Feb. 25, 1969 R. B. ASHLEY 3,430,099

SIMPLIFIED DEFLECTION SYSTEM FOR PLURAL IN-LINE BEAM CATHODE RAY TUBE

Filed Aug. 23, 1966 Sheet 1 of 8

FIG. 1

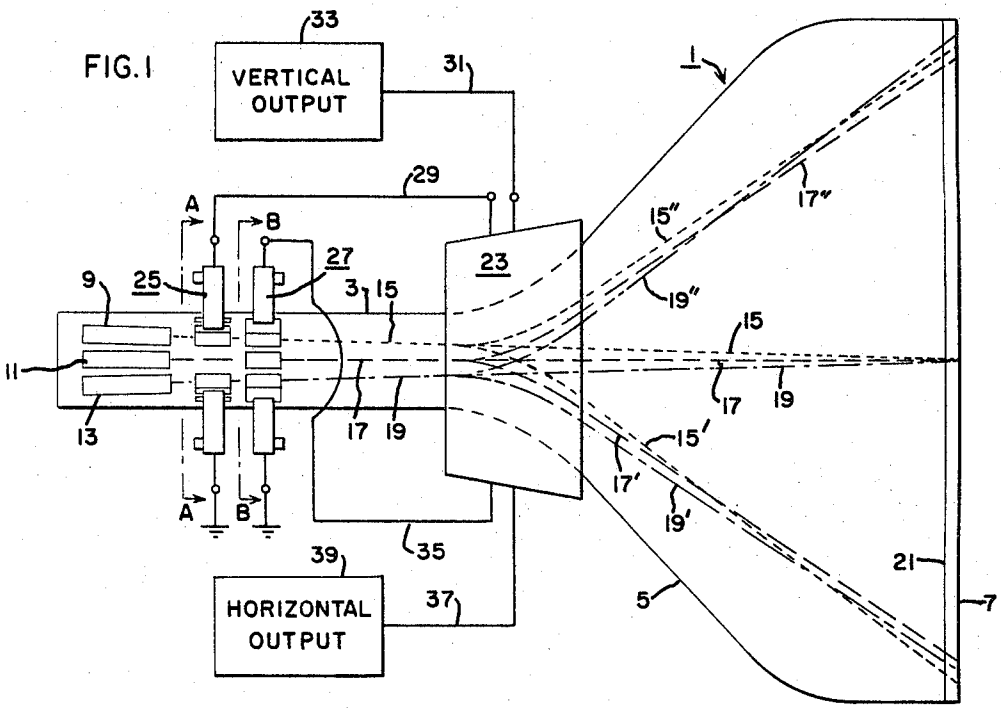
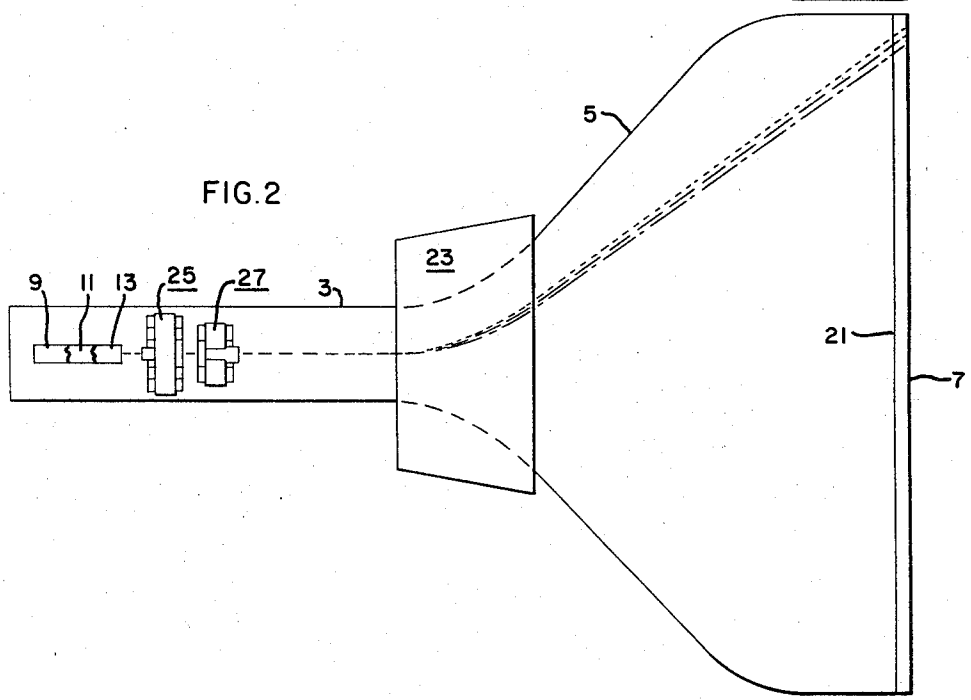


FIG. 2



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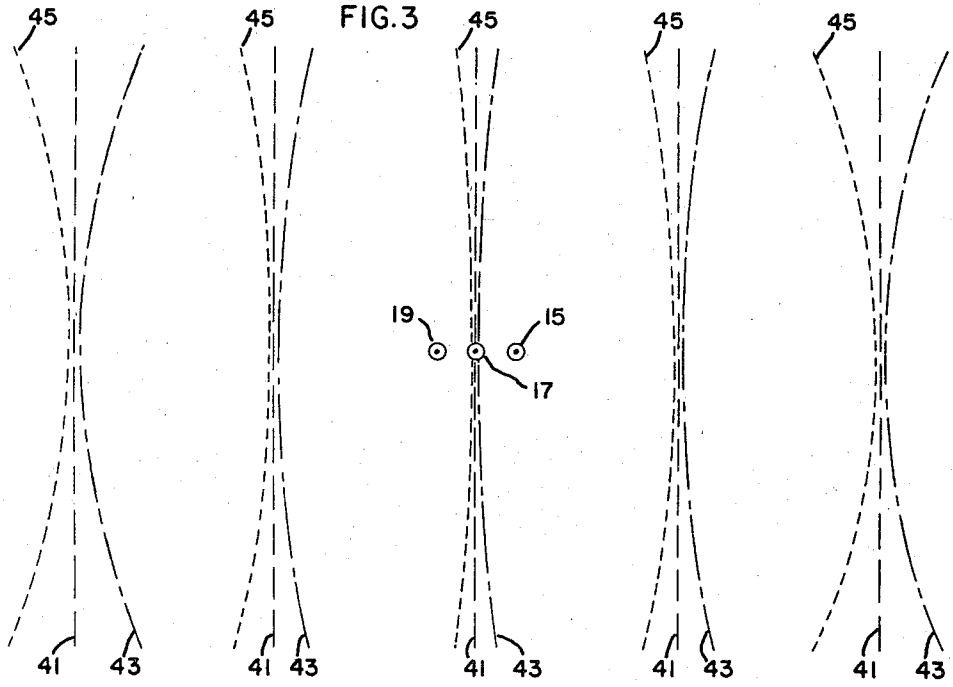
SIMPLIFIED DEFLECTION SYSTEM FOR PLURAL IN-LINE BEAM CATHODE RAY TUBE
Filed Aug. 23, 1966 Sheet 2 of 8

