

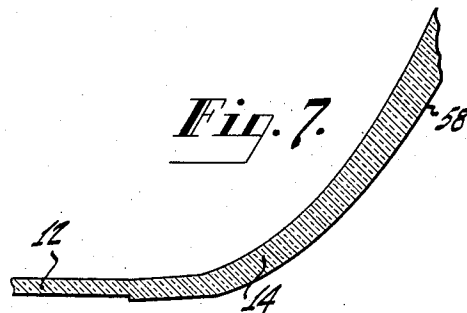
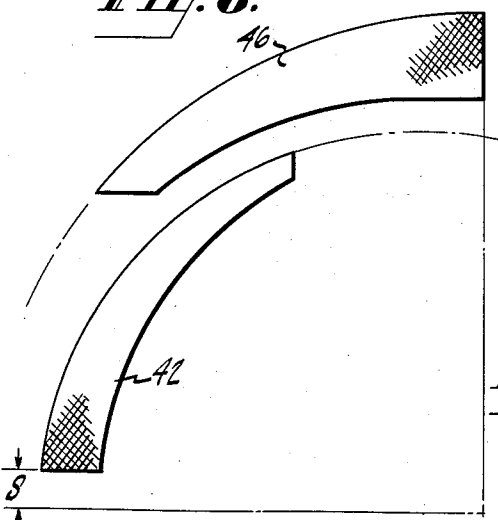
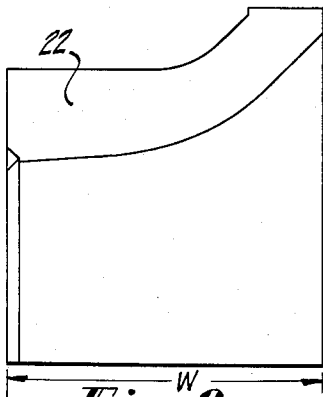
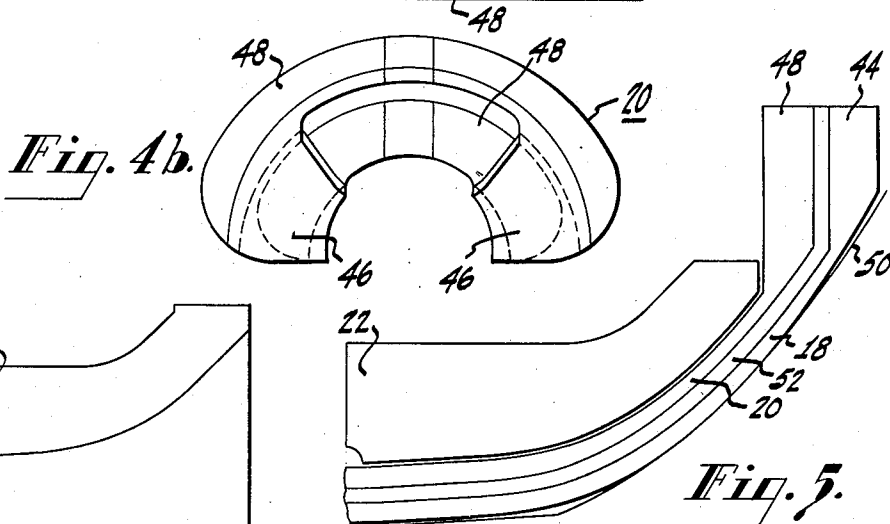
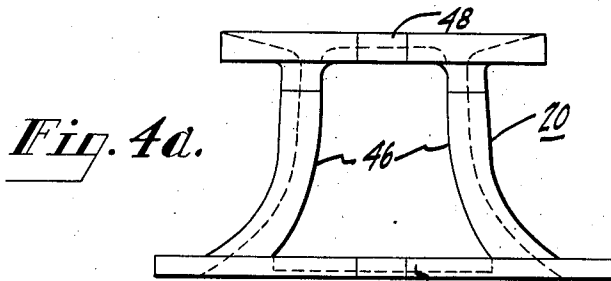
Aug. 25, 1959

