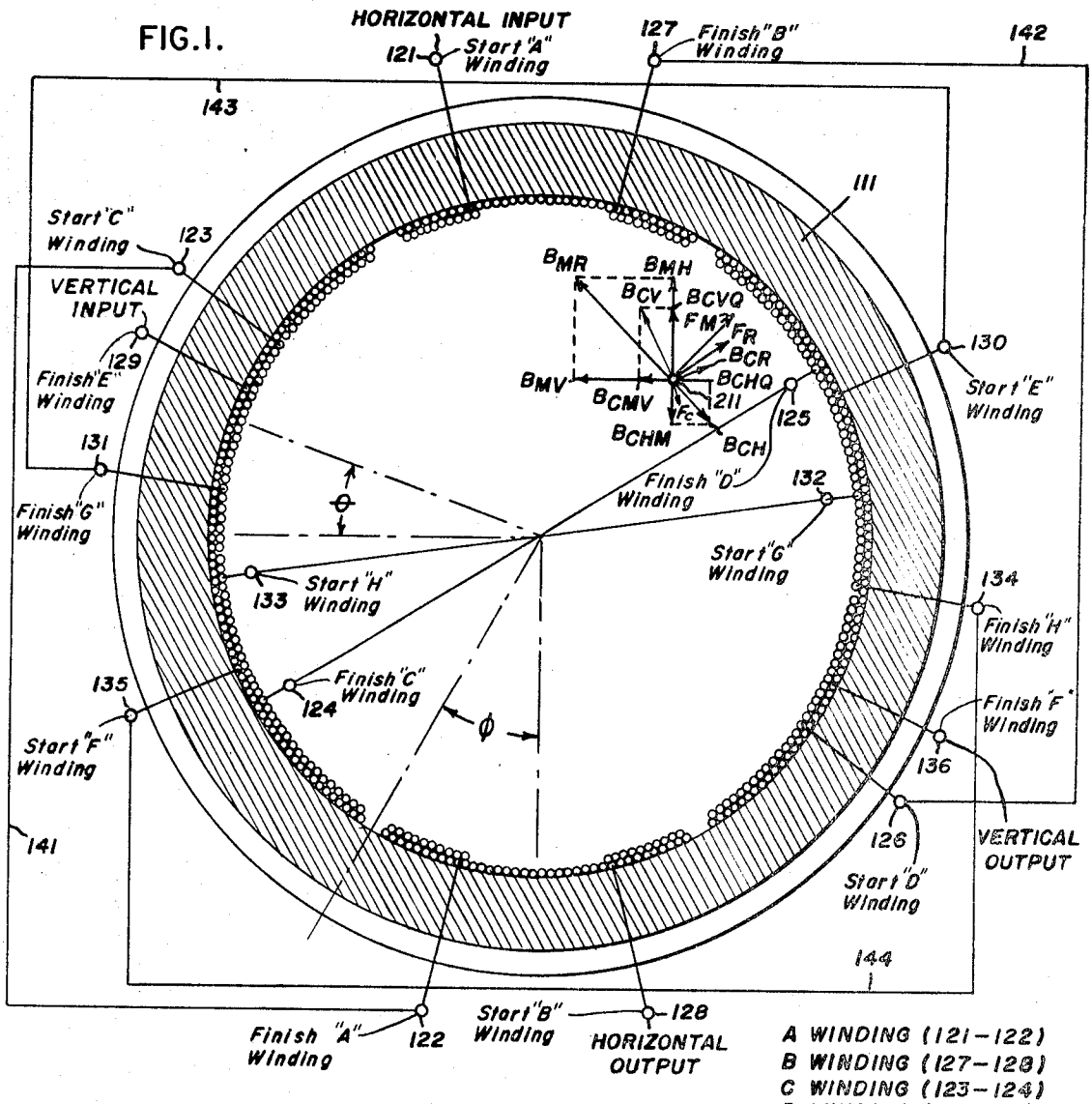
Dec. 15, 1970 J. R. ARCHER 3,548,350

WIDE ANGLE DEFLECTION YOKE FOR PRODUCING OPTIMALLY NON-UNIFORM DEFLECTION FIELDS

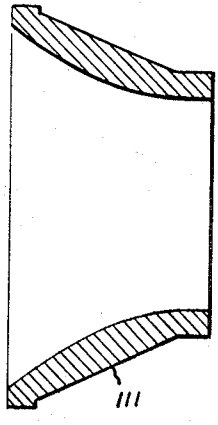
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FIG. 1.



A WINDING (121–122)
B WINDING (127–128)
C WINDING (123–124)
D WINDING (125–126)
E WINDING (129–130)
F WINDING (135–136)
G WINDING (131–132)
H WINDING (133–134)

FIG. 2.



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FIG.3.