FIG.3



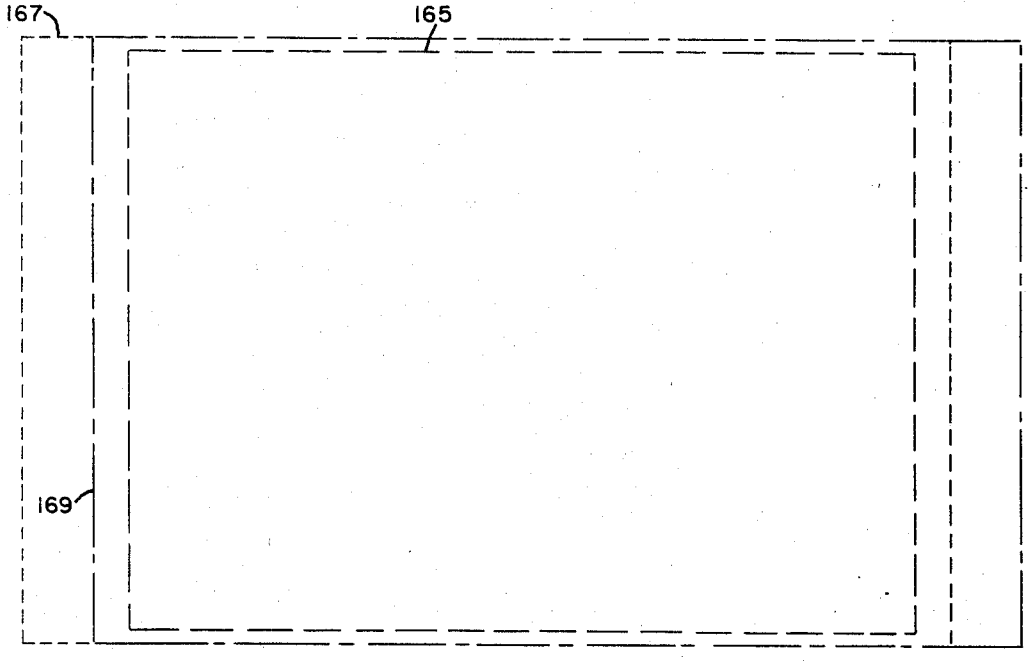


FIG.9

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FIG.4

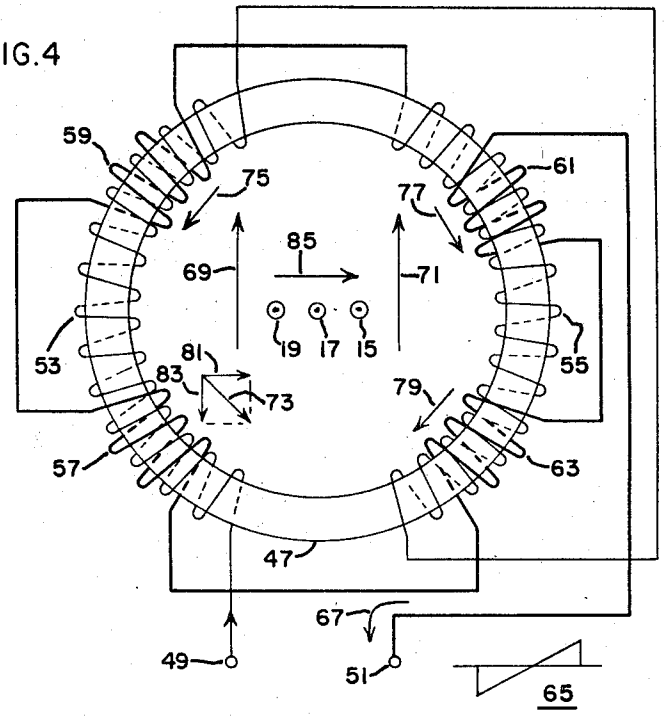
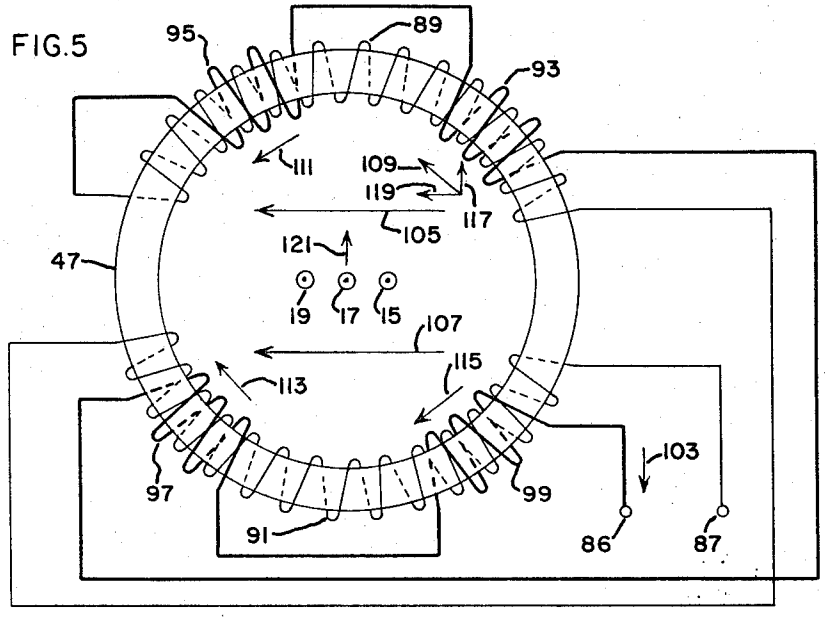


FIG.5



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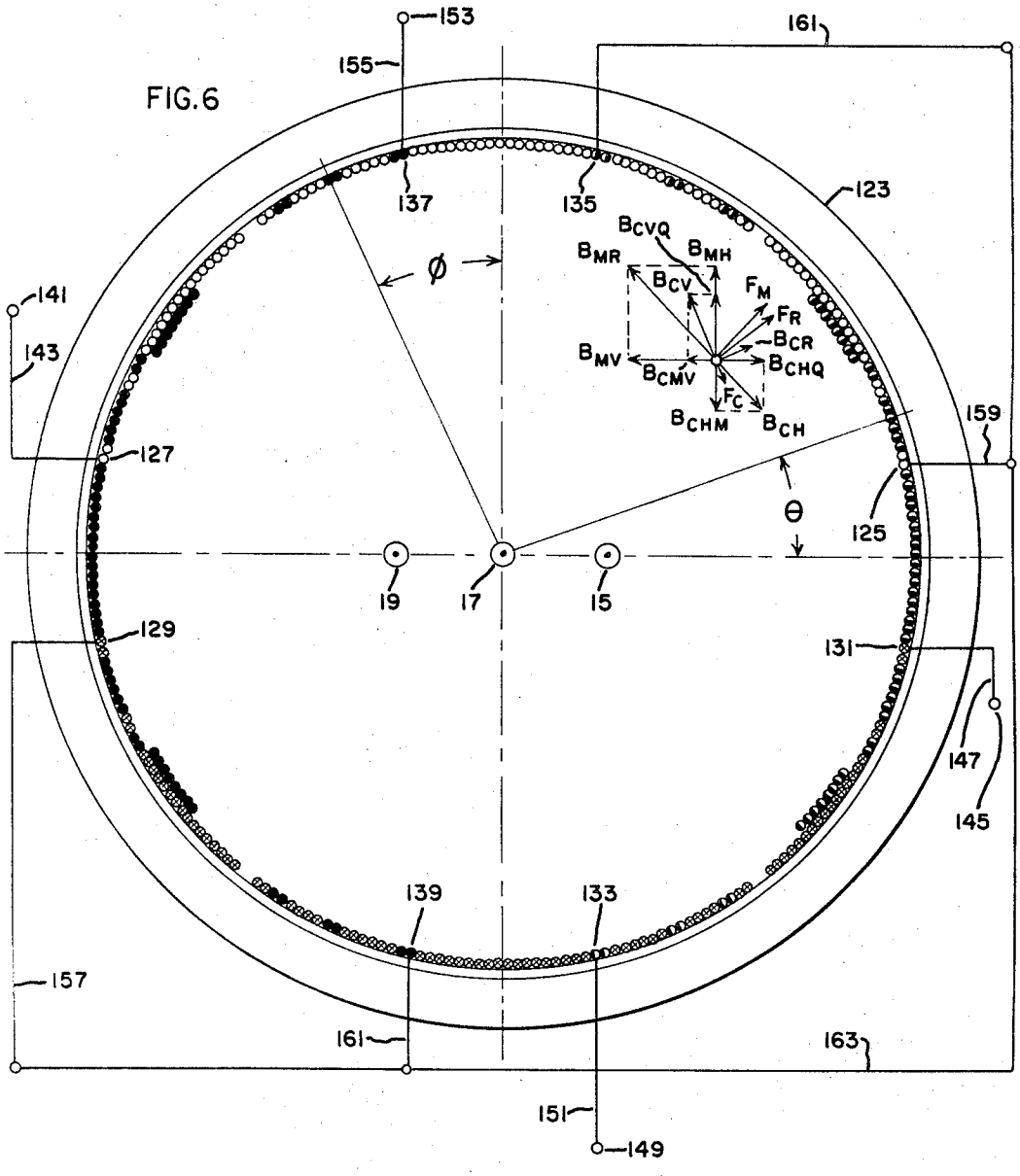
SIMPLIFIED DEFLECTION SYSTEM FOR PLURAL IN-LINE BEAM CATHODE RAY TUBE
Filed Aug. 23, 1966 Sheet 4 of 8

FIG.6



KEY

- ○ FIRST WINDING (124)
- ⊗ SECOND WINDING (128)
- ◑ THIRD WINDING (132
- ● FOURTH WINDING (136)

