 90 percent (0.90), the voltage applied across the leads **148** and **150** to the convergence windings has decreased from 100 percent of its normal value to 95 percent (i. e., 0.95) which is substantially the square root of 0.90. It will thus be understood that a 10 percent decrease in the high voltage at the lead **38** for application to the kinescope final anode is accompanied by a 5 percent decrease in the voltage impressed across the electromagnetic static convergence windings, or, in other words, the static convergence field components will vary as the square root of the high voltage, thereby satisfying the above equation which defines magnetic deflection sensitivity in terms of final anode voltage.

Throughout the foregoing description of the operation of the static convergence arrangement of Figure 3, it has been assumed that the +B voltage at the terminal **130** is equal to the B-boost voltage across the capacitor **128**. Assuming, however, that the +B voltage is greater than the normal B-boost voltage across the capacitor, the slider tap **152** may be moved upwardly along the potentiometer **154** to provide an initial setting according to which the voltage impressed across the leads **148** and **150** is made up equally of B-boost and B+ voltages.

Where, on the other hand, the fixed B+ voltage is less than the B-boost voltage normally developed across the capacitor **128**, an arrangement such as that shown in Figure 4 may be employed for providing the initial half-power relationship between the high voltage and the convergence winding energization. In Figure 4, reference numerals identical to those employed in Figure 3 are used to identify corresponding elements. In the arrangement of Figure 4, the association of the +B terminal **130**, the B-boost capacitor **128** and the damper diode **134** is the same as that set forth in connection with Figure 3. Since it is assumed that the voltage developed across the B-boost capacitor **128** in Figure 4 is normally greater than the voltage at the B+ terminal **130**, a potentiometer **160** is connected in parallel with the capacitor **128** and is provided with an adjustable slider tap **162** connected to the lead **148**. Again, as in the case of Figure 3, the individual static beam convergence windings **70**, **70***a* and **70***b* are connected, respectively, in series with the variable resistors **146**, **146***a* and **146***b* which, as will be understood, serve the purpose of adjusting the individual field strengths of the several beam convergence windings by varying the currents therethrough. When the slider tap **162** is at the extreme left end of the potentiometer **160** as viewed in the drawing (i. e., electrically connected to the terminal **126**) the full B-boost voltage plus the B+ voltage will appear across the beam convergence windings. By moving the slider tap **162** to the right, the amount of B-boost voltage actually applied across the windings may be made equal to the B+ voltage, in order that the half-power relation between the high voltage and the beam convergence winding energy may be obtained.

Once the initial setting of the slider tap **162** on the potentiometer **160** has been made so that B-boost and B+ voltages actually applied to the convergence windings are equal, the operation of the circuitry of Figure 4 is substantially identical to that described in connection with Figure 3. While its operation should, therefore, be apparent, an example will be given in the interest of insuring such understanding. Assuming, by way of illustration, that the high voltage developed by the rectifier tube **120** should decrease by 20 percent, the B-boost voltage developed across the capacitor **128** through the rectifying action of the tube **134** will also decrease by 20 percent. The total voltage (i. e., B+ plus B-boost) applied across the convergence windings will, however, be decreased by only half that amount, or 10 percent. Analyzing these figures, it may be stated that, while the high voltage developed by the rectifier has decreased from 100 percent of its normal value to 80 percent thereof (i. e., 0.80), the beam convergence energy has decreased from 100 percent (i. e., B-boost plus B+) to 90 percent (i. e., B+ plus 0.80 B-boost). Since 90 percent (0.90) is approximately equal to the square root of 80 percent (0.80) it will be seen that

the desired square root relationship between the high voltage and the convergence winding energy is maintained. It should also be apparent from the foregoing that, while the two examples given have assumed a decrease in the high voltage applied to the final anode of the kinescope, corresponding results are obtained in case of an increased high voltage. That is to say, if the high voltage should increase, the amount of energy provided for impression across the beam convergence windings would also increase and in such manner as to retain the half power relationship.