W. H. BARKOW ET AL
CATHODE RAY TUBE DEFLECTION YOKE

2,901,665

Filed Feb. 13, 1956

4 Sheets-Sheet 2



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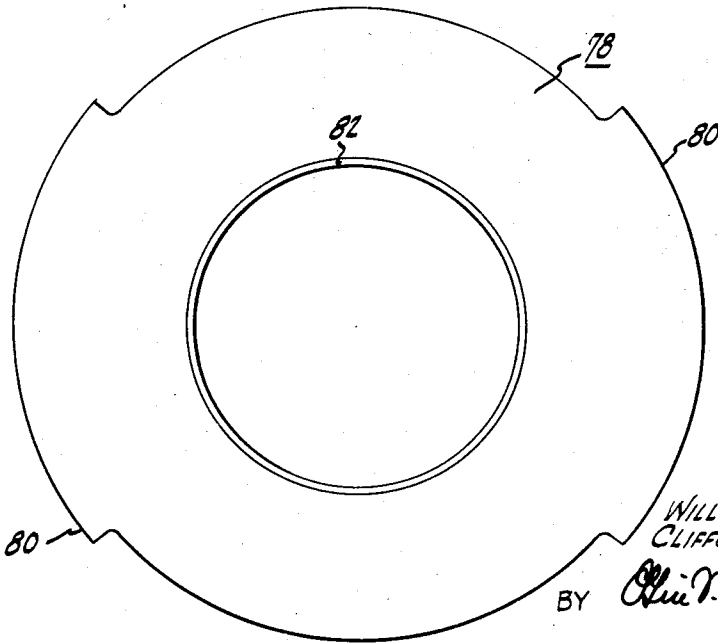
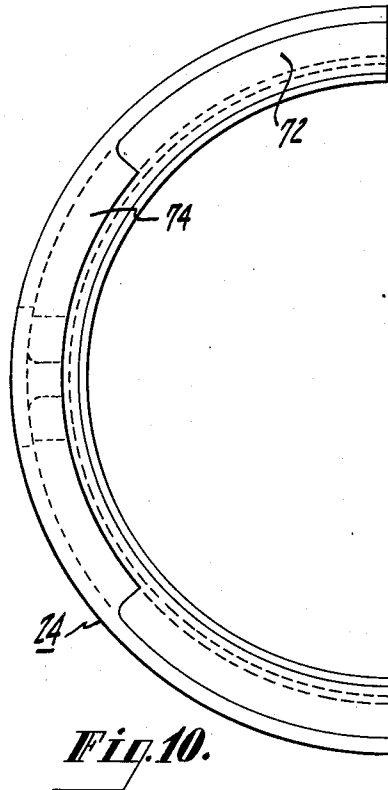
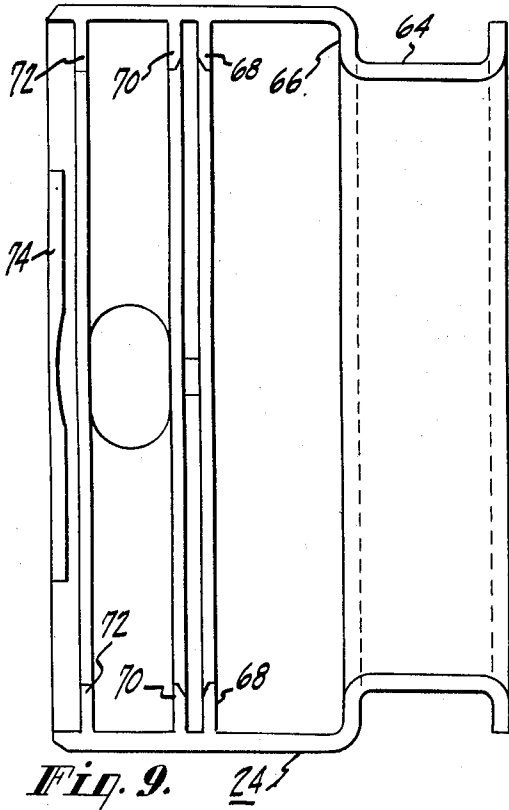
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CATHODE RAY TUBE DEFLECTION YOKE

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4 Sheets-Sheet 3



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CATHODE RAY TUBE DEFLECTION YOKE

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4 Sheets-Sheet 4

Fig. 12.

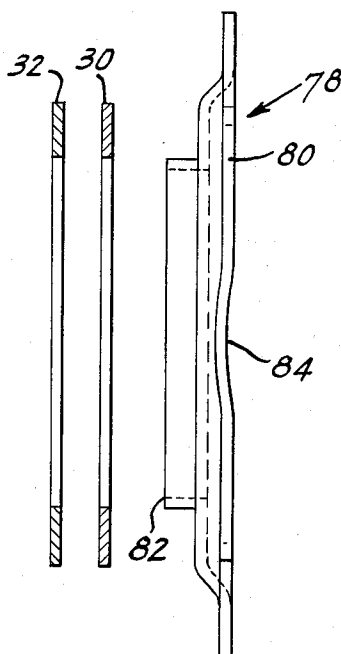


Fig. 13.

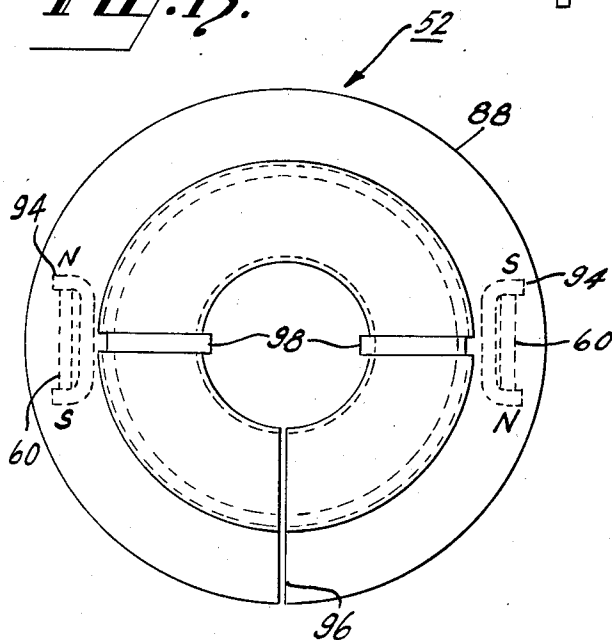
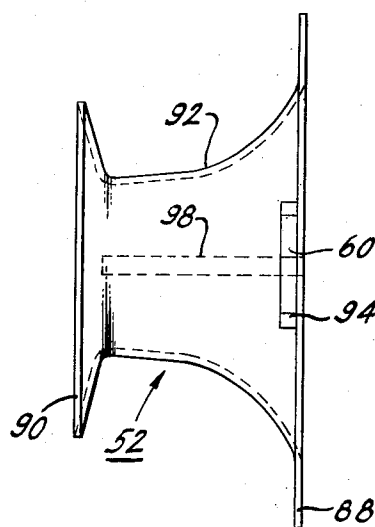