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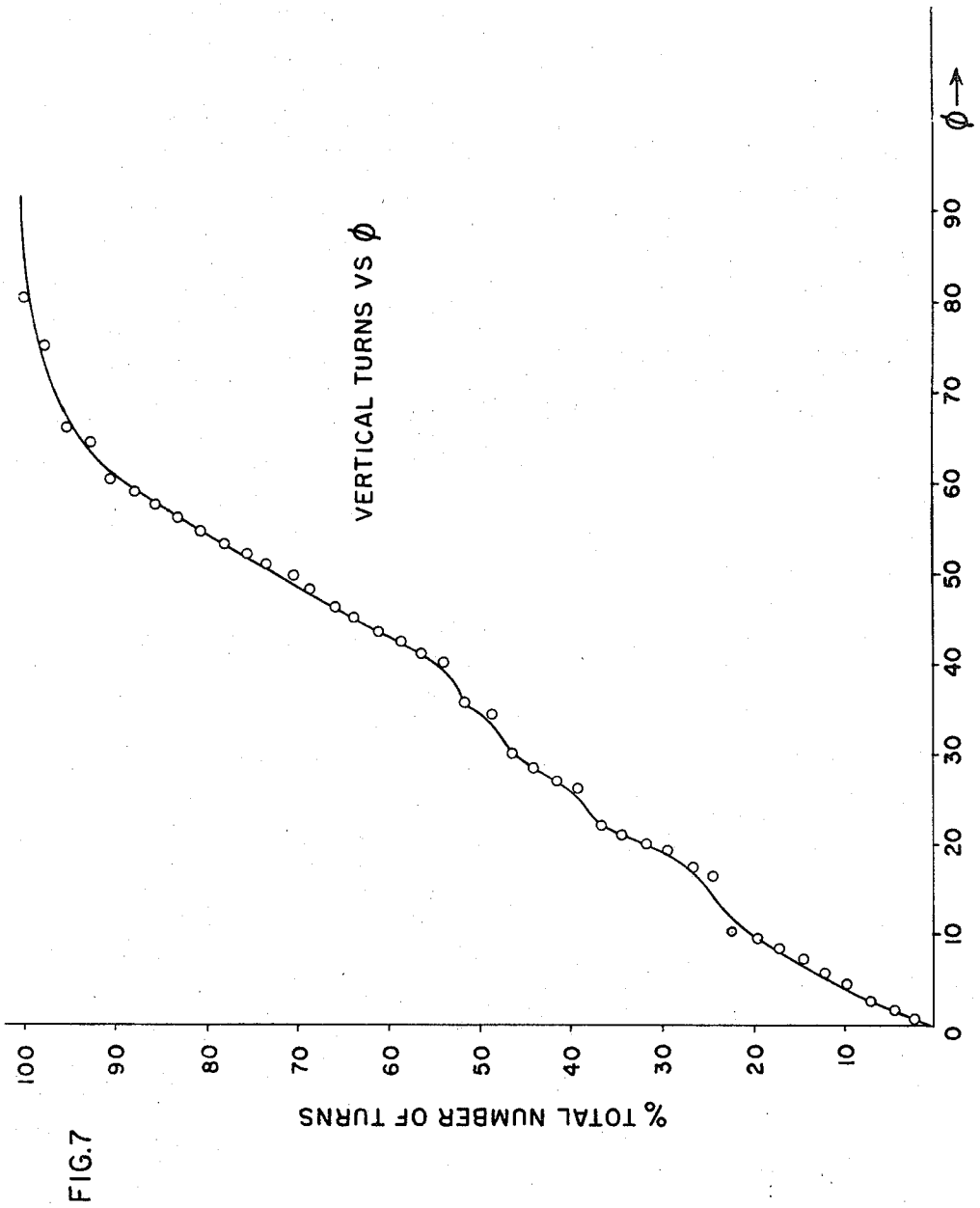

FIG.7

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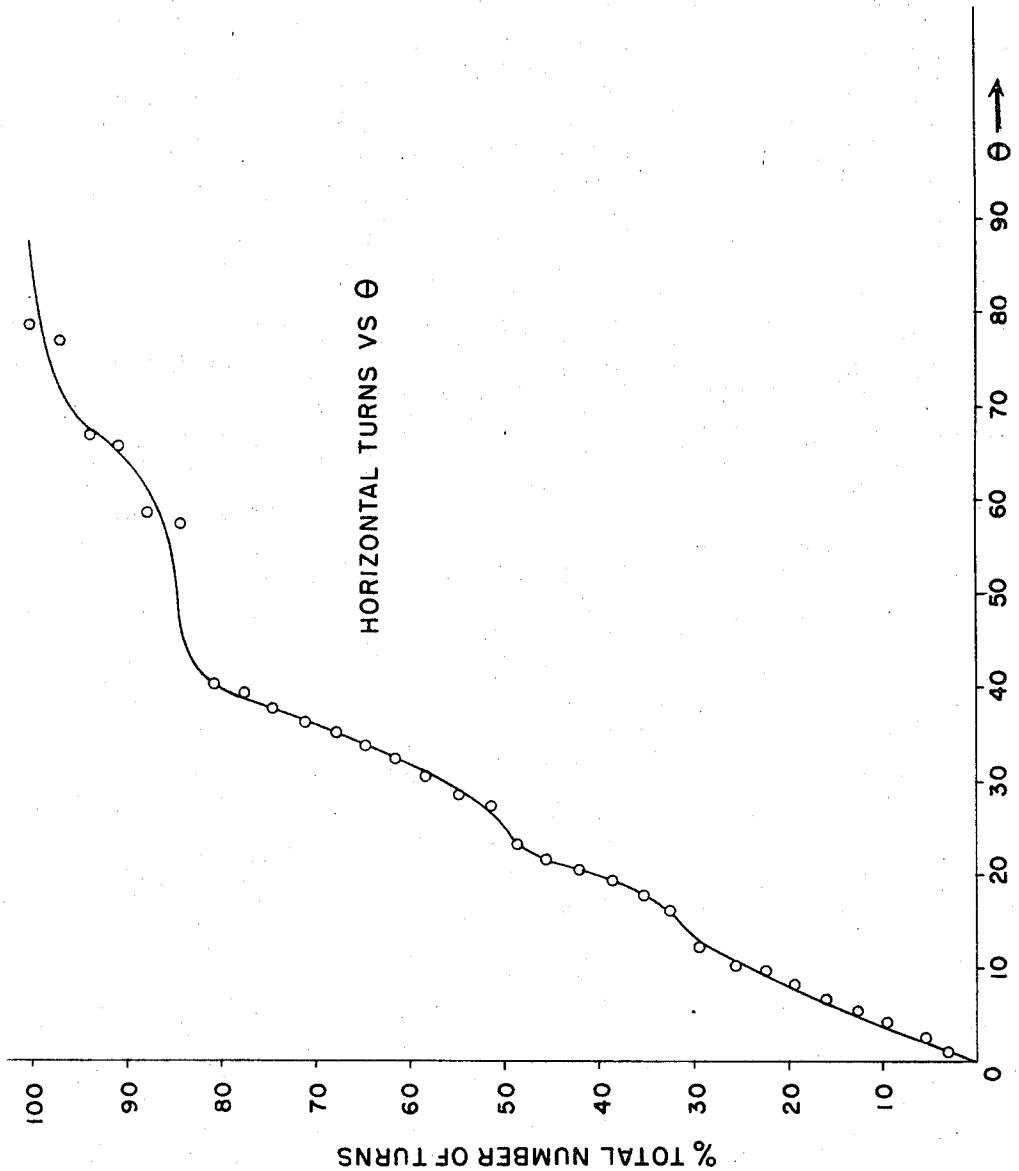

FIG.8

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FIG. 10

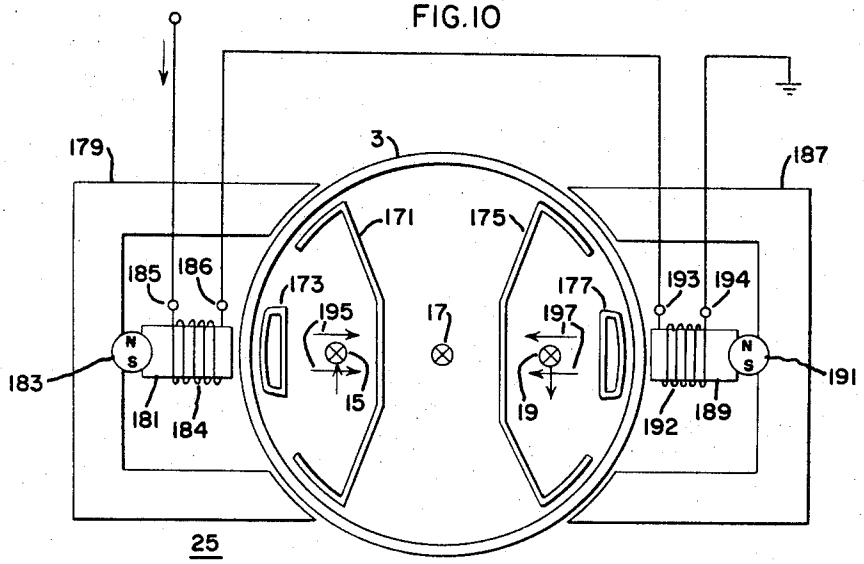
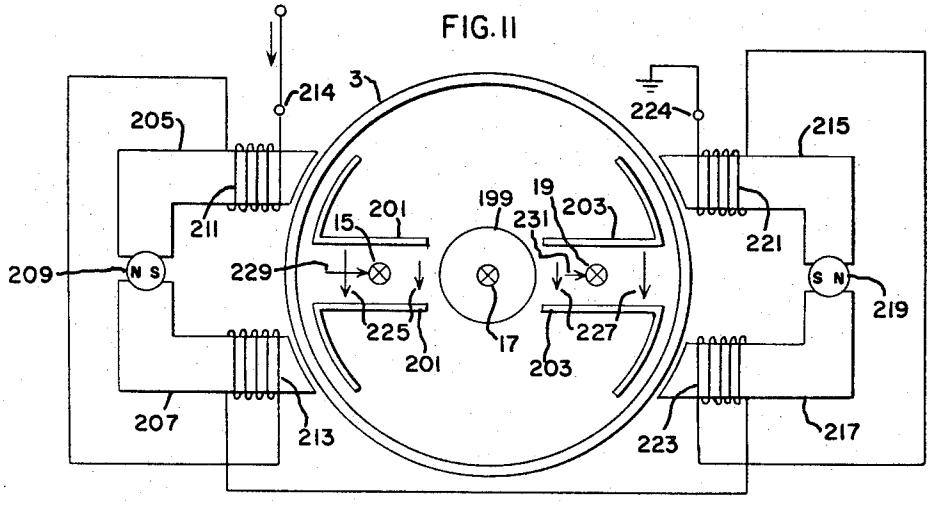