While the arrangements of Figures 3 and 4 illustrate forms of the present invention in accordance with which the requisite square root relationship between the static beam convergence energy and the high voltage is afforded through the use of means for energizing the convergence windings partially from the B-boost energy usually present in combined deflection and high voltage arrangements, there is illustrated in Figure 5 another form of the invention, namely, one in accordance with which energization of the static convergence windings is provided by auxiliary rectifier means. Those elements of Figure 5 corresponding to portions of Figures 3 and 4 are identified by the same reference numerals. In the arrangement of Figure 5, the deflection and high voltage circuitry is the same as in the preceding figures, including the horizontal output tube **94**, output transformer **114**, high voltage rectifier **120**, damper tube **134**, B-boost capacitor **128** and +B terminal **130**. Associated with the transformer **114**, however, is an auxiliary transformer winding **168** which is so related to the transformer that voltage is induced therein by deflection energy in the transformer **114**. The winding **168** is serially connected, as shown, with a rectifier diode **170** having an anode **172** and a cathode **174** and a storage capacitor **176**. The junction of the rectifier cathode **174** and the storage capacitor **176** is connected to a lead **148** corresponding to the lead bearing the same reference numeral in Figures 3 and 4. The junction of the transformer winding **168** and the capacitor **176**, on the other hand, is connected to a slider tap **178** which is adjustably positioned on a potentiometer **180** connected across a source of positive potential illustrated as a battery "B". A lead **150** corresponding to the lead bearing the same reference numeral in Figures 3 and 4, is connected to the lower terminus of the potentiometer **180** (i. e., ground) and is designated for connection, together with the lead **148**, to the static convergence windings of the electromagnets **70**, **70***a* and **70***b* in the manner explained in connection with the preceding figures.

In the operation of the apparatus of Figure 5, it will be understood that the voltage induced in the auxiliary winding **168** by the deflection energy of the transformer **114** will be proportional to the amount of energy rectified by the diode **120** to provide the final anode voltage for the kinescope. Such voltage induced in the winding **168** has the same polarity with respect to diode **170** as the voltage on the main transformer winding has to diode **134**. The energy from winding **168** will be rectified by the diode **170** to provide a charge across the capacitor **176**, as shown. Assuming that the voltage of the battery "B" is somewhat greater than the charge normally produced across the capacitor **176** by rectification of the deflection energy, the slider tap **178** may be moved downwardly from the upper terminus of a potentiometer **180** until the battery voltage between the tap **178** and ground is equal to the charge across the capacitor. With this initial setting accomplished, the square root relationship between the static convergence energy applied across the leads **148** and **150** and the high voltage developed by the rectifier **120** will be secured. The specific fractional portion of the deflection energy which is induced in the winding **168** is not material, except insofar as it is necessary to provide sufficient voltage across the leads **148** and **150** to energize the convergence windings properly.

Assuming that, for some reason, the high voltage provided by the rectifier **120** should decrease by 10 percent, the amount of voltage induced in the winding **168** will be correspondingly decreased by 10 percent, so that the voltage across the storage capacitor **176** will also be decreased by the same percentage. The reduction in the total voltage across the leads **148** and **150**, however, will be only 5 percent, as explained earlier, so that, while the high voltage has decreased to 90 percent of its normal value, the energy for the static convergence windings will be understood as having decreased to 95 percent of its normal value, or approximately the square root of the high voltage percentage. In the arrangement of Figure 5 employing a separate winding and rectifier for the derivation of energy for the convergence windings, it has been assumed that the voltage of the battery "B" is greater than that normally developed across the capacitor **176**. Where, on the other hand, the reverse situation is the case, the potentiometer may be connected across the capacitor in the manner illustrated in Figure 4.

In each of the foregoing described forms of the invention, means have been provided in the form of variable series resistors for affording individual adjustment of the strength of the respective fields produced by the static convergence windings. Figures 6, 7 and 8, on the other hand, illustrate what may be termed mechanical (as opposed to electrical) arrangements for affording adjustability of the strength of the static beam convergence fields. In each of Figures 6, 7 and 8, the U-shaped magnetic external pole piece is indicated by the reference numeral **64** and the dynamic convergence windings are shown at **68** and **69**, while the static convergence winding is indicated by the numeral **70**. In Figure 6, the U-shaped external pole piece **64** is provided with an adjustable shunt **184** which may, for example, be formed of any suitable magnetic material of low reluctance. The shunt **184** is connected at one end to the pole piece **64**, as by a suitable fastening element **185**. The other end of the shunt **184** may be adjustably spaced from the U-shaped pole piece **64** in the region of the static winding **70**, as through the agency of a bolt **186** threaded through an aperture in the shunt piece. That is to say, the shunt piece **184** is capable, when the bolt **186** is fully retracted so that the shunt rests at both ends on the "bight" of the U-shaped member **64**, of effectively short-circuiting flux produced by the static convergence winding **70**. As the bolt **186** is threaded within the shunt piece **184** in such manner as to move the end of the shunt away from the pole piece **64**, the amount of such short-circuiting is decreased, so that the strength of the magnetic field produced within the tube between the internal pole pieces **65** and **66** is gradually increased.