Fig. 14.



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1

2,901,665

CATHODE RAY TUBE DEFLECTION YOKE

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Application February 13, 1956, Serial No. 564,897

18 Claims. (Cl. 315—27)

The present invention relates to new and improved electromagnetic deflection apparatus and, particularly, to apparatus capable of producing deflection of electrons in a cathode ray tube through a wide angle of deflection of the order of 110° .

With increasing deflection angles, the problems of electron beam defocusing and raster pattern distortion become more acute than in the case of narrow angles of deflection. This fact is apparent from a consideration of the geometry of cathode ray tubes such as those employed as television image reproducing devices, in that the electron beam is caused to scan from what may be termed its center of deflection through a wide angle so that it covers a generally rectangular area on the face plate of the tube. These problems are accompanied by practical considerations which require that the deflection apparatus be maintained within reasonable physical limits and that the cost be kept as low as possible.

It is, therefore, a primary object of the present invention to provide a new and improved deflection system capable of producing wide angle deflection of electrons in a cathode ray tube.

As is generally known, an electron beam which is acted upon by a uniform transverse magnetic deflection field is caused to travel along a path which is a sector of a circle. Such theoretical conditions as a uniform field do not, however, exist in the case of practical beam deflection systems. One reason is that a conventional electromagnetic deflection yoke is of finite length and produces a field which is not symmetrical. Thus, it has been found that the path of an electron in the case of a practical deflection field is more nearly represented by a parabola rather than by an arc of a circle. Since one of the requirements of a deflection yoke is sensitivity (i.e., amount of deflection per unit of yoke energization), it has been found to be desirable to design cathode ray tube deflection yokes such that the conductors of the coils comprising the yoke follow closely the path of the beam in its extremities of deflection.

In U.S. Patent No. 2,570,425, granted October 9, 1951, to C. V. Bocciarelli, it is stated, for example, that the desired relationship between the configuration of a deflection yoke and the path of a beam electron traversing the magnetic field thereof will be substantially satisfied as the displacement of the turns of the yoke from the longitudinal axis of the cathode ray tube is related to the displacement along such axis measured from the point of entry of the beam into the yoke in accordance with a hyperbolic function. In contradistinction to the foregoing statement in the patent, the present applicants have found, as mentioned briefly above, that the beam path from a point within the deflection yoke to the target screen of the cathode ray tube follows closely and may be defined by the equation for a parabola. Each a beam path was measured in a cathode ray tube kinescope whose beam was deflected through a total angle of approximately 110° . It is, therefore, a feature of the present invention that the deflection yoke associated with a cathode ray tube

2

be shaped in such manner as to conform to the path of an electron beam within such tube, namely, in such manner that the inner surface of the deflection yoke windings are shaped to define a surface of revolution which, upon intersecting a plane passed through the longitudinal axis of the yoke, defines, at least in part, a parabolic curve. In order that full advantage may be had of the known beam deflection path, it is a further feature of the present invention that the bulb portion of a cathode ray tube be formed to conform to a surface of revolution produced by revolving a portion of a parabola about the longitudinal axis of the tube. By such means, highly efficient deflection through a wide angle of the order of 110° is achieved.

In accordance with the present invention, the bulb portion of a cathode ray tube kinescope is formed, at least in part, so that it constitutes the surface of a paraboloid of revolution whose axis coincides with the longitudinal axis of the tube. An electro magnetic deflection yoke associated with such tube comprises first and second pairs of coils located around the tube such that the coils of the second pair lie around the coils of the first pair, the bundles of conductors forming the coils being shaped at their inner surfaces to conform to the parabolic curvature of the tube. Thus, substantial efficiency is afforded, since the conductors of the coils forming the yoke lie in close proximity to the path of the beam during maximum deflection, while not undesirably lying within the beam path at any point.

In accordance with another feature of the invention, the efficiency of the yoke is optimized by allocating conductor material to the first and second pairs of coils (i.e., conventionally termed the "horizontal" and "vertical" coils) in such manner as to exploit the fact that the two pairs of coils are energized with current of rather widely different frequencies. Further, the cross-sectional shapes of the bundles of the conductors of the coils are controlled according to the invention in such manner as to produce minimum astigmatism of the beam without undesirably degrading the shape of the raster scanned by the beam. Magnetic means are further provided in accordance with the present invention to aid in controlling the raster shape.