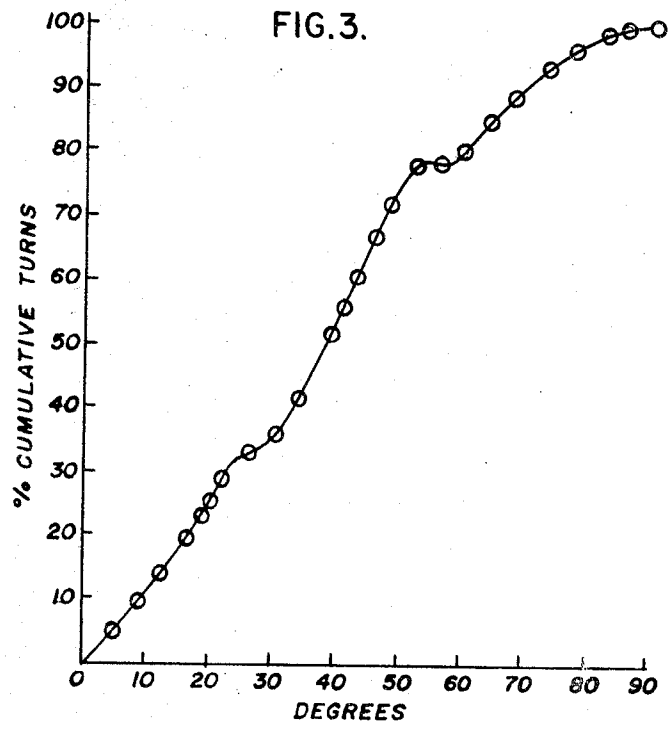


FIG.4.

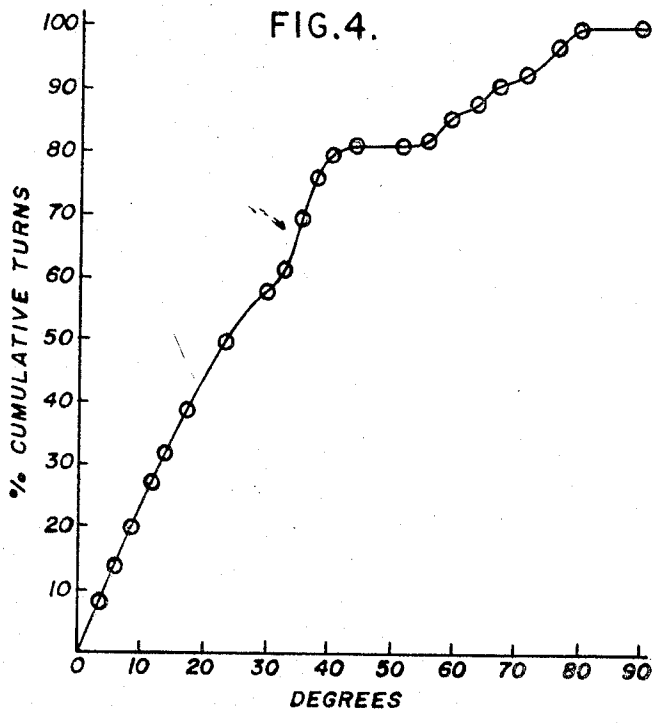


FIG.6.

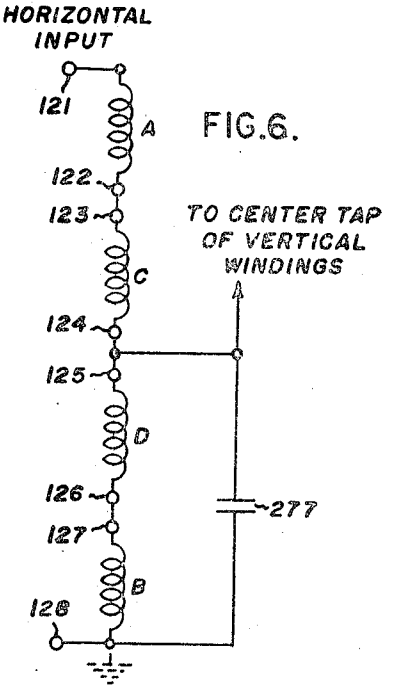
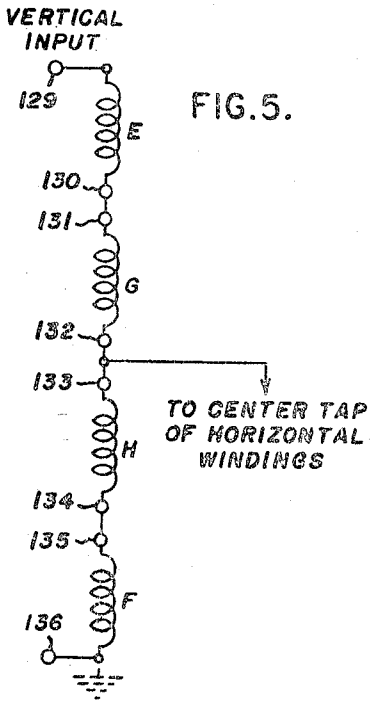


FIG.5.