FIG. 11



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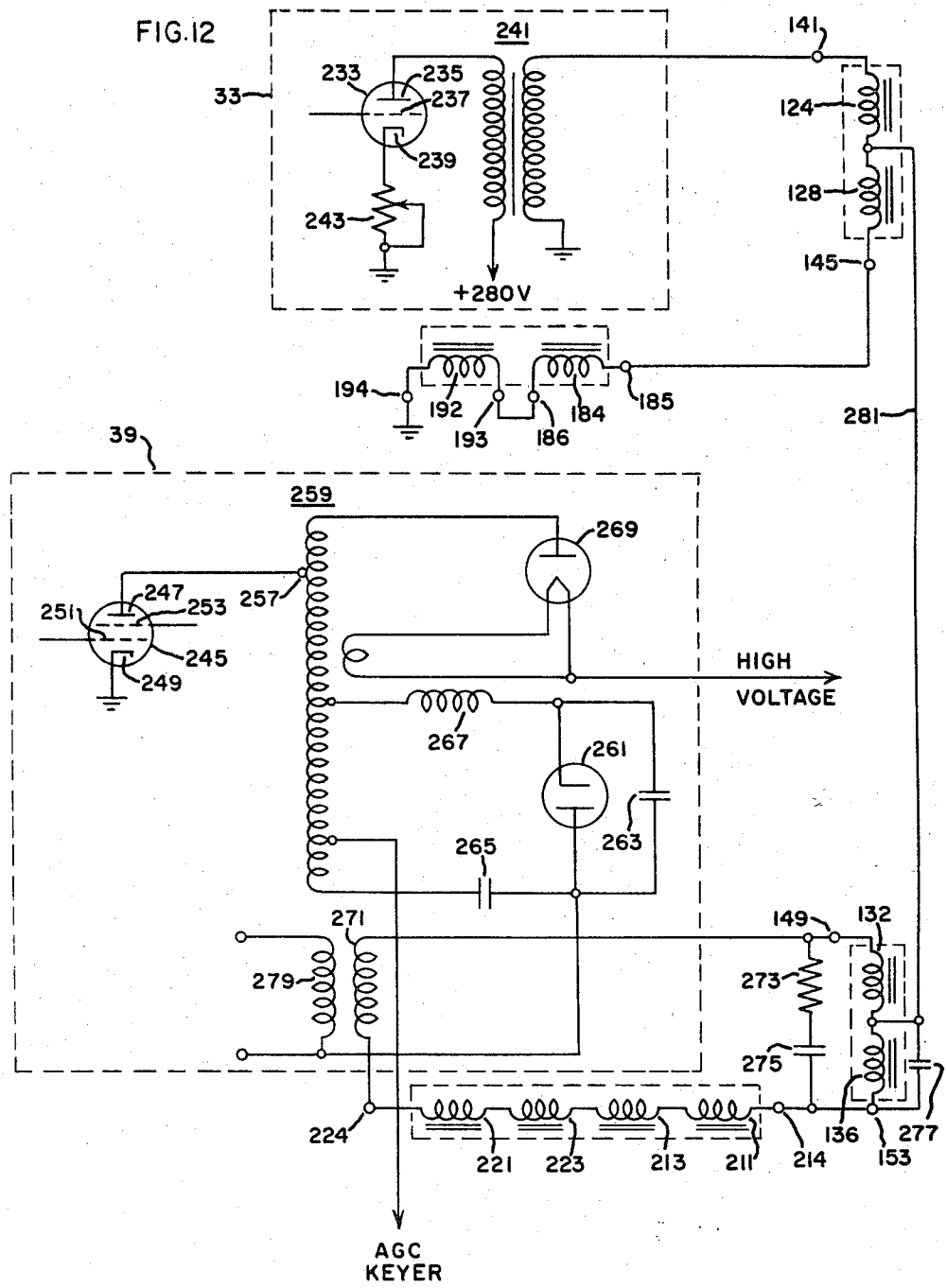
Feb. 25, 1969 R. B. ASHLEY 3,430,099
SIMPLIFIED DEFLECTION SYSTEM FOR PLURAL IN-LINE BEAM CATHODE RAY TUBE
Filed Aug. 23, 1966 Sheet 8 of 8

FIG. 12



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United States Patent Office 3,430,099 Patented Feb. 25, 1969

3,430,099

SIMPLIFIED DEFLECTION SYSTEM FOR PLURAL IN-LINE BEAM CATHODE RAY TUBE

Robert B. Ashley, Chesapeake, Va., assignor to General Electric Company, a corporation of New York

Filed Aug. 23, 1966, Ser. No. 574,411
U.S. Cl. 315—27 13 Claims
Int. Cl. H01j 29/72

ABSTRACT OF THE DISCLOSURE

In a plural, in-line beam color cathode ray tube, convergence of the beams is achieved by means of optimally non-uniform fields in the deflection yoke which produces parallel-sided beam rasters. For this purpose, toroidal horizontal and vertical deflection windings are used, the turns distribution being different as between the two windings, the vertical winding having a greater number of turns than the horizontal. Any resulting difference in raster sizes is compensated for by size correction windings responsive to the linear deflection currents of the deflection yoke to provide linearly varying predeflection fields operative on the outermost beams of the illustrated three beam arrangement.

The present invention relates to plural beam cathode ray tubes of the type suitable for displaying a color television presentation and more specifically to a simplified deflection system for such a plural beam cathode ray tube.

Plural beam cathode ray tubes employing three electron guns in a triad arrangement are conventionally employed in the prior art. Plural beam cathode ray tubes are also known wherein three in-line electron guns are employed in contrast to the conventional triad arrangement. Either of these electron gun arrangements can be employed in a conventional aperture mask tube or in a tube of the post acceleration type.

In the past, the deflection systems for such cathode ray tubes whereby deflection and convergence of the plural beams is achieved have been extremely complicated and expensive. Thus, the almost universal approach has been to employ an aperture mask tube having a triad arrangement of electron guns in conjunction with a massive deflection yoke, the yoke utilizing a large amount of copper wire wound in a cosine distribution to achieve as nearly as possible a linear deflection field within the yoke. However, such a linear deflection field inherently produces parabolic errors and misconvergence of the resultant rasters. Accordingly, it has been conventional to employ pre-deflection to achieve the necessary dynamic convergence of the plural electron beams. Such dynamic convergence requires the generation of complex parabolic correction signals of proper amplitude and phase relative to the sweep currents in the deflection yoke. The circuitry for generating such complex parabolic convergence signals is extremely complex and expensive.

It is also known that the convergence problems associated with such a plural beam cathode ray tube can be simplified somewhat through the use of a deflection yoke producing a non-uniform deflection field. Thus in U.S. Patent 2,925,542—Gethmann, issued Feb. 16, 1960 and assigned to the assignee of the present invention, there is disclosed a deflection yoke for providing deflection of plural in-line electron beams, the yoke including horizontal and vertical windings having identical winding distributions.

Through the use of the distribution disclosed by the Gethmann patent, deflection of in-line plural electron beams was simplified since dynamic convergence was not required in the direction normal to the planes in which the electron guns lie.

However, even with the improvements of the Gethmann patent dynamic convergence was necessary in the direction parallel to the plane in which the guns lie. Thus, even though the Gethmann patent represented a significant improvement, it was necessary to employ dynamic convergence in at least one direction thus adding a great deal of expense and complexity to the television receiver.

The present invention presents a simplified deflection system which completely eliminates the necessity for complex dynamic convergence signals.

Accordingly, an object of the invention is to provide a simplified deflection system for a plural in-line beam cathode ray tube.

A further object is to provide a simplified deflection system for a plural in-line beam cathode ray tube which is less complex and expensive than prior art systems.

Yet another object is to provide a simplified deflection system for a plural in-line beam cathode ray tube which completely eliminates the necessity for complex dynamic convergence signals.

These and other objects are achieved in one embodiment of the invention through the use of a deflection yoke which produces an optimally non-uniform field by the utilization of different winding distributions for the horizontal and vertical windings. Through the use of such a deflecton yoke three rasters are produced from which parabolic errors are eliminated, the rasters only requiring correction as to size. The size correction is easily achieved by passing the sawtooth deflection currents through a predeflection system. In this manner, substantial registry of the three rasters is achieved without the necessity for complex dynamic convergence waveforms.