According to another feature of the invention, the efficiency of the yoke is increased by reason of a novel yoke casing and terminal board assembly which permits full utilization of the axial length of the yoke coils between the end conductors for a ferro magnetic core, the presence of which increases the efficiency of the yoke.

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

Figure 1 is an elevational view of a cathode ray tube kinescope and deflection yoke in accordance with a specific form of the present invention;

Figure 2 illustrates certain beam path and deflection yoke and tube contours to be described;

Figures 3a and 3b are illustrative of the horizontal coils of a yoke in accordance with the invention;

Figures 4a and 4b are similar views of a vertical deflection coil;

Figure 5 illustrates the contours of the tube and deflection yoke of the preceding figures;

Figure 6 is a vertical sectional view of the yoke of Figure 1;

Figure 7 is an enlarged vertical sectional view of a portion of the tube of Figure 1;

Figure 8 illustrates one portion of the core forming means associated with the yoke of the present invention;

Figures 9 and 10 are, respectively, side and end views of a novel form of yoke casing;

Figures 11 and 12 are, respectively, side and end views of a portion of the yoke casing of Figures 1 and 9; and

Figures 13 and 14 are, respectively, end and side views of a yoke insulating member according to the invention.

Referring to the drawing and, particularly, Figure 1 thereof, there is shown an electromagnetic deflection system in accordance with the present invention. The system comprises a cathode ray tube kinescope 10 having a generally cylindrical neck portion 12 and a flared bulb portion 14, to be described more fully hereinafter. Associated with the kinescope 10 is an electromagnetic deflection yoke indicated in its entirety by reference numeral 16, which yoke comprises a first pair of deflection coils 18 (i.e., the horizontal deflection coils), a second pair of deflection coils 20 (i.e., the vertical deflection coils), a multi-part ferromagnetic core 22 and a yoke casing 24. The assembled parts of the yoke 16 are secured together by means of a steel strap 26 passed around the yoke and secured at its end by means of a bolt 28. Mounted at the rear end of the yoke casing 24 in a manner to be described more fully are two permanently magnetized rings 30 and 32 which serve as centering means for the yoke.

Before describing the tube and yoke in greater detail, reference will be made to Figure 2 which illustrates diagrammatically certain of the considerations involved in the design of the present yoke and tube. Specifically, the curve 34 illustrates the forward portion of the path of an electron beam such as is produced within the tube 10 of Figure 1 in its extreme deflected position when the total angle of deflection is of the order of 110°. By "forward" beam path is meant that portion of the trajectory of the electrons from the beam from a point within the deflection yoke 16 to the screen (not shown) of the tube. It will be seen that the beam path 34 is approximately parabolic in curvature. This curvature, as measured in practice, departs substantially from the theoretical arcuate path of an electron beam which is assumed for a uniform transverse deflection field. The degree of departure is readily apparent from a comparison of the curve 34 with the curve 36 which represents an arc of the circle whose radius is chosen such that the arc most nearly approximates the curve 34. Also shown in Figure 2 by the curve 38 is a selected contour of the portion of the bulb portion 14 of the tube of Figure 1. It is apparent from the relation of the curves 36 and 38, both of which are drawn in the same relation to the curve 34, that in the region of the deflection yoke 16 there exists a rather wide departure of the circular contour 36 from the beam path 34 as compared to the departure of the parabolic contour 38 from the path 34. This departure, in the region in question, is of importance insofar as the efficiency of a deflection yoke is concerned, since, as mentioned, it is desirable that a deflection yoke be in close proximity to the desired beam path at all points along the yoke longitudinally of the axis of the tube.

Assuming for the present that the inner and outer surfaces of the bulb portion 14 of the tube 10 are parallel (which is not completely true in the case of practical tubes) it may be assumed that the curve 38 represents the contours of the inner and outer surfaces of the bulb portion 14 of the tube of Figure 1. Moreover, and as will be treated in greater detail, the parabolic curve 38 is also illustrative of the contour of the inner surface of the coils forming the deflection yoke 16. Despite certain minor differences in curvature between the inner and outer surfaces of the tube bulb and the surface of the coils of the deflection yoke which will be described below, it will be appreciated that the parabolic contour of these surfaces quite closely approximates the parabolic path 34 of the beam electrons. Further, this degree of approximation is seen to be much greater than that afforded by the circular contour 36, as indicated by the shaded area 40 between the curves in the region of the yoke. It may also be noted, in this connection, that the beam path 34 is more truly defined as a parabola than as a hyperbola, since the latter curve is one which,

by definition, is asymptotic at both extremities to a pair of intersecting axes.