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United States Patent Office 3,548,350 Patented Dec. 15, 1970

3,548,350

WIDE ANGLE DEFLECTION YOKE FOR PRODUCING OPTIMALLY NON-UNIFORM DEFLECTION FIELDS

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Filed Jan. 15, 1969, Ser. No. 791,291
Int. Cl. H01f 7/00
U.S. Cl. 335—210 10 Claims

ABSTRACT OF THE DISCLOSURE

An improved wide angle deflection yoke for producing optimally non-uniform deflection fields is described. The deflection yoke is for use in 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 with the yoke adapted to be positioned intermediate the gun arrangement and viewing screen in the path of the electron beams. The yoke includes an open-ended, quasi-cylindrical core member adapted to have the electron beams pass therethrough. A vertical winding is formed on the core member with toroidally wound turns wound in a first distribution providing a main field to deflect the electron beams in a vertical deflection. A horizontal winding is formed on the core member with toroidally wound turns wound in a second distribution providing a main field to deflect the electron beams in a horizontal direction. The vertical winding includes additional toroidally wound turns providing flux components in quadrature and in opposition to the main vertical field, and the horizontal winding includes additional toroidally wound turns providing flux components in quadrature and in opposition to the main horizontal field. The horizontal and vertical quadrature and opposition flux components coact with the main horizontal and vertical fields to produce within the yoke optimally non-uniform forces acting on the electron beams that cause each beam to form a curvilinear or pincushion raster substantially geometrically similar in shape to the rasters produced by the other beams. The vertical and horizontal windings and the additional toroidally wound turns are doubly wound over a substantial portion of the circumference of the quasi-cylindrical core member. That is, more than fifty percent of the circumferential surface of the quasi-cylindrical core member is doubly wound, and to be more exact approximately eighty-five percent of the circumference is doubly wound. In addition, both the vertical and horizontal windings and their additionally toroidally wound turns are comprised of N winding segments where N is a number greater than two (2) and wherein intermediate each winding segment electrical connections back to a doubly wound, winding segment are made in a flyback manner whereby potential differences between adjacent doubly wound turns of the same winding function are minimized to the greatest practical extent, to reduce horizontal-vertical cross talk.

BACKGROUND OF INVENTION

Field of invention

This invention relates to a new and improved, wide angle, deflection yoke of the type for producing optimally non-uniform deflection fields for plural, in-line beam, color cathode ray, television picture tubes.

More particularly, the invention relates to an improved, wide angle deflection yoke of the optimally non-uniform deflection field producing type for use with plural in-line beam, color cathode ray, television picture tubes of the

type having a three in-line electron gun arrangement for producing a plurality of co-planar electron beams impingent upon the viewing screen of the picture tube to produce a raster of given color thereon, the optimally non-uniform field forces produced by the yoke acting on the plural electron beams in a manner such that each beam forms a curvilinear or pincushion raster substantially geometrically similar in shape to the rasters produced by the other beams.

Description of prior art

U.S. patent application Ser. No. 574,411, filed Aug. 23, 1966, and issued Feb. 25, 1969, as U.S. Pat. No. 3,430,099 for "Simplified Deflection System for Plural In-Line Beam Cathode Ray Tube"—Robert B. Ashley, inventor—assigned to the General Electric Company, discloses and claims a color television picture tube deflection system employing a deflection yoke of the optimally non-uniform deflection field producing type for use with plural in-line beam, color television, cathode ray picture tubes. The deflection system disclosed in the aforenoted Ashley patent was designed primarily for a maximum scanning deflection angle of about 70°. By maximum scanning deflection angle is meant the maximum angle through which an electron beam can be scanned by its associated deflection system in tracing out a picture to be reproduced on the face of the television system in tracing out a picture to be reproduced on the face of the television picture tube. Thus, the angle which the extreme or outermost paths of an electron beam subtend with respect to the center of the deflection yoke, is defined as the maximum deflection angle. For example, the outermost upper electron beam path and the outermost lower electron beam path subtend or define the maximum, vertical deflection scanning angle. The aforenoted Ashley patent discloses a deflection system wherein this maximum, vertical scanning deflection angle is of the order of 70°.

It will be appreciated that the maximum scanning deflection angle of a picture tube greatly affects the overall design parameters of the picture tube deflection system such as size, power consumption, etc., to provide a given viewing area of stated quality on the face of the tube. In order to provide larger viewing areas on a television receiving set of given front to back dimension, it is necessary for such sets to utilize television picture tubes having deflection systems providing a wider maximum scanning deflection angle. To meet this need, the present invention was devised.

SUMMARY OF INVENTION

It is therefore a primary object of the invention to provide a new and improved wide, scanning deflection angle deflection yoke of the type for producing optimally non-uniform deflection fields for plural, in-line beam, color cathode ray television picture tubes.

Another object of the invention is to provide such a wide angle, non-uniform deflection field producing deflection yoke wherein to accommodate the wider scanning deflection angle, the toroidally wound windings of the yoke are doubly wound over a substantial portion of the circumference of the yoke.

A further object of the invention is to provide a deflection yoke having the above characteristics wherein the horizontal and vertical deflection windings are comprised of N winding segments where N is a number greater than two (2) and wherein intermediate each winding segment, electrical connections back to a doubly wound winding segment are made in a flyback manner whereby potential differences between adjacent, doubly wound turns of the same winding function are minimized to the greatest practical extent.