The novel and distinctive features of the invention are set forth in the appended claims. The invention itself together with further objects and advantages thereof may best be understood by reference to the accompanying drawings in which:

FIGURE 1 is a top view of a plural in-line beam cathode ray tube utilizing the simplified deflection system of the invention.

FIGURE 2 is a side view of the plural in-line beam cathode ray tube depicted in FIGURE 1,

FIGURE 3 depicts the parabolic errors inherent in the prior art deflection systems,

FIGURE 4 is a schematic representation of a horizontal deflection winding in accordance with the invention,

FIGURE 5 is a schematic representation of a vertical deflection winding in accordance with the invention,

FIGURE 6 depicts a preferred embodiment of the winding distributions shown in FIGURES 4 and 5,

FIGURE 7 is a graphical representation of the vertical winding distribution shown in FIGURE 6,

FIGURE 8 is a graphical representation of the horizontal winding distribution shown in FIGURE 6,

FIGURE 9 depicts the raster size errors produced by the deflection yoke of FIGURE 6,

FIGURE 10 is a view taken along the line A—A of FIGURE 1 depicting the pre-deflection system for correcting the vertical size errors shown in FIGURE 9,

FIGURE 11 is a view taken along the line B—B of FIGURE 1 depicting the pre-deflection system for correcting the horizontal size error shown in FIGURE 9, and

FIGURE 12 is a schematic diagram of the deflection circuitry of a color television receiver employing the simplified deflection system of the invention.

Referring to FIGURES 1 and 2, there is depicted in simplified form a top view of a plural in-line beam cathode ray tube shown generally at 1 employing the simplified deflection system of the invention. The cathode ray tube 1 includes a neck portion 3, a funnel portion 5 and a faceplate 7 upon the interior face of which are deposited phosphor dots (not shown) for the production of a color

television image. A plurality of electron guns **9**, **11** and **13** are positioned in the neck portion **3**, the electron guns **9**, **11** and **13** producing electron beams **15**, **17** and **19** respectively. As depicted, the electron guns **9**, **11** and **13** are aligned in a horizontal plane with the axis of the guns **9** and **13** positioned at a slight angle relative to the axis of the gun **11** such that the electron beams **15**, **17** and **19** are statically converged at approximately the center of the faceplate **7**. By way of example, the electron guns **9**, **11** and **13** may be utilized to respectively excite blue, green and red light producing phosphors positioned on the faceplate **7** and for purposes of clarity will be hereafter referred to as the blue, green, and red electron guns respectively. For clarity the electron beams **15**, **17** and **19** are shown as dotted, dashed and dash-dot lines respectively.

The electron beams **15**, **17**, and **19** are directed through suitable apertures in an aperture mask **21** in accordance with known techniques to selectively excite the blue, green and red light producing phosphor dots on the faceplate **7**. The aperture mask **21** may be of the type disclosed and claimed in the co-pending application of W. D. Rublack, Ser. No. 573,604 filed Aug. 19, 1966.

In accordance with the invention, the electron beams **15**, **17** and **19** are deflected by a deflection yoke shown generally at **23** to produce three superimposed rasters of different colors on the faceplate **7**.

The yoke **23** is provided with horizontal and vertical deflection windings having distributions such that an optimally non-uniform magnetic field is produced within the yoke whereby the parabolic errors associated with the use of a uniform field yoke are eliminated. Through the use of the yoke **23** of the invention, complex dynamic convergence signals are no longer required, simple size correction of the rasters produced by the blue electron gun **9** and the red electron gun **13** being all that is necessary. In this regard a vertical static convergence and size correction assembly shown generally at **25** including a vertical size correction winding is positioned around the neck **3** of the cathode ray tube **1** intermediate the electron guns **9**, **11** and **13** and the deflection yoke **23**. Similarly, a horizontal static convergence and size correction assembly shown generally at **27** including a horizontal size correction winding is positioned around the neck **3** of the cathode ray tube **1** intermediate the assembly **25** and the deflection yoke **23**.

In accordance with the invention as shown in FIGURE 1 the size correction winding of the vertical static convergence and size correction assembly is serially connected to the vertical deflection winding of the yoke **23** via a line **29**, the vertical winding of the deflection yoke **23** being itself connected via a line **31** to the vertical output stage **33**. In this manner a sawtooth deflection current flows between the vertical output stage and ground through the vertical winding of the deflection yoke **23** and the vertical size correction winding of the vertical static convergence and size correction assembly **25**.

Similarly, the size correction winding of the horizontal static convergence and size correction assembly **27** is serially connected via a line **35** to the horizontal deflection winding of the yoke **23**, the horizontal deflection winding being itself connected via a line **37** to the horizontal output stage **39**. In this manner, a sawtooth deflection current flows between the horizontal output stage and ground through the horizontal deflection winding of the yoke **23** and the horizontal size correction winding of the horizontal static convergence size correction assembly **27**.

In FIGURE 2, portions of the electron guns **9** and **11** are broken away to more clearly show the electron guns **9**, **11** and **13** and the circuit connections shown in FIGURE 1 have been omitted for purposes of clarity.

The operation of the system shown in FIGURES 1 and 2 is such that the deflection yoke **23** produces an optimally non-uniform field which inherently corrects for parabolic deflection errors by providing a cross-hatch raster from each electron beam **15**, **17** and **19** which exhibits substantial parallelism across the entire face **7** of the cathode ray tube. The three cross-hatch rasters thus produced although parallel are found to vary slightly in size. Accordingly, the same sawtooth deflection currents applied to the deflection yoke **23** are applied to the size deflection windings of the vertical static convergence and size correction assembly and the horizontal static convergence and size correction assembly to achieve substantial registry of the three rasters across the face of the cathode ray tube.

In understanding the invention, it is useful to consider the type of parabolic errors produced by the prior art system wherein a deflection yoke providing a substantially uniform field was employed. Thus, referring to FIGURE 3, there is shown a view from the front of the faceplate **7** of the type raster produced when a uniform field yoke is employed. It is seen that in such a system even where the beam **17** from the green gun **11** produces a plurality of vertical lines **41**, inherent parabolic errors result in splitting of the electron beams **15** and **19** produced by the blue and red guns **9** and **13** respectively. Thus, as depicted, the beam **15** produced by the blue gun **9** instead of traversing the desired vertical paths describes parabolic paths **45**, the parabolic error being seen to increase toward the edge of the tube. Similarly, inherent parabolic errors cause the beam **19** generated by the red gun **13** to describe parabolic paths **43** rather than the desired vertical paths, the parabolic error again increasing toward the edge of the tube. The manner in which the electron beams cross to produce the type of errors shown in FIGURE 3 is seen by reference to the electron beams **15'**, **17'** and **19'** and also **15''**, **17''** and **19''** of FIGURE 1.

As is well known, the type of parabolic errors shown in FIGURE 3 are inherent in the prior art systems due to the tube geometry and the action of the axial component of the deflection field on the beams as the beams are deflected.

In the prior art, the severe beam splitting depicted in FIGURE 3 could only be corrected through the use of a complicated predeflection system, a complex and difficult to generate correction signal being utilized for this purpose. In accordance with the present invention, the prior art problems are overcome through the use of an optimally non-uniform deflection yoke which inherently eliminates the parabolic errors depicted in FIGURE 3 by producing three linear rasters exhibiting parallelism at all points.

More specifically, it is found that by adding quadrature flux components to a substantially uniform deflection field, a deflection field can be achieved which will inherently correct for the parabolic errors depicted in FIGURE 3. Thus, referring to FIGURES 4 and 5 there is depisted schematically the manner in which quadrature flux components may be added to the vertical and horizontal deflection windings respectively. Referring specifically to FIGURE 4 there is shown a ferrite core **47** upon which is positioned a toroidally wound horizontal deflection winding. The core **47** may take the shape of a generally truncated conical member and be formed from a ferrite material.

The horizontal deflection winding comprises a pair of terminals **49** and **51**, a main winding comprising windings **53** and **55** and four correction windings **57**, **59**, **61** and **63**.

It will be seen that starting from terminals **51** the various windings are serially connected in the following order, namely winding **61**, winding **63**, winding **57**, winding **59**, winding **55** and winding **53**. In this manner the flux produced by the respective winding **53** and **55** of the main winding is additive to produce a substantially uniform main deflection field. Further the flux produced by each of the correction windings **57**, **59**, **61** and **63** includes a component in quadrature to the main field and a component bucking the main field. Since the correction windings contain fewer turns than the main field windings, the

flux produced by these windings will have a pronounced effect only on electron beams in the immediate vicinity thereof.

Thus for example, where a sawtooth deflection wave **65** is applied to the terminal **51** such that current flow in the deflection winding is in the direction of arrow **67** during the negative half cycle of the sawtooth, the windings **53** and **55** produce a substantially uniform main field having a direction represented by the arrows **69** and **71** while the correction windings **57, 59, 61** and **63** produce fields having directions represented by the arrows **73, 75, 77** and **79** respectively.