In order that the various curvatures mentioned briefly thus far and shown in detail in Figure 5 may be better appreciated, the structure of the coils themselves is illustrated in Figures 3 and 4. Figures 3a and b are, respectively, planned and front elevational views of one of the horizontal deflection coils 18 of Figure 1. As shown in Figure 3a, each of the horizontal coils 18 is made up of side or longitudinal conductors 42 and end conductors 44; in general accordance with conventional practice. That is to say, each coil 18 is made up of a plurality of turns of wire of suitable size (e.g., No. 30-B and S gage), such that the longitudinal conductors and end conductors actually comprise a bundle of turns. The longitudinal conductors 42 may, if desired, be shaped, for a portion of their length "d," to conform to a cylindrical shape. The remaining portion of the length of the longitudinal conductors 42 is flared outwardly from the axis of the yoke in such manner that the inner surface of the latter portion of the longitudinal conductor bundles is of parabolic configuration. The end conductors 44 are turned generally radially outwardly from the axis of the yoke in order to remove the fringe flux linking the end conductors from the region of the tube. Such turning-up of the end conductors of a deflection coil is well known in the art and need not be described further.

Figures 4a and b are views similar to those of Figures 3a and b but are illustrative of one of the vertical deflection coils 20 of the yoke 16. Each coil 20 is made up of a plurality of turns of wire (e.g., No. 26-B and S gage) and comprises longitudinal conductor bundles 46 and end conductor bundles 48. The longitudinal conductors 46 of the vertical deflection coils 20 are flared outwardly from the axis of the yoke along parabolic curves so that the coils 20 may be placed around the coils 18 with a close fit. When the vertical deflection coils 20 are thus located around the coils 18, the longitudinal conductors 46 partly overlap the longitudinal conductors 42 of the horizontal deflection coils and lie, in part, within the window openings defined by the longitudinal and end conductors of the coils 18. The end conductors 48 of the vertical deflection coils are curved to fit snugly behind the up-turned end turns of the horizontal coils, both at the front and rear of the yoke.

Referring now to Figure 5 of the drawing, there is shown, in section, a portion of the yoke and tube assembly of Figure 1, from which showing the several curvatures described thus far are more readily apparent. More specifically, Figure 5 illustrates certain specific contours of a tube and yoke in accordance with a specific, operative embodiment of the present invention. The outer surface of the bulb 14 of the kinescope 10 is represented by reference numeral 50 and constitutes a surface of revolution of a parabolic curve having the equation

$$y = .62x^2 + .570 \quad (1)$$

which takes into account the fact that the bulb portion 14 is "blended" into the cylindrical neck 12 of the tube. That is to say, the joint of the neck and bulb is made with a gradual flare, as shown. The horizontal deflection coil 18 is so shaped that its inner surface is a surface of revolution of a parabola defined by the equation

$$y = .74x^2 + .625 \quad (2)$$

In a similar manner the inner surface of the vertical deflection coils 20 is a surface of revolution of a parabola of approximately the same shape as that of the outer surface of the coils 18. In the interest of completeness of description, it may be noted that the horizontal and vertical coils 18 and 20 are separated from each other by insulating means 52, to be described in greater detail hereinafter.

5

The outer surface of the vertical deflection coils 20, in the region of their longitudinal conductors, is a surface of revolution of a parabola having the equation

$$y = .73x^2 + .806 \quad (3)$$

The relationship of the up-turned end turns 44 and 48 of the horizontal and vertical coils, respectively, is also illustrated in Figure 5, showing their parallel relation.

The core 22 is also shown in Figure 5 so that its relation to the coils of the yoke may be better appreciated. The core 22 may, for example, be made up of four longitudinal sections of high permeability material, such as ferrite, the sections being disposed around the coils so that they form a continuous sleeve. The inner surface of the core sleeve is a surface of revolution of a parabola which may be defined by the equation

$$y = .79x^2 + .815 \quad (4)$$

which is seen to be only slightly larger than the outer surface of the vertical deflection coils 20. The core 22 will further be seen to have an outer surface shaped somewhat in conformity with its inner surface, that is, convexly toward the axis of the yoke. The curvature of the outer surface of the core 22 is not particularly critical but is curved, according to the present invention, in order to economize on the use of the core material over the amount required if the outer surface of the core were to be cylindrical. The only other requirement on the core 22 is that it have sufficient thickness to provide the desired low reluctance return path for the yoke flux, except as to its length which aids in increasing the sensitivity of the yoke. This last mentioned matter will be explained more fully below.

As has been mentioned, the inner and outer surfaces of the bulb portion of the kinescope 10 need not be parallel to each other and, in fact, the requirements of manufacture may militate against such parallelism. Thus, for example, as shown in Figure 7, the inner surface 58 of the bulb 14 has a curvature defined by the relationship

$$y = .5x^2 + .420 \quad (5)$$

which results in a gradual thickening of the bulb from the neck toward the screen of the tube, for purposes of mechanical strength. The difference in curvature between the inner and outer surfaces of the bulb, however, is too slight to have any appreciable effect upon the sensitivity of the yoke. That is to say, the parabolic contour of the outer surface of the tube bulb and the substantially equal contour of the inner surface of the deflection yoke coils insures that the active conductors of the coils are as close as possible to the maximum deflected beam path.