In practicing the invention, an improved, wide angle deflection yoke for use in a plural in-line beam cathode ray tube, is provided. The cathode ray tube is of the type having three in-line electron guns arranged for producing a plurality of co-planar electron beams impingent upon the viewing area of the picture tube to produce a raster of a given color. The yoke is adapted to be positioned intermediate the gun arrangement and the viewing area and is comprised by an open-ended, quasi-cylindrical core member adapted to have the electron beams pass therethrough. A vertical winding is formed on the core member with toridally wound turns wound in a first distribution providing a main field to deflect the electron beams in a vertical direction. A horizontal winding is formed on the core member with toroidally wound turns wound in a second distribution to provide a main field to deflect the electron beams in a horizontal direction. Both the vertical and horizontal windings include additional toroidally wound turns providing flux components in quadrature and in opposition to the main vertical and horizontal fields. The horizontal and vertical quadrature and opposition flux components coact with the main horizontal and vertical fields to produce within the yoke optimally non-uniform forces acting on the beams that cause each beam to form a curvilinear or pincushion raster that is geometrically similar in shape to the rasters produced by the other beams. The vertical and horizontal windings and the additional toroidal wound turns are doubly wound over a substantial portion of the circumference of the quasi-cylindrical core member so that the doubly wound turns comprise more than fifty percent of the circumferential surface of the quasi-cylindrical core member and preferably comprise on the order of eighty-five percent (85%) of the circumferential surface.

The vertical winding and its additional, toroidally wound turns is comprised of N winding segments where N is a number greater than two (2) and wherein intermediate each winding segment, electrical connections back to a doubly wound winding segment are made in a fly-back manner whereby potential differences between adjacent doubly wound turns of the same winding function are minimized to the greatest practical extent to reduce horizontal-vertical crosstalk.

In a preferred form of the new and improved, wide angle deflection yoke, the vertical winding distribution is defined by a formula substantially of the form:

$$Y_V = 92.25 \sin \phi + 7.83 \sin (3\phi) + 1.94 \sin (5\phi) + 1.97 \sin (9\phi) + 1.70 \sin (13\phi) + 1.04 \sin (17\phi) + \ldots$$

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 clockwise direction from the vertical axis of the deflection yoke, and the horizontal winding distribution is defined by a formula substantially of the form:

$$Y_H = 104.35 \sin \theta + 7.92 \sin (3\theta) + 2.91 \sin (5\theta) + 2.49 \sin (7\theta) + 2.23 \sin (11\theta) + 1.16 \sin (19\theta) + \ldots$$

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 clockwise direction from the horizontal axis of the deflection yoke.

BRIEF DESCRIPTION OF DRAWINGS

Other objects, features and many of the attendant advantages of this invention will be appreciated more readily as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein like parts in each of the several figures are identified by the same reference character, and wherein:

FIG. 1 is a planar, cross-sectional view of a wide angle, deflection yoke constructed in accordance with the invention, and illustrates the actual, physical, winding layout and configuration made possible by the invention. The key to the winding layout pattern is shown in the lower right-hand corner of FIG. 1;

FIG. 2 is a sectional view of an open-ended, quasi-cylindrical core member constructed in accordance with the invention, and comprising a part of the wide angle, deflection yoke constructed in accordance with the invention;

FIG. 3 is a graphical respresentation of the vertical winding distribution shown in FIG. 1;

FIG. 4 is a graphical representation of the horizontal winding distribution shown in FIG. 1;

FIG. 5 is a schematic, electrical wiring diagram illustrating the manner in which the various winding segments comprising the vertical winding and additional torodially wound turns for producing the corrective quadrature and opposition field, are electrically interconnected upon the deflection yoke being assembled in the deflection system of a color, cathode ray television picture tube; and

FIG. 6 is a schematic, electrical wiring diagram that illustrates the electrical interconnection of the winding segments comprising the horizontal winding and its additional, toroidally wound quadrature and opposition field producing turns, and the manner in which these winding segments are electrically interconnected upon the deflection yoke being assembled in a deflection system of a color, cathode ray television picture tube.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The above-identified U.S. patent of Robert B. Ashley describes and claims a deflection system for a plural in-line beam, color, cathode ray television picture tube, and which utilizes a deflection yoke that 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 deflection yoke, three rasters are produced from which parabolic convergence errors are eliminated, the rasters only requiring correction as to size. The size correction is easily achieved by passing the sawtooth deflection current used to excite the deflection yoke through a pre-deflection system in order to obtain substantial registry of the rasters produced by the three electron beams without the necessity for complex, dynamic, convergence wave worm, energizing currents being supplied to the deflection yoke. For a more detailed description of the problem sought to be overcome by the optimally non-uniform field producing deflection yoke, and the manner of its operation, reference is made to the aforenoted Ashley patent. Briefly, however, the wide angle deflection yoke comprising the invention is designed for use in a plural, in-line beam, color, cathode ray tube having three in-line electron guns positioned in the neck portion of the cathode ray tube and arranged to direct three separate co-planar electron beams upon a viewing screen formed on the face plate of the tube to thereby produce a color television image. The three co-planar electron beams then are deflected by the wide angle, optimally non-uniform deflection field producing deflection yoke to produce three superposed rasters of different colors on the face plate of the tube.