It will be appreciated that the flux produced by each of the correction windings **57, 59, 61** and **63** include a quadrature component and a component bucking the main field as indicated for example by arrows **81** and **83** respectively with respect to correction winding **57**. It will be seen that the main field as represented by the arrows **69** and **71** in conjunction with the component of the correction flux which bucks the main field produces a force on the beams as indicated by the arrow **85** during the negative half cycle of the sawtooth wave **65**, the beams being directed out of the plane of the drawing as shown. Similarly, the quadrature component of the flux produced by each correction winding produces a force in a vertical direction on the beams in the vicinity of the correction windings.

Referring to FIGURE 5 there is shown a vertical deflection winding including a pair of terminals **86** and **87**. The winding comprises windings **89** and **91** of the main winding and correction windings **93, 95, 97** and **99**. It will be seen that starting from terminal **86**, the correction windings and main windings are serially connected in the following order, namely winding **99**, winding **97**, winding **93**, winding **95**, winding **89**, and winding **91**.

The flux produced by the windings **89** and **91** is additive to produce a substantially uniform main deflection field while the flux produced by each of the correction windings **93, 95, 97** and **99** includes a component in quadrature with the main field and a component which adds to the main field.

Thus, for example where a sawtooth deflection wave **101** is applied between the terminals **86** and **87** such that current through the deflection winding flows in the direction of the arrow **103** during the negative half cycle of the deflection wave so that the windings **89** and **91** produce a main field having a direction represented by arrows **105** and **107** while the correction windings **93, 95, 97** and **99** produce fields having directions represented by the arrows **109, 111, 113**, and **115** respectively.

It will be appreciated that in a manner similar to the horizontal deflection winding shown in FIGURE 4, the flux produced by each of the correction windings includes a quadrature component as well as a component that adds to the main field as indicated for example by arrows **117** and **119** respectively with respect to correction winding **93**. The main field indicated by arrows **105** and **107** in conjunction with the component of the correction field which adds thereto provides a force on the beams as indicated by arrow **121** dupring the negative half cycle of the sawtooth wave **101**, the beams again being directed out of the plane of the drawing as shown. Further, the quadrature component of the correction fields as represented for example by arrow **117** produces a correcting force in a horizontal direction, this correcting force being most pronounced in the vicinity of the various correcting windings.

In accordance with the invention, the main horizontal and vertical windings and the associated correction winding shown in FIGURES 4 and 5 are so related that the correction forces provided by the correction windings produce three linear rasters exhibiting substantial registry across the entire face of the cathode ray tube.

In a preferred embodiment of the invention, the windings shown separately in FIGURES 4 and 5 are combined into a composite winding distribution as depicted in FIGURE 6.

In the composite distribution of the preferred embodiment of FIGURE 6, each of the main vertical and horizontal deflection windings have been combined with their associated correction windings as shown in FIGURES 4 and 5. Thus, the main horizontal winding **53** of FIGURE 4 has been combined with the correction windings **57** and **59** while the main horizontal winding **55** has been combined with the correction windings **61** and **63**. Similarly, the main vertical deflection winding **89** of FIGURE 5 is combined with correction windings **93** and **95** while the main vertical winding **91** is combined with correction windings **97** and **99**. Further, as shown the horizontal and vertical deflection windings are combined to provide a composite distribution which is easily wound on a single core. In this manner the necessity for discrete correction windings is eliminated while producing the same effect.

In FIGURE 6 the composite distribution is shown wound in toroidal fashion on a ferrite core member **123** of generally truncated conical shape. For purposes of simplicity only the turns abutting the inner surface of the core member have been shown. It will be appreciated that these turns will be in closest proximity to the electron beams **15, 17** and **19** and thus will have the greatest effect thereon.

The composite distribution of FIGURE 6 can be easily wound in progressive fashion through the use of four windings. Thus, a first winding represented by the unshaded turns **124** may be started at turn **125** and wound in a counterclockwise direction in progressive fashion to turn **127**. A second winding **128** represented by the turns having an "*x*" therein may be initiated at turn **129** and wound in a counterclockwise direction in progressive fashion to turn **131**.

The first and second windings thus comprise the vertical deflection winding including the correction windings as shown in FIGURE 5.

Similarly, a third winding **132** represented by the partially shaded turns may be initiated at turn **133** and wound counterclockwise in progressive fashion to turn **135**. A fourth winding **136** represented by the completely shaded turns may be initiated at turn **137** and wound in a counterclockwise direction in progressive fashion to turn **139**. As depicted, there are seen to be gaps at some positions of the resultant composite winding while at other positions the windings necessarily overlie each other.

The third and fourth turns comprise the horizontal deflection windings including the correction windings shown in FIGURE 4.

A terminal **141** is connected to the turn **127** of the first winding via a lead **143**, a terminal **145** being connected to the turn **131** of the second winding via a lead **147**. Terminals **141** and **145** thus comprise the input terminals to the vertical deflection winding and serve the function of the terminals **86** and **87** of FIGURE 5.

Similarly, a terminal **149** is connected to the turn **133** of the third winding via a lead **151** while a terminal **153** is connected to turn **137** of the fourth winding via a lead **155**. Terminals **149** and **153** thus comprise the input terminals of the horizontal deflection winding and serve the same function as the terminals **49** and **51** of the winding shown in FIGURE 4.

As depicted, the turns **125, 129, 135**, and **139** are connected in common through leads **157, 159, 161** and **163** respectively.

It will be seen that in accordance with an important feature of the invention different distributions are utilized for the horizontal and vertical deflection windings. In accordance with the invention, each of these distributions differ significantly from the distribution utilized in the prior art to achieve a substantially uniform deflection field. Thus, in the preferred embodiment of the invention, distributions represented graphically in FIGURES 7 and 8 were utilized for the vertical and horizontal windings respectively to provide an optimally non-uniform field.

Referring to FIGURE 7 there is shown a normalized plot of the vertical winding distribution shown in FIGURE 6. In the graph of FIGURE 7 the Y axis represents a percentage of the total number of vertical turns in the second quadrant of FIGURE 6 while the X axis represents an angle ϕ increasing counterclockwise. The placement of the individual turns is represented by the circles through which the curve is drawn. Accordingly, the curve represents the position of each turn within the quadrant. For purposes of illustration, where 41 vertical turns are employed per quadrant as shown in FIGURE 6, 50% of these turns would be located within a quadrant angle ϕ of 35°. Accordingly, the 20.5th turn would be located at a quadrant angle of 35°. The vertical winding in the first quadrant is of course a mirror image of that in the second quadrant.

The curve shown in FIGURE 7 can be represented by a Fourier series of the form

$$Y_V = A \sin(\phi) + B \sin(3\phi) + C \sin(5\phi) + D \sin(7\phi) + E \sin(9\phi) + F \sin(11\phi) + G \sin(13\phi) + H \sin(15\phi) + \ldots$$

where the coefficients are generally:

A	97.99
B	−4.55
C	0.69
D	3.48
E	−0.25
F	−0.56
G	0.75
H	0.62

Referring to FIGURE 8 there is shown a normalized plot of the horizontal winding distribution shown in FIGURE 6. In the graph of FIGURE 8 the Y axis represents a percentage of the total number of horizontal turns in the first quadrant of FIGURE 6 while the X axis represents an angle θ increasing counterclockwise within the quadrant. Again the placement of the individual turns is represented by the circles through which the curve is drawn, each circle representing an individual turn. Accordingly, the curve represents the position of each turn within the quadrant. For purposes of illustration where 31 horizontal turns are employed per quadrant as shown in FIGURE 6, 50% of these turns would be located within a quadrant angle θ of 25°. Accordingly, the 15.5th turn would be located at a quadrant angle of 25°. The horizontal winding in the fourth quadrant is of course a mirror image of that in the first quadrant.

The curve shown in FIGURE 8 can be represented by a Fourier series of the form:

$$Y_H = S \sin(\theta) + T \sin(3\theta)\ U \sin(5\theta) + V \sin(7\theta) + W \sin(9\theta) + X \sin(11\theta) + Y \sin(13\theta) + Z \sin(15\theta)$$

where the coefficients are generally:

S	105.62
T	7.51
U	1.51
V	−1.65
W	0.68
X	2.42
Y	0.50
Z	−0.61

In some instances both horizontal and vertical turns will be found to be located at the same angular position and these turns will necessarily overlie one another as clearly shown in FIGURE 6.

In the particularly successful embodiment of the distribution shown in FIGURE 6 mentioned above, the horizontal and vertical windings were wound from a #25 AWG magnet wire on a ferrite core of generally truncated conical shape having an inner diameter at the beam entry and beam exit ends thereof of 1.788" and 2.830" respectively. Further the core had outer diameters at the beam entry and exit ends of 2.289" and 3.104" respectively. The end surfaces of the ferrite core can be notched or provided with a notched insert to maintain the various turns in the desired location. Such a deflection yoke was found to provide an optimally simplified deflection system for use with the General Electric type 11SP22 color cathode ray tube.