Figure 7 illustrates another form of mechanical adjustment arrangement employing a magnetic shunt piece **187** which may be a rod or bar of soft iron or other magnetic material slidably received within a bore **188** in one of the legs of the U-shaped external pole piece **64**. A threaded bolt **189** connected to the end of the shunt piece **187** is threadedly received by an arm **190** offset laterally from the U-shaped member **64**, so that threading of the bolt **189** in one direction will cause the shunt piece **187** to move to the right as viewed in the drawing until it reaches the right hand leg of the U-shaped pole piece, thereby substantially short-circuiting the flux produced by the static convergence winding **70**, to decrease the strength of the static convergence field between the internal pole pieces **65** and **66** to a minimum value. As the bolt **189** is threaded in the other direction, thereby moving the shunt piece **187** to the left as shown in the drawing, the air gap between the member **187** and the right hand leg of the U-shaped pole piece **64** will be increased, thereby to increase the strength of the effective static convergence field within the tube.

The U-shaped external pole piece **64** shown in Figure 8, and having wound thereon the static convergence winding **70** and the dynamic convergence windings, is

provided further with inwardly extending legs **191** and **192**. Each of the legs **191** and **192** is provided with an arcuate recess in its surface facing the other of the legs, which recesses slidably receive therebetween a shunt piece in the form of a rod **193** of iron or other low reluctance magnetic material. When the rod **193** is fully inserted between the legs **191** and **192**, an effective short circuit is provided for the flux from the winding **70** through the legs **191** and **192** and the shunt piece **190**. In this event, the static convergence field produced within the tube is of a minimum value. When, on the other hand, the shunt piece **193** is retracted, as shown, the amount of the shunting is decreased, thereby increasing the strength of the static convergence field within the tube.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In combination with a cathode ray tube having a target electrode and electron gun, means for directing an electron beam toward said electrode, power supply means for applying to said target electrode a unidirectional operating voltage subject to variation; beam position controlling means comprising an electromagnetic deflection winding associated with said tube for producing a magnetic field transversely of at least a portion of such tube to control the position of such electron beam; means for supplying said winding with energy; and means coupled to said power supply means and to said last-named means for causing such energy to vary in percentage as a certain fractional function of the percentage of such unidirectional voltage applied to said target electrode, such that a change in such operating voltage is attended by a smaller change, percentagewise, in such energy.

2. In combination with a cathode ray tube having a target electrode and electron gun means for directing an electron beam toward said electrode, power supply means for applying to said target electrode a unidirectional operating voltage subject to variation; beam position controlling means comprising an electromagnetic deflection winding associated with said tube for producing a magnetic field transversely of at least a portion of such tubes to control the position of such electron beam; means for supplying said deflection winding with energy; and means coupled to said power supply means and to said last named means for causing such energy to vary in percentage as a square root function of the percentage of such unidirectional operating voltage applied to said target electrode, such that a change in such operating voltage is attended by a smaller change, percentagewise, in such energy.

3. In combination with a cathode ray tube having a target electrode and electron gun means for directing an electron beam toward said electrode, power supply means for applying to said target electrode a unidirectional operating voltage subject to variation; beam position controlling means comprising an electromagnetic deflection winding associated with said tube for producing a magnetic field transversely of at least a portion of said tube to control the position of such electron beam; means for supplying said deflection winding with energy; and rectifier means operatively coupled to said power supply means for rectifying a portion of the energy therein and coupled to said last named means for causing the energy supplied to said deflection winding to vary in percentage as a certain fractional function of the percentage of such unidirectional operating voltage which is applied to said target electrode, such that a change in such operating voltage is attended by a smaller change, percentagewise, in such energy.

4. In combination with a cathode ray tube having a target electrode and electron gun means for directing an electron beam toward said electrode, electromagnetic deflection apparatus associated with said tube for causing such electron beam to scan across said target electrode; flyback power supply means associated with said deflection apparatus for deriving energy therefrom and for applying to said target electrode a unidirectional operating voltage subject to variation; beam position controlling means comprising an electromagnetic deflection winding associated with said tube for producing a magnetic field transversely of at least a portion of such tube to control the position of such electron beam in addition to the control afforded by said electromagnetic deflection apparatus; means for supplying said deflection winding with energy; and means operatively coupled to said power supply means and to said last-named means for causing the energy supplied to said winding to vary in percentage as a certain fractional function of the percentage of such unidirectional operating voltage applied to said target electrode by said power supply means, such that a change in such operating voltage is attended by a smaller change, percentagewise, in such energy.