The optimally non-uniform deflection field producing deflection yoke is provided with horizontal and vertical deflection windings having distributions such that an optimally non-uniform magnetic deflecting field is produced within the yoke whereby parabolic convergence errors associated with the use of a uniform field producing yoke are eliminated. Through the use of such a deflection yoke, complex, dynamic convergence signals are not required, and only simple size correction of the rasters produced by the two outermost in-line electron guns is all that is necessary. For this purpose, vertical and horizontal static convergence and size correction assemblies are provided around the neck portion of the color cathode ray tube intermediate the electron guns and the deflection yoke. The size correction winding of the vertical static con-

vergence and size correction assembly is serially connected in electrical circuit relationship with the vertical deflection winding of the yoke and supplied with the output energizing current from the vertical output stage of a television receiver. By this arrangement, only the simple, sawtooth deflection current supplied from the vertical output stage through the vertical winding of the deflection yoke need be supplied to the vertical size correction winding of the vertical static convergence and size correction assembly. Similarly, the size correction winding of the horizontal static convergence and size correction assembly is serially connected in electrical circuit relationship with the horizontal deflection winding of the deflection yoke that in turn is excited from the horizontal output stage of a television receiver. In this manner, sawtooth deflection current supplied from the horizontal output stage of the receiver through the horizontal deflection winding of the deflection yoke also flows through the horizontal size correction winding of the horizontal static convergence size correction assembly. While the particular vertical and horizontal static conversion convergence size correction assemblies disclosed in the aforenoted Ashley patent would have to be modified for use with the wide angle deflection yoke comprising the present invention, such modification is believed to be within the skill of a person versed in the art in the light of the teachings of the aforenoted Ashley patent once the wide angle deflection yoke comprising the present invention is made available.

The operation of an overall deflecting system employing a wide angle, optimally non-uniform deflection field producing deflection yoke such as that of the present invention is as follows. The wide angle deflection yoke produces an optimally non-uniform deflecting field which inherently corrects for parabolic convergence errors by providing a curvilinear or pincushion raster for each electron beam and which forms a curvilinear rectangle across the entire viewing area on the face plate of the cathode ray tube. The three pincushion rasters thus produced although geometrically similar in shape are found to vary slightly in size. For this reason, the same sawtooth deflection currents supplied to the deflection yoke also are applied to the size deflection windings of the horizontal and vertical static convergence and size correction assemblies to achieve substantial registry of the three rasters across the viewing area on the face plate of the cathode ray tube. Specifically, the arrangement operates to add quadrature and opposition flux components to the otherwise substantially uniform vertical and horizontal deflection fields whereby a resultant deflection field is achieved which inherently corrects the above-mentioned, undesired parabolic convergence errors. To produce the quadrature and opposition flux components, additional, further corrective windings are included in both the vertical and horizontal windings at critically placed locations on the circumference of a toroidal core member of quasi-cylindrical shape with both the vertical and horizontal windings and their associated additional corrective windings being toroidally wound around the core member. For convenience, and ease of manufacture, the vertical windings and its associated corrective winding turns are combined into a composite vertical winding distribution as depicted in FIG. 1 of the drawings, and the horizontal winding and its associated corrective winding turns are combined into a composite horizontal winding distribution also shown in FIG. 1 of the drawings. Combination of the vertical and horizontal deflection windings with their associated corrective winding turns into separate composite winding distributions allows the deflection yoke to be easily wound on a single core, and eliminates the necessity for providing discrete, separate correction windings while producing the same effect.

Referring now to FIG. 1 of the drawings, the vertical and horizontal winding distributions are shown wound in toroidal fashion on a ferrite core member **111** of generally, truncated-conical quasi-cylindrical shape the construction of which is best shown in FIG. 2 of the drawings. To simplify the illustration, only the portions of the winding turns abutting the inner surface of the core member **111** have been shown in FIG. 1. It will be appreciated that these portions of the turns are in proximity to the three co-planar electron beams which pass through the center of the core member, and thus will have the greatest effect on the electron beams.

The composite, horizontal winding distribution is shown in FIG. 1 as starting at terminal **121** labeled START "A" WINDING, and is wound in a progressive, toroidal fashion in a counterclockwise direction as viewed by the reader looking into the yoke from the narrow (smaller diameter) end. Winding A is wound in a counterclockwise direction around the circumference of core **111** to a terminal **122** labeled FINISH "A" WINDING. This A winding is the first winding segment of the composite, horizontal winding distribution and is connected through the medium of a flyback interconnecting conductor **141** to a terminal **123** labeled START "C" WINDING. It will be noted that the C winding is formed by doubly wound turns and progresses in a counterclockwise direction around to terminal **124** labeled FINISH "C" WINDING. The winding segment A and the flyback connected, doubly wound, winding segment C form one-half of the composite horizontal winding distribution. The remaining half is comprised by a D winding segment at terminal **125** labeled FINISH "D" WINDING with the terminal point **125** being directly electrically connected to the C winding terminal point **124**. It should be noted that although the electrical connection is illustrated as extending across the center of the core member **111**, this is done for convenience of illustration, and the electrical connection will be made external to the deflection yoke so as to not adversely affect the optimally non-uniform deflecting field produced within the core member.

The D winding is comprised of progressively, doubly wound turns extending in a clockwise direction to the terminal point **126** labeled START "D" WINDING. The terminal point **126** is connected in a flyback manner back through a conductor **142** to a terminal point **127** labeled FINISH "B" WINDING. The B winding is progressively, toroidally wound in a clockwise direction to the terminal point **128** labeled START "B" WINDING and comprises the output terminal for the composite, horizontal winding. The winding segments "A," "C," "D," and "B" thus comprise the composite horizontal winding distribution and include the correction windings for producing the optimally non-uniform deflecting field within the deflection yoke.