Figure 6 is a vertical sectional view of a portion of the yoke 16 showing the cross sectional shape of one of the vertical coil longitudinal conductor bundles 46 and one of the horizontal coil conductor bundles 42. The turns distribution of the coil 42 is, as shown, selected to provide a slightly pin cushioned magnetic field such as has been found in practice to be necessary for minimizing beam focus distortion or astigmatism. The turns distribution of the longitudinal conductors of the horizontal coils is constant throughout the length of the coils, although the thickness of the bundles of conductors gradually changes from one end of the coil to the other, in accordance with known practice. It will further be noticed that the horizontal coils are spaced from each other (i.e., in the region of their longitudinal conductors 42) by a distance equal to $2s$, the dimension " s " being shown in Figure 6 as the distance of one of the conductor bundles 42 from the horizontal axis. It will be understood that the adjacent longitudinal conductor bundle of the other horizontal deflection coil is similarly spaced a distance " s " from the axis. This spacing serves to reduce materially the pin cushioning of the field produced by the coils in this region, so that optimum spot focus may be maintained throughout horizontal deflection of the beam.

6

The vertical deflection coils on the other hand, have their turns distributed in such manner as to provide a more greatly pin cushioned magnetic field than that which is provided by the horizontal deflection coils. That is to say, the coils of the present yoke take advantage of the fact that, where a scanned raster has an aspect ratio other than unity (e.g., the conventional 4:3 aspect ratio of television practice), the beam defocusing effect of the field which produces the smaller angle of deflection is less than in a case of the field which produces the wider angle of deflection. More specifically, the vertical deflection angle in the present case is less than the horizontal deflection angle, so that the vertical deflection coils are wound in such manner as to produce a pin cushion deflection field which results in optimum scanning raster rectangularity. The small amount of defocusing of the beam in the vertical direction which thus results has been found to be so slight as to be unobjectionable. The shape of the vertical deflection field is further controlled in the present case by reason of the fact that the adjacent longitudinal conductor bundles of the vertical deflection coils are in close proximity to each other, rather than being separated by the rather wide spacing described in connection with the horizontal deflection coils. As in the case of the horizontal deflection coils, the turns distribution of the vertical deflection coils is constant throughout their length, despite the gradual change in width and thickness of the coils.

Figure 6 also illustrates the manner in which the present invention exploits the difference in operation of the horizontal and vertical coils of the deflection yoke, insofar as the respective efficiencies of the two pairs of coils are concerned. The efficiency of the vertical deflection coils which operate at 60 c.p.s. depends upon the resistance of the coils, the figure of merit of the vertical coils being proportional to the I^2R of the coils. On the other hand, the figure of merit of the horizontal deflection coils is proportional to the stored energy, so that it is proportional to the product LI^2 , where L is the inductance of the horizontal deflection coils. Stated otherwise, the reactive impedance plays a greater part in determining the current which flows through the horizontal coils than does the resistance of the coils, as opposed to the case of the vertical deflection coils. Thus, as illustrated in Figure 6, the vertical deflection coils are made up of a sufficient amount of conductor material (e.g., copper wire) to present a rather small resistance to the energy source, such as a total resistance for the two vertical deflection coils of 11 ohms. The amount of copper allocated to the horizontal deflection coils, however, is appreciably less than that contained in the vertical coils, thereby economizing on the use of copper while not affecting undesirably the efficiency of the horizontal deflection coils. Since, in the case of both the horizontal and vertical deflection coils, the amplitude of deflection is proportional to the product of the number of turns of the coil and the current flowing through the coil, the optimum deflection efficiency is realized through the selective allocation of conductor material to the two pairs of coils, respectively. It will thus be appreciated that the size and turns distribution of the two pairs of coils are selected, in accordance with the present invention, in such manner as to take full advantage of the different deflection angles horizontally and vertically, both with respect to economical use of conductor material without attendant decrease in deflection sensitivity and with respect to beam focus and raster pattern shape. In this connection, it may be noted that, in designing the horizontal deflection coils for optimum beam focus throughout the horizontal deflection angle, a certain amount of horizontal pin cushioning of the deflection raster may result. This raster distortion is readily corrected by locating a small permanent magnet (one of which is shown at 60 in Figure 1) on each side of the deflection yoke, each of the two permanent magnets being polarized so that its flux aids the flux produced by

the horizontal deflection coils of the yoke, thereby increasing the amplitude of deflection between the top and bottom edges of the raster in a manner to "pull out" the sides of the raster. In addition to improving raster shape, the permanent magnets will also be understood as aiding generally in effecting a wider angle of deflection in the horizontal plane.

As has been set forth briefly above, the magnetic core 22 associated with the deflection coils 18 and 20 has its inner surface shaped as a surface of revolution of a parabola whose equation is substantially equal to the parabola of which the outer surface of the vertical deflection coils is a surface of revolution. The core 22 actually comprises, in the specific embodiment described, four longitudinal sections of a cylinder, one of which is shown separately in Figure 8. The longitudinal surfaces of the core sections may be ground so that a close fit between the sections without undesirable air gaps is achieved. The axial length "W" of the core 22 is substantially equal to the distance between the inner surfaces of the up-turned front and rear end turns 46 of the vertical deflection coils. In this connection, it may be noted that conventional deflection yokes require a terminal board or member to which the start and finish leads of the deflection coils are brought out and connected for electrical connection to the deflection wave generating circuits. Typically, the terminal board is located directly behind the core member which surrounds the coils, so that the thickness of the terminal board requires shortening of the axial dimension of the core itself. Such shortening, although of the order of one-eighth inch, for example, undesirably decreases the sensitivity of the yoke coils, since the low reluctance core does not extend throughout the length of the coils. In accordance with the present invention, as mentioned above, a novel yoke casing and terminal board arrangement permit full utilization of the axial distance between the end turns of the vertical deflection coils for core material.