The manner in which the main fields and the correcting fields interact to provide the necessary correcting forces to overcome inherent parabolic errors is extremely complex and difficult to describe since these forces differ from point to point within the field and vary with time.

However, the manner in which the correctional forces affect the electron beams may be considered with reference to the vector diagrams shown in the first quadrant of FIGURE 6. Thus, for example, where an electron beam directed as shown is positioned somewhere in the first quadrant, the main vertical field B_{MV} and the main horizontal field B_{MH} combine to produce a resultant main field B_{MR}. It must be understood that the horizontal field varies at the line rate while the vertical field varies at the field rate. From the vector equation $\overline{B} \times \overline{V} = \overline{F}$ it is seen that a force is produced by the main fields on the electron beam identified by the vector F_M.

Similarly, the correction field produced by the vertical correction windings B_{CV} can be resolved into a component B_{CVM} in phase with the main vertical field and a component B_{CVQ} in quadrature with the main vertical field. Further, the field produced by the horizontal correction windings produce a correction field B_{CH} which can be resolved into an in-phase component B_{CHM} and a quadrature component B_{CHQ}. Thus, a resultant correction field B_{CR} is provided. The correction fields produce a force F_C on the electron beam which in conjunction with the force produced by the main field F_M provides a resultant force F_R. In this manner, correcting forces are applied to the electron beam which eliminate the parabolic errors inherent in the prior art systems.

It will be appreciated that the vector diagram shown in FIGURE 6 represents conditions existing only for a particular time and a particular axial position within the yoke as well as for a particular position within the quadrant. Thus the total correcting forces acting upon each electron beam during its passage through the yoke is the line integral of forces existing at each point along the beam path. The line integral necessarily differs for the beams **15**, **17** and **19** since the path of these various beams differ through the yokes as shown in FIGURE 1.

It should be emphasized that through the use of a deflection yoke in accordance with the invention as shown in FIGURE 6 the line integral of the forces acting on the respective electron beam is such that the parabolic errors depicted in FIGURE 3 which take the form of a beam splitting are eliminated and linear rasters are produced as shown in FIGURE 9 which exhibit parallelism at all points.

As depicted in FIGURE 9 the use of the yoke of FIGURE 6 provides three rasters of differing sizes namely a raster **165** produced by the green gun **11**, a raster **167** produced by the blue gun **9**, and a raster **169** produced by the red gun **13**. The view shown in FIGURE 9 is from the front of the faceplate and the blue raster has been shown by a dotted line, the red raster by a dash-dot line, and the green raster by a dashed line.

Since the three rasters shown in FIGURE 9 differ only in size, in accordance with an important feature of the invention a linear correction signal can be applied to a predeflection system to achieve substantial registry of the three rasters. Thus, in accordance with the invention the necessity for complex parabolic correction signals is completely eliminated and the sawtooth deflection currents can themselves be employed for this purpose.

Referring to FIGURE 10 there is shown a sectional view of the vertical static convergence and size correction systems shown in FIGURE 1, like reference numerals

being utilized to identify those components shown in FIGURES 1 and 2. As depicted, each of the electron beams **15** and **19** passes through a pair of pole pieces positioned within the tube neck **3**. Thus, the electron beam **15** passes between a generally C-shaped pole piece **171** and a generally planar pole piece **173**. Similarly, the electron beam **19** passes between a generally C-shaped pole piece **175** and a generally planar pole piece **177**. The electron beam **17** is unaffected by the action of the pole pieces on the beams **15** and **19**.

A generally E-shaped core member overlies the tube neck in proximity to each of the electron beams **15** and **19**. The core member for the beam **15** comprises a generally U-shaped member **179** and a central arm **181** having a cylindrical ferrite magnet **183** rotatably positioned therebetween. A winding **184** provided with terminals **185** and **186** is positioned on the central arm **181** to provide the desired vertical size correction. The ferrite magnet **183** is diagonally polarized as shown and is positioned in suitable grooves in the U-shaped member **179** and the central arm **181**.

Similarly, the beam **19** is provided with a generally C-shaped core member **187** and a central arm **189** having a cylindrical ferrite magnet **191** rotatably positioned therebetween. A ferrite magnet **191** is diagonally polarized in the same manner as the magnet **183** and is positioned in suitable grooves in the U-shaped core member **187** and the central arm **189**. A vertical size correction winding **192** provided with terminals **193** and **194** is positioned on the central arm **189**, the windings **184** and **192** being serially connected as shown.

The operation of the vertical convergence and size correction assembly of FIGURE 10 is such that the magnets **183** and **191** can be rotated to control the magnitude and polarity of the steady state field through which beams **15** and **19** pass. The field is represented by the arrows **195** with respect to beam **15**, and arrows **197** with respect to beam **19**, the beams being directed into the plane of the drawing as shown. Further, the proximity of the C-shaped core members **179** and **187** to the internal pole pieces **171** and **175** respectively can be varied to control the field magnitude as described and claimed in co-pending application Ser. No. 469,161 filed July 2, 1965, now Patent No. 3,305,807 and assigned to the assignee of the present invention.

In accordance with an important feature of the invention, the sawtooth deflection currents are applied directly to the size correction windings **184** and **192** to apply a linear but time varying correction field to the electron beams **15** and **19** respectively. In this manner the vertical size of the blue and red rasters produced by the electron beams **15** and **19** respectively can be controlled to achieve substantial registry with the green raster.

Referring to FIGURE 11 there is shown a sectional view of the horizontal static convergence and size correction assembly shown at FIGURES 1 and 2. As depicted, the beam **17** is shielded by a cylindrical shielding member **199**, the beam **15** being provided with a pair of spaced generally V-shaped pole pieces **201** while the beam **19** is provided with a pair of similar V-shaped pole pieces **203**.

Each of the beams **15** and **19** is provided with a generally U-shaped core member positioned external to the tube neck **3** in proximity to the pole pieces **201** and **203** respectively. Thus, the beam **15** is provided with a generally U-shaped core member comprising a pair of L-shaped core segments **205** and **207** having a cylindrical ferrite magnet **209** rotatably positioned therebetween. Size correction windings **211** and **213** are provided on the core segments **205** and **207** respectively, the winding **211** being provided with a terminal **214**. Similarly, the beam **19** is provided with a pair of generally L-shaped core segments **215** and **217** having a cylindrical ferrite magnet **219** rotatably positioned therebetween. Size correction windings **221** and **223** are positioned on the core segments **215** and **217** respectively and these segments being notched to receive the magnets **209** and **219** respectively. The winding **221** is provided with a terminal **224** as shown.

As depicted, the horizontal size correction windings **211**, **213**, **223** and **221** are serially connected in the order named.

The operation of the horizontal static convergence and size correction assembly of FIGURE 11 is such that the rotatable magnets **209** and **219** can be rotated to control the magnitude and polarity of the static field acting upon the electron beams **15** and **19** respectively. The flux passing between the pole pieces **201** and the pole pieces **203** is represented by the arrows **225** and **227**, respectively, this flux producing forces on the respective beams represented by the arrows **229** and **231** respectively with the beams again being directed into the plane of the drawing as shown. Thus, in a manner similar to the vertical static convergence and size correction assembly, the angular positions of the magnets **209** and **219** can be independently controlled and the proximity of the core segments **215** and **217** to the internal pole pieces **201** and **203** may be varied to statically converge the beams **15**, **17** and **19** in the desired fashion. In addition, as with the vertical static convergence and size correction assembly, the sawtooth horizontal deflection current is applied directly to the size correction windings **211**, **213**, **221** and **223** to control the flux acting upon the electron beams **15** and **19** thereby causing the size of the rasters produced by these electron beams to correspond to that of the green beam.

It will be seen that there are different reasons for the horizontal and vertical size differences shown in FIGURE 9. Thus, the horizontal size differences result from the action of the deflection yoke in producing correction forces to overcome the parabolic errors inherent in the prior art systems. However, with an in-line gun system as disclosed, the vertical size errors result almost entirely from gun misalignment. Thus, in instances where gun alignment is such that no vertical size errors are produced, it is possible to utilize horizontal size correction alone while eliminating vertical size correction to further simplify the deflection system.

Referring to FIGURE 12 there is shown a schematic diagram of the deflection circuitry of a representative television receiver employing the simplfied deflection system of the invention. In FIGURE 12 like reference numerals have been utilized to identify those elements identified in the previous figures.

As shown, the vertical output stage **33** comprises a vertical driver tube **233** having anode, cathode and control grid electrodes **235**, **239** and **237** respectively.

The output of the vertical oscillator (not shown) is applied to the control grid **237** to develop a sawtooth deflection current in the primary of a vertical output transformer **241** connected to the anode **235**. The cathode **239** is connected to ground through a vertical linearity control **243** in conventional fashion.

The secondary of the vertical output transformer **241** is connected to the terminal **141** which is in turn connected to the first winding **124** of the composite winding as shown in FIGURE 6. The first winding **124** is connected to the second winding **128** which is in turn connected to a terminal **145** as discussed above.