In a similar manner, the composite, vertical first winding distribution is comprised by an "E" winding whost terminal **129** labeled FINISH "E" WINDING comprises the input terminal to the composite, vertical winding. The "E" winding is progressively wound toroidally in a clockwise direction around to terminal **130** labeled START "E" WINDING. The terminal **130** is connected in a flyback manner through a conductor **143** back to the terminal **131** labeled FINISH "G" WINDING. The "G" winding is doubly toroidally wound in a clockwise direction to the terminal **132** labeled START "G" WINDING. It will be noted that the two winding segments E and G form the upper half of the composite, vertical first winding distribution that is further comprised by the lower winding segments H and F. To interconnect the two halves, the terminal point **132** is directly connected to a terminal **133** labeled START "H" WINDING. The H winding segment is a doubly toroidally wound segment that extends counterclockwise to the terminal **134** labeled FINISH "H" WINDING that is connected through a flyback interconnecting conductor **144** to the terminal **135** labeled START "F" WINDING. The F winding segment is progressively toroidally wound in a counterclockwise direction to the terminal **136** labeled FINISH "F" WINDING that also serves as the

output terminal of the composite, vertical first winding distribution.

It should be noted in connection with FIG. 1 that the various labels "START A WINDING," "FINISH A WINDING," "START B WINDING," etc. denote the physical starting and finish points of each of the winding segments A through H, all of which are wound in the same direction during manufacture. The key identifying each winding segment is shown in the lower right-hand corner of FIG. 1 and provides an indication of the sequence in which the various winding segments are wound on the core member **131** during manufacture of the yoke. The sequence of the terminal points (**121–122**), (**123–124**), etc., indicates the preferred manner of interconnecting the various winding segments A through D and E through A in electrical circuit relationship to excite the composite horizontal and vertical windings, respectively. As best shown in FIG. 1, the composite vertical and horizontal windings are doubly wound over a substantial portion of the circumference of the core member **111** with the number of doubly wound turns being in excess of fifty percent of the circumferential surface of the core member and comprising approximately eight-five percent (85%) of the circumference.

It will be appreciated that an important feature of the present invention is the provision of the different first and second winding distributions utilized for the composite vertical and horizontal deflection windings. Each of these distributions differs significantly from the distribution utilized in prior art deflection yokes to achieve a substantially uniform deflection field, and differs significantly from the distribution employed in the Ashley deflection yoke described in the aforenoted Ashley patent. The preferred distribution for the composite vertical and horizontal winding is illustrated in FIGS. 3 and 4 of the drawings.

FIG. 3 illustrates a normalized graphical representation of the composite vertical winding distribution in a single quadrant of the overall winding pattern shown in FIG. 1. In FIG. 3, the Y axis represents a percentage of the total number of vertical turns in the third quadrant (which encompasses the start of the H and F winding segments and the finish of the A and C winding segments) while the X axis represents an angle ϕ increasing in a clockwise direction from a vertical axis extending through the center of the yoke. That placement of certain individual turns is represented by the circles through which the curve shown in FIG. 3 is drawn. Accordingly, the curve represents the position of each turn within the quadrant. Assuming that 66 vertical turns are utilized per quadrant in the yoke shown in FIG. 1, then fifty percent of these turns would be located within the quadrant angle ϕ of about 38 degrees. Accordingly, the 33rd turn would be located at a quadrant angle of 38 degrees. The vertical winding distribution in the remaining three quadrants are mirror images of that disclosed for the third quadrant.

The composite, vertical winding distribution can be represented by a Fourier series formula substantially 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 coefficient have the following values:

$$A_V = 92.25$$
$$B_V = 7.83$$
$$C_V = 1.94$$
$$C_V = 1.94$$
$$E_V = 1.97$$
$$G_V = 1.70$$
$$I_V = 1.04$$

FIG. 4 of the drawings is a normalized graphical representation of the composite, horizontal winding distribution shown in FIG. 1. In FIG. 4, the Y axis represents a percentage of the total number of horizontal turns in the second quadrant (which encompasses the finish of the G and E winding segments and the start of the C and A winding segments) of FIG. 1 while the X axis represents an angle θ increasing in a clockwise direction within the quadrant from a horizontal axis drawn through the center of the yoke. Again the placement of certain individual turns is represented by the circles through which the curve is drawn, and the curve represents the position of each turn within the quadrant. For example, assuming there are fifty-two horizontal turns used in forming each quadrant as shown in FIG. 1, then twenty-six of fifty percent of these turns would be located within a quadrant angle θ of twenty-three degrees. Accordingly, the 26th turn would be located at a quadrant angle of 23 degrees. The composite horizontal winding distribution in the remaining three quadrants is a mirror image of that shown for the second quadrant.

The horizontal winding distribution curve shown in FIG. 4 can be represented by a Fourier series formula of the form:

$$Y_H = A_H\sin(\theta) + B_H\sin(3\theta) + C_H\sin(5\theta) + D_H\sin(7\theta) + E_H\sin(9\theta) + F_H\sin(11\theta) + G_H\sin(13\theta) + H_H\sin(15\theta) + I_H\sin(17\theta) + J_H\sin(17\theta) + \ldots$$

where the coefficients have substantially the following values:

$$A_H = 104.35$$
$$B_H = 7.92$$
$$C_H = 2.91$$
$$D_H = 2.49$$
$$F_H = 2.23$$
$$J_H = 1.16$$

The equations noted above have been evaluated to a value $(Z_V, Z_H)\sin 51[(\phi), (\theta)]$ but all coefficients having a value of less than one percent have not been listed for reasons of simplification.