5. In combination with a cathode ray tube having a target electrode and electron gun means for directing an electron beam toward said electrode, electromagnetic beam deflection apparatus of the type having a deflection winding, means operatively coupled to said winding for developing a high, unidirectional voltage from a portion of the energy in said winding and an energy storage device for receiving and storing electrical energy from said winding such that the amount of such stored energy varies as a function of the level of energy in said winding and said voltage developing means, said unidirectional voltage being subject to variation; beam position controlling means comprising an electromagnetic deflection winding associated with said tube for producing a magnetic field transversely of at least a portion of such tube to control the position of such electron beam in addition to the control afforded by said electromagnetic deflection apparatus; and means operatively coupling said energy storage device to said beam position controlling winding for energizing said winding in such manner that the energy therein varies in percentage as a certain function of the percentage variation of such unidirectional voltage applied to said target electrode so that a change in such unidirectional voltage is attended by a smaller change, percentagewise, in the energy applied to said beam position controlling winding.

6. The invention as defined by claim 5 including a source of relatively fixed voltage of value substantially equal to the nominal value of the energy stored in said storage device; means connecting said voltage source in series-aiding relationship with said energy storage device, said means operatively coupled to said beam position controlling winding being so connected to said voltage source that the energy applied to said winding comprises the sum of the voltage of said source and the energy stored in said storage device, whereby said certain function is a fractional power.

7. In a cathode ray tube image reproducing system wherein a plurality of electron beam components which traverse spaced pre-deflection paths which bear a predetermined relation to the longitudinal axis of such tube are angularly deflected both horizontally and vertically by electromagnetic beam deflection apparatus to scan a raster on a target electrode, power supply means for applying to said target electrode a unidirectional operating voltage subject to variation; and electron beam convergence apparatus comprising: electromagnetic means mounted adjacent to said predeflection beam paths and energizable dynamically to produce respective fields transversely of said beam paths; means coupled to said raster-scanning beam deflection apparatus in energy receiving relation thereto and to said electromagnetic beam convergence means for energizing said electromagnetic beam convergence means in such manner as to direct said beam components relative to one another and to said longitudinal tube axis so as to effect substantial convergence of said beam components at all points of such raster; and means operatively coupled to said power supply means and to said electromagnetic beam convergence means for energizing said beam convergence means with

static energy variable percentage-wise as a certain fractional function of the percentage of such unidirectional voltage applied to said target electrode, such that a change in such unidirectional voltage is attended by a smaller change, percentagewise, in such static energy.

8. In a cathode ray tube image reproducing system wherein a plurality of electron beam components which traverse spaced pre-deflection paths which bear a predetermined relation to the longitudinal axis of such tube are angularly deflected both horizontally and vertically by electromagnetic beam deflection apparatus to scan a raster on a target electrode, power supply means for applying to said target electrode a unidirectional operating voltage subject to variation; and electron beam convergence apparatus comprising: electromagnetic means mounted adjacent to said predeflection beam paths and energizable dynamically to produce respective fields transversely of said beam paths; means coupled to said raster-scanning beam deflection apparatus in energy receiving relation thereto and to said electromagnetic beam convergence means for energizing said electromagnetic beam convergence mean in such manner as to direct said beam components relative to one another and to said longitudinal tube axis so as to effect substantial convergence of said beam components at all points of such raster; and means operatively coupled to said power supply means and to said electromagnetic beam convergence means for energizing said beam convergence means with static energy variable percentage-wise as a square root function of the percentage of such unidirectional voltage applied to said target electrode, such that a given change in the magnitude of such unidirectional voltage is attended by a smaller percentage change in the magnitude of such static energy.

9. In a cathode ray tube image reproducing system wherein a plurality of electron beam components which traverse pre-deflection paths which bear a predetermined relation to the longitudinal axis of such tube are angularly deflected both horizontally and vertically by electromagnetic beam deflection apparatus to scan a raster on a target electrode, flyback power supply means associated with said beam deflection apparatus and coupled to said target electrodes for applying to said electrode a unidirectional operating voltage subject to variation; electromagnetic means mounted adjacent to said predeflection beam paths and energizable to produce respective fields transversely of said beam path; means coupled to said raster-scanning beam deflection apparatus in energy receiving relation therewith and to said electromagnetic beam convergence means for energizing said convergence means in such manner as to direct said beam components relative to one another and to said longitudinal tube axis so as to effect substantial convergence of said beam components at all points of said raster; means for rectifying a portion of the energy in said raster-scanning deflection and high voltage supply apparatus; capacitive storage means coupled to said last named means for receiving and storing energy therefrom, which energy varies in proportion to variations in such unidirectional voltage; and means coupling said capacitive storage means to said electromagnetic beam convergence means for energizing said beam convergence means statically in such manner that such static energization varies in percentage as a certain fractional function of the percentage of such unidirectional operating voltage applied to said target electrode so that a change in such unidirectional voltage is attended by a smaller change, percentagewise, in such static energization.

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