In accordance with the invention the terminal **145** is directly connected to the terminal **185** of size correction winding **184**. Similarly, terminal **186** of size correction winding **184** is directly connected to terminal **193** of size correction winding **192**, terminal **194** of size correction winding **192** being grounded as shown. In this manner the identical sawtooth current flowing in the deflection windings **124** and **128** also flows in the correction windings **184** and **192** to provide the necessary size correction as discussed above.

The horizontal output stage **39** comprises a horizontal driver tube **245** having anode, cathode, control grid and

screen grid electrodes **247**, **249**, **251** and **253** respectively.

The output of the horizontal oscillator (not shown) is applied to the control grid **251**, the cathode **249** being grounded. The anode **247** is connected to a tap **257** of a conventional auto-transformer **259**. The auto-transformer **259** is provided with a damping circuit including damping diode **261** and associated capacitors **263** and **265** and inductor **267**. The damping diode **261** serves to develop the desired sawtooth deflection signal across the auto-transformer in well known fashion.

A high voltage rectifier **269** is connected to a tertiary portion of the auto-transformer **259** in conventional fashion to develop a high voltage for application to the cathode ray tube.

The sawtooth deflection signal developed across the auto-transformer **259** is coupled to a secondary winding **271**, the secondary winding **271** being connected to the terminal **149** of the winding **132** shown in FIGURE 6. The winding **132** is connected to winding **136** as shown in FIGURE 6, the terminal **153** of winding **136** being directly connected to the terminal **214** of the horizontal size correction winding **211** shown in FIGURE 9. The horizontal size correction windings **211**, **213**, **223** and **221** are serially connected in the order named, the terminal **224** of winding **221** being connected to the secondary **271** as shown.

A serially connected resistor **273** and capacitor **275** is connected in shunt with the deflection windings **132** and **136** to damp sweep striations in well know fashion while a capacitor **277** is connected in shunt with the winding **136** as shown to balance the capacity across the windings **132** and **136**.

The secondary winding **271** is coupled to a blanking winding **279**, the winding **279** being utilized to provide the necessary horizontal blanking. Since the blanking circuitry shown in FIGURE 10 forms no part of the present invention it will not be described in detail.

It will be seen in the circuit of FIGURE 10 that as shown in FIGURE 6, the junction between the windings **124** and **128** and the junction between the windings **132** and **136** are connected in common via a lead **281**.

The operation of the horizontal output stage **39** is such that sawtooth deflection signal is developed across the secondary **271** to develop a sawtooth deflection current in the windings **132** and **136**. In accordance with the invention the identical deflection current flows in the size correction windings **211**, **213**, **223** and **221** to effect the necessary size correction as discussed above.

The magnitude of the flux produced by the size correction windings can be controlled by varying the proximity of the respective members to the external pole pieces as discussed above. The polarity of the size correction flux required in a particular instance can be selectively controlled by controlling the direction of current flow through the individual windings.

Although the invention has been described with respect to certain specific embodiments, it will be appreciated that modifications and changes may be made by those skilled in the art without departing from the true spirit and scope of the invention.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. A deflection system for a plural in-line beam cathode ray tube having a gun arrangement for producing a plurality of co-planar electron beams impingent upon a viewing screen to produce a raster of a given color thereon, said system comprising:

(a) a deflection yoke positioned intermediate the gun arrangement and the viewing screen in the path of the electron beams and including a vertical winding having toroidally wound turns providing a main field to deflect the electron beams in a vertical direction and a horizontal winding having toroidally wound turns providing a main field to deflect the electron beams in a horizontal direction,

(b) said vertical winding further including toroidally wound turns providing flux components in quadrature to the main vertical field,

(c) said horizontal winding further including toroidally wound turns providing flux components in quadrature to the main horizontal field, there being, with respect to the yoke deflection field, at least one fourth greater number of net flux producing turns in the vertical winding than in the horizontal winding,

(d) said horizontal and vertical quadrature flux components exerting forces on said beams to produce from each beam a raster substantially parallel at all points to the rasters produced by the other beams but differing in size with respect thereto.

2. A deflection system for a plural in-line beam cathode ray tube having a gun arrangement for producing three co-planar electron beams impingent upon a viewing screen to produce a raster of a given color thereon, said system comprising:

(a) a deflection yoke positioned intermediate the gun arrangement and the viewing screen in the path of the electron beams and including horizontal and vertical windings,

(b) said vertical winding being toroidally wound in a first distribution providing a main field to deflect the electron beams in a vertical direction and flux components in quadrature therewith,

(c) said horizontal winding being toroidally wound in a second distribution different from said first distribution of the vertical winding providing a main field to deflect the electron beams in a horizontal direction and flux components in quadrature therewith, there being, with respect to the yoke deflection field, at least one fourth greater number of net flux producing turns in the vertical winding than in the horizontal winding,

(d) said horizontal and vertical quadrature flux components exerting forces on said beams to produce from each beam a raster substantially parallel at all points to the rasters produced by the other beams but differing in size with respect thereto.

3. The deflection system set forth in claim **2** wherein said first distribution is defined by a formula substantially of the form:

$$Y_V = 97.99 \sin \phi - 4.55 \sin (3\phi) + 0.69 \sin (5\phi) + 3.48 \sin (7\phi) - 0.25 \sin (9\phi) - 0.56 \sin (11\phi) + 0.75 \sin (13\phi) + 0.62 \sin (15\phi)$$

where Y_V represents a percentage of the total number of vertical turns in a quadrant of the deflection yoke and where ϕ is an angle increasing in a counterclockwise direction from the vertical axis of the deflection yoke, and said second distribution is defined by a formula substantially of the form:

$$Y_H = 105.62 \sin \theta + 7.51 \sin (3\theta) + 1.51 \sin (5\theta) - 1.65 \sin (7\theta) + 0.68 \sin (9\theta) + 2.42 \sin (11\theta) + 0.50 \sin (13\theta) - 0.61 \sin (15\theta)$$

where Y_H represents a percentage of the total number of horizontal turns in a quadrant of the deflection yoke and θ is an angle increasing in a counterclockwise direction from the horizontal axis of the deflection.

4. The deflection system defined in claim **3** wherein said first distribution comprises a total of 41 winding turns per quadrant and said second distribution comprises a total of 31 winding turns per quadrant.

5. The deflection system defined in claim **2** including horizontal size correction means positioned intermediate said yoke and said gun arrangement to cause the horizontal size of each of said rasters to be substantially identical to the other rasters.

6. The deflection system defined in claim **5** wherein said horizontal size correction means includes horizontal size correction windings directly connected to said deflection yoke and being responsive to the linear deflection

current from said yoke to apply a linearly varying size correction flux to the outermost of said electron beams to cause the rasters produced by the outermost beams to correspond in size to that produced by the center beam.

7. The deflection system defined in claim **6** wherein said horizontal size correction windings are wound on core segments positioned exterior to the cathode ray tube in proximity to the associated electron beams.

8. The deflection system defined in claim **2** including vertical size correction means positioned intermediate said yoke and said gun arrangement to cause the vertical size of each of said rasters to be substantially identical to the other rasters.

9. The deflection system defined in claim **8** wherein said vertical size correction means includes vertical size correction windings directly connected to said deflection yoke and being responsive to the linear deflection current from said yoke to apply a linearly varying size correction flux to the outermost of said electron beams to cause the rasters produced by the outermost beams to correspond in size to that produced by the center beam.

10. The deflection system defined in claim **9** wherein said size correction windings are wound on core segments positioned exterior to the cathode ray tube in proximity to the associated electron beams.

11. A deflection system for a plural in-line beam cathode ray tube having a gun arrangement for producing a plurality of co-planar electron beams impingent upon a viewing screen to produce a raster of a given color thereon, said system comprising:

(a) a deflection yoke positioned intermediate the gun arrangement and the viewing screen in the path of the electron beams and having vertical and horizonal deflection windings including turns providing quadrature flux components exerting forces on said beams to produce from each beam a raster substantially parallel at all points to the rasters produced by the other beams but differing in size with respect thereto,

(b) horizontal size correction means including a horizontal size correction winding positioned intermediate said electron guns and said deflection yoke to apply size correction forces to selected ones of said beams, said horizontal size correction winding being directly connected to said horizontal deflection winding,

(c) horizontal output means connected to said horizontal deflection winding to produce a common linearly varying sawtooth deflection current in said horizontal deflection winding and said horizontal size correction winding.

12. The deflection system defined in claim **11** further including:

(a) vertical size correction means including a vertical size correction winding positioned intermediate said gun arrangement and said deflection yoke to apply vertical size correction forces to selected ones of said beams, said vertical size correction windings being directly connected to said vertical deflection winding,

(b) vertical output means connected to said vertical deflection winding to produce a common linearly varying sawtooth deflection current in said vertical deflection winding and said vertical size correction winding.

13. The deflection system defined in claim **12** wherein the cathode ray tube includes first, second and third linearly arrayed electron guns producing first, second and third linearly arrayed electron beams and said horizontal and vertical size correction forces are applied to the outermost electron beams to cause the rasters produced by the outermost beams to correspond in size to the raster produced by the center beam.

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