It will be noted that as a result of the above winding distributions, a substantial portion of the windings are comprised by doubly wound turns wherein one turn overlies another. The use of this larger number of double windings is necessitated by the wider scanning deflection angle of the yoke disclosed and the need to reduce the power requirements of the structure. By utilizing a larger proportion of double windings, the inductance to resistance (L/R) ratio of the yoke is substantially increased making it possible to increase the voltage at which a picture tube employing the yoke is operated. Since the power consumption of a television picture tube increases approximately with the sine of the deflection scanning angle, provision of the increased number of doubly wound turns allows the increased tube voltage to be used without vastly increasing the current that is required to be supplied from the output stages of the television receiver to the deflection system. Additionally, the wider deflection scanning angle tube has a different face plate radii than do the narrower scanning deflection angle tubes, and this characteristic further requires a different winding distribution between the two types of deflection systems.

In one known embodiment of the wide angle deflection yoke shown in FIG. 1, the composite vertical and horizontal windings were wound in eight different winding segments A–H from number 25 AWG insulated magnet wire on a ferrite core of generally truncated-conical, quasi-cylindrical shape shown in FIG. 2 and to be described more fully hereinafter. The doubly wound windings comprise approximately eight-five percent (85%) of the circumferential surface of the core member having the distribution indicated above. The yoke was designed to be used in conjunction with a cathode ray tube deflection system operating at 22 kilovolts as compared to 15 kilovolts for the deflection system described. While thus operated, the horizontal deflection winding exhibits an inductive reactance of about 2 millihenrys and requires 3.7

amperes of current peak to peak horizontal scan driving current. This is in contrast to the Ashley 70° tube which exhibited an inductive reactance of around 800 microhenrys and required 5 amps peak to peak, horizontal scan energizing current.

FIG. 2 of the drawings is a longitudinal sectional view of the quasi-cylindrical core member **111** which, as shown in FIG. 2 is generally truncated-conical in configuration. The core member **111** is fabricated from ferrite and has an axial length of 1.75 inches. The major (larger) diameter end of the core member has an outside diameter of 3.56 inches and an inside diameter of 3.22 inches, and the minor (smaller) diameter end has an outside diameter of 2.30 inches and inside diameter of 1.80 inches. The inner surface of the core member intermediate the major and minor diameter ends thereof is flared inwardly along a circular path in the direction of the longitudinal axis of the core member with the circular path being defined by a radius of 5.01 inches centered 1.52 inches by 5.4 inches from the minor diameter end of the core member. Preferably, the end surfaces of the ferrite core member **111** are notched or provided with a notched end cap to maintain the various turns of the deflection yoke in their desired location in accordance with the first and second winding distributions noted above.

FIGS. 5 and 6 of the drawings are schematic, electrical circuit wiring diagrams of the composite, vertical and horizontal windings, respectively, and illustrate the manner in which the respective winding segments comprising each of the composite vertical and horizontal windings, are electrically interconnected within the deflection yoke. The two circuits shown in FIGS. 5 and 6 can be excited from the horizontal and vertical output stages of a television receiver deflection circuit such as that shown in FIG. 12 of the above referenced Ashley patent. While certain modifications may have to be made to the exact circuit shown in the Ashley patent in order to accommodate the different L/R ratio of the present yoke, and higher operating voltage, the circuit is sufficiently satisfactory to enable one skilled in the art to accommodate it for use with the deflection yoke comprising the invention.

The manner in which the main vertical and horizontal deflection fields and their respective correcting quadrature and opposition fields interact to provide the necessary correcting forces on the co-planar electron beams to overcome inherent parabolic errors, is quite complex, and not easily envisioned since these forces differ from point to point within the field along the longitudinal axis of the yoke, and vary with time; however, it is best illustrated in the vector diagrams shown in the first quadrant of FIG. 1. It is assumed that an electron beam **211** is directed into the plane of the paper as shown, and 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 should be understood that the horizontal field varies at the horizontal line scan rate while the vertical field varies at the field rate.

From the vector equation $\overline{B}\times\overline{V}=\overline{F}$, it will be appreciated that a force is produced by the main field on the electron beam identified by the vector F_M. In a similar manner, the correction field V_{CV} produced by the vertical correction winding turns can be resolved into a component B_{CMV} in phase with the main vertical field and a component B_{VQ} in quadrature with the main vertical field. Further, the field produced by the horizontal correction winding turns produce a correction field B_{CH} which can be resolved into an opposition component B_{CHM} and a quadrature component B_{CHQ}. Thus, a resultant correction field B_{CR} is provided. The correction field produces 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 co-planar electron beams which eliminate the parabolic errors inherent in prior art, uniform fields deflecting systems.

It should be appreciated that the vector diagram shown in FIG. 1 represents a condition existing for only a single electron beam at a particular time, and at a particular axial location within the deflection yoke as well as the condition existing for a particular angular position within the first quadrant. Thus, it will be seen that the total correcting forces acting upon each electron beam during its passage through the deflection yoke will be the line integral of forces existing at each point along the beam path in the axial direction. The line integral necessarily differs for the several co-planar electron beams since the path for each of the beams through the yoke will differ.