The yoke casing of the present invention is illustrated in Figures 9 and 10.

Figure 9 shows one of the two parts of the yoke casing per se. The casing is formed of suitable insulating material such as a plastic material. Each half of the casing is generally a longitudinal half section of a cylinder having a portion 64 of reduced diameter which fits snugly around the outer surface of the core 22. The remainder of the length of the yoke casing is of sufficient diameter to clear the up-turned rear end turns of the coils 18 and 20 which, therefore, are accommodated within the annular space defined by the wall 66 and the rib 68. A second rib 70, extending radially inwardly from the yoke casing 24 as does the rib 68, is spaced from the latter rib by approximately one-eighth inch, so that the ribs 68 and 70 serve in a manner to be described, to support a terminal board directly behind the yoke coils. A further annular, inwardly extending rib 72 is located rearwardly of the rib 70 and cooperates with a pair of radially inwardly extending tabs 74, one of which is shown in its entirety in Figure 10. Each of the tabs 74 may, for example, subtend an angle of approximately 80° of the circle defined by the two sections of the casing 24.

The yoke casing is assembled on the yoke in the following manner: a disk-like terminal board of suitable insulating material and of outer diameter generally equal to the inner diameter of the chamber defined by the ribs 68 and 70 is placed edgewise between the ribs 68 and 70 of one of the casing halves which is then placed around the assembled coils and core of the yoke such that the reduced portion 64 fits around the core 22 while the rear end turns of the coils fit within the chamber defined by the wall 66 and the rib 68. The other half of the casing is then placed around the core, facing the first half so as to complete the cylindrical form of the casing. The clamp or strap 26 is then placed around the two halves of the casing 24 in the region 68 and tightened

by the bolt 28, thereby rigidly securing the two halves of the casing around the yoke. The strap 26 may, if desired, be permanently magnetized across its diameter for the purpose of imparting a fixed amount and direction of centering field for the beam which passes through the yoke field. It will be appreciated from the foregoing that the terminal board is conventionally located behind the yoke coils and does not require any space around the coils themselves. Moreover, the novel yoke casing, by reason of the manner in which it is secured to the yoke, requires no space between the core and coils of the yoke, as is the case with certain prior art arrangements.

In accordance with conventional practice, the yoke 16 may further be provided with a pair of permanent magnet rings for effecting initial centering of the beam. Such rings and their operation are well known in the art and need not be described. The yoke casing 24 of the present invention, however, affords ready means for mounting such magnets in operative position with respect to the yoke. Specifically, a magnet supporting member 78 such as that shown in Figures 11 and 12 is provided. The member 78 is in the form of a disk having a pair of radial, outwardly extending tabs 80 which are narrow enough to fit within the openings defined by the tabs 74 which extend inwardly at the rear end of the casing 24. An axial tubular extension 82 of sufficient diameter to accommodate the neck 12 of the cathode ray tube extends rearwardly from the member 78 so that the ring magnets 30 and 32 may be slid onto the tubular extension 82. The rear end of the extension 82 may then be turned outwardly to prevent removal of the ring magnets. The tabs 80 of the magnet supporting member 78 may further be provided with bent portions 84, so that when the member 78 is placed between the rib 72 and tabs 74 and rotated so that the tabs 80 are between the rib 72 and tabs 74, a tight fit results.

The final arrangement of the yoke is the insulating member 52 mentioned earlier in connection with Figure 5. A specific form of insulator for this purpose is shown in Figures 13 and 14. The insulator 52 has front and rear radial flanges 88 and 90, respectively, which are designed to fit between the horizontal and vertical deflection coils in the regions of their front and rear end turns. The body portion 92 of the insulator 52 is generally in the form of a paraboloid so that it conforms to the total outer surface of the horizontal coils and the inner surface of the vertical deflection coils. The insulator, which may be formed of vulcanized rubber or other resilient insulating material may further be provided with a pocket 94 on each side of its horizontal axis for supporting one of the magnets 60, described above. The insulator 52 may be split longitudinally as at 96 to facilitate the placing of the insulator around the assembled horizontal deflection coils. A pair of radially, inwardly extending ribs 98 at opposite sides of the inner surface of the body portion 92 of the insulator serve to space the adjacent conductor bundles of the coils 18 from each other by the required amount 2s described earlier.

By way of résumé, it will be appreciated that the yoke of the present invention, while low cost, affords a high degree of sensitivity and is capable of producing a wide angle deflection of the order of 110°. By virtue of the parabolic contour of the tube bulb and the yoke coils, this sensitivity is maximized. In comparing the present yoke with one which was designed so that its inner surface was the surface of revolution of an arc of a circle and adapted to produce the same order of deflection, it has been found that the present yoke used 37% less copper in the horizontal deflection coils and 17% less copper in the vertical deflection coils than was used in the circular yoke. Moreover, by virtue of the concavity of the outer surface of the core, a saving in core material of approximately three times was effected.