From the foregoing description, it will be appreciated that the present invention provides a new and improved wide scanning angle deflection yoke of the type for producing optimally non-uniform deflection fields for plural, in-line beam, color cathode ray, television picture tubes. In order to accommodate the wider deflection scanning angle made possible by the new yoke, the toroidally wound turns of the yoke are doubly wound over a substantial portion of the circumference of the yoke and encompass approximately eighty-five percent (85%) of the circumference. This was required to provide the wider deflection scanning angle in a given size unit, and results in a larger L/R ratio which allows the yoke to be operated in a deflection system at considerably higher operating potentials.

What is claimed is:

1. An improved wide angle deflection yoke for use in 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 with the yoke adapted to be positioned intermediate the gun arrangement and the viewing screen in the path of the electron beams:

(a) said yoke including an open-ended, quasi-cylindrical core member adapted to have the electron beams pass therethrough;

(b) a vertical winding formed on the core member with toroidally wound turns wound in a first distribution providing a main field to deflect the electron beams in a vertical direction;

(c) a horizontal winding formed on the core member with toroidally wound turns wound in a second distribution providing a main field to deflect the electron beams in a horizontal direction;

(d) said vertical winding including additional toroidally wound turns providing flux components in quadrature and in opposition to the main vertical field;

(e) said horizontal winding including additional toroidally wound turns providing flux components in quadrature and in opposition to the main horizontal field;

(f) said horizontal and vertical quadrature and opposition flux components coacting with the main horizontal and vertical fields to produce within the yoke optimally non-uniform forces acting on said beams that cause each beam to form a curvilinear rectangular raster substantially geometrically similar in shape to the rasters produced by the other beams; and

(g) said vertical and horizontal windings and the additional toroidally wound turns thereof being doubly wound over a substantial portion of the circumference of the quasi-cylindrical core member.

2. A deflection yoke according to claim **1** wherein more than fifty percent (50%) of the circumferential surface of the quasi-cylindrical core member is wound with doubly wound turns.

3. A deflection yoke according to claim **1** wherein approximately eighty-five percent (85%) of the circumference of the quasi-cylindrical core member is wound with doubly wound turns.

4. A deflection yoke according to claim **1** wherein the vertical winding and its additional toroidally wound turns are comprised of N winding segments where N is a number greater than two (2) and wherein intermediate each

winding segment electrical connections back to a doubly wound winding segment are made in a flyback manner whereby potential differences between adjacent doubly wound turns of the same winding function are minimized to the greatest practical extent to reduce horizontal-vertical crosstalk.

5. A deflection yoke according to claim 1 wherein the open ended quasi-cylindrical core member is generally truncated-conical in configuration with the axial length thereof 1.75 inches, the major diameter end thereof having an outside diameter of 3.56 inches and an inside diameter of 3.22 inches and the minor diameter end having an outside diameter of 2.30 inches and an inside diameter of 1.80 inches, and with the inner surface of the core member intermediate the major and minor diameter ends being flared inwardly along a circular path in the direction of the longitudinal axis of the core member, the circular path being formed by a radius of about 5.01 inches centered 1.52 inches by 5.4 inches from the minor diameter end of the core member.

6. A deflection yoke according to claim 1 wherein:

(i) said first distribution is defined by a formula substantially of the form:

$$Y_V 92.25 \sin \phi + 7.83 \sin (3\phi) + 1.94 \sin (5\phi) + 1.97 \sin (9\phi) + 1.70 \sin (13\phi) + 1.04 \sin (17\phi) + \ldots$$

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 clockwise direction from the vertical axis of the deflection yoke, and

(ii) said second distribution is defined by a formula substantially of the form:

$$Y_H = 104.35 \sin \theta + 7.92 \sin (3\theta) + 2.91 \sin (5\theta) + 2.49 \sin (7\theta) + 2.23 \sin (11\theta) + 1.16 \sin (19\theta) + \ldots$$

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 clockwise direction from the horizontal axis of the deflection yoke.

7. A deflection yoke according to claim 6 wherein the vertical winding and its additional toroidally wound turns are comprised of N winding segments where N is a number greater than two (2) and wherein intermediate each winding segment electrical connections back to a doubly wound winding segment are made in a flyback manner whereby potential differences between adjacent doubly wound turns of the same winding function are minimized to the greatest practical extent to reduce vertical-horizontal crosstalk.

8. A deflection yoke according to claim 7 wherein the open ended quasi-cylindrical core member is generally truncated-conical in configuration with the axial length thereof 1.75 inches, the major diameter end thereof having an outside diameter of 3.56 inches and an inside diameter of 3.22 inches and the minor diameter end having an outside diameter of 2.30 inches and an inside diameter of 1.80 inches, and with the inner surface of the core member intermediate the major and minor diameter ends being flared inwardly along a circular path in the direction of the longitudinal axis of the core member, the circular path being formed by a radius of about 5.01 inches centered 1.52 inches by 5.4 inches from the minor diameter end of the core member.

9. A deflection yoke according to claim 8 wherein approximately eighty-five percent (85%) of the circumference of the quasi-cylindrical core member is wound with doubly wound turns.

10. A deflection yoke according to claim 9 wherein said first distribution comprises a total of 67 winding turns per quadrant and said second distribution comprises a total of 52 winding turns per quadrant.

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