In the interest of completeness of description, it may be noted that a practical, operative, tube with which the

yoke of the present invention may be associated is one having a neck whose outer diameter is reduced from the conventional dimensions of 1.5 inches to 1.125 inches.

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

1. An electromagnetic deflection yoke for a cathode ray tube having a generally cylindrical neck and a flared bulb whose contour is generally parabolic, said yoke comprising: a pair of deflection coils, said coils being arranged in opposing relation and shaped, for at least a portion of their length, with a generally parabolic contour so that said coils may conform to the flared contour of such tube, the parabolic contour of said bulb and the parabolic contour of said coils being defined by the equation $y=ax^2+C$, where x and y are the loci of points defining a parabolic curve in a system of rectangular coordinates and C is a constant.

2. An electromagnetic deflection yoke for a cathode ray tube having a generally cylindrical neck and a flared bulb whose contour is generally parabolic, said yoke comprising: a first pair of deflection coils, said coils being arranged in opposing relation and shaped, for at least a portion of their length, with a generally parabolic contour so that said coils may conform to the flared contour of such tube; and a second pair of coils arranged around said first pair of coils, the parabolic contour of said bulb and the parabolic contour of said first pair of coils being defined by the equation $y=ax^2+C$, where x and y are the loci of points defining a parabolic curve in a system of rectangular coordinates and C is a constant.

3. An electromagnetic deflection yoke for a cathode ray tube having a generally cylindrical neck and a flared bulb whose contour is generally parabolic, said yoke comprising: a first pair of deflection coils, said coils being arranged in opposing relation and shaped, for at least a portion of their length, with a generally parabolic contour so that said coils may conform to the flared contour of such tube; and a second pair of coils arranged around said first pair of coils, said second pair of coils being shaped to conform to the contour of said first pair of coils, the parabolic contour of said bulb and the parabolic contour of said first pair of coils being defined by the equation $y=ax^2+C$, where x and y are the loci of points defining a parabolic curve in a system of rectangular coordinates and C is a constant.

4. An electromagnetic deflection yoke for a cathode ray tube having a generally cylindrical neck and a flared bulb whose contour is generally parabolic, said yoke comprising: a first pair of deflection coils, said coils being arranged in opposing relation and shaped, for at least a portion of their length, with a generally parabolic contour so that said coils may conform to the flared contour of such tube; and a second pair of coils arranged around said first pair of coils, said second pair of coils being shaped to conform to the contour of said first pair of coils; and a core of magnetic material surrounding said first and second pairs of coils, said core being formed with an inner surface of generally parabolic contour to conform to said coils, each of said parabolic contours being defined by the equation $y=ax^2+C$, where x and y are the loci of points defining a parabolic curve in a system of rectangular coordinates and C is a constant.

5. An electromagnetic deflection yoke for a cathode ray tube having a generally cylindrical neck and a flared bulb whose contour is generally parabolic, said yoke comprising: a first pair of deflection coils, said coils being arranged in opposing relation and shaped, for at least a portion of their length, with a generally parabolic contour so that said coils may conform to the flared contour of such tube; and a second pair of coils arranged around said first pair of coils, said second pair of coils being shaped to conform to the contour of said first pair of coils; and a core of magnetic material surrounding said first and second pairs of coils, said core being formed with an inner surface of generally parabolic contour to conform to said coils and with an outer surface which is

shaped concave inwardly toward the neck of such tube, the inner dimensions of said first pair of coils being of minimum value so that the inner surface of said first pair of coils is spaced a minimum distance from such tube.

6. A cathode ray tube having a generally cylindrical neck portion and a bulb portion extending therefrom, said bulb portion having outer and inner surfaces of generally parabolic contour, each parabolic contour being defined by the equation $y=ax^2+C$, where x and y are the loci of points defining a parabolic curve in a system of rectangular coordinates and C is a constant.

7. In combination with a cathode ray tube having a generally cylindrical neck portion and a bulb portion extending therefrom, said bulb portion having an outer surface which is a surface of revolution of a parabola, an electromagnetic deflection yoke which comprises a first pair of deflection coils arranged in opposing relation around a portion of the length of said tube including a portion of said bulb portion, said coils having an inner surface which conforms to the outer surface of said tube; and a second pair of coils arranged around said first pair of coils, said parabola being defined by the equation $y=ax^2+C$, where x and y are the loci of points defining a parabolic curve in a system of rectangular coordinates and C is a constant.

8. In combination with a cathode ray tube having a generally cylindrical neck portion and a bulb portion extending therefrom, said bulb portion having an outer surface which is a surface of revolution of a parabola, an electromagnetic deflection yoke which comprises a first pair of deflection coils arranged in opposing relation around a portion of the length of said tube including a portion of said bulb portion, said coils having an inner surface which conforms to the outer surface of said tube; and a second pair of coils arranged around said first pair of coils, said parabola being defined by the equation $y=.62x^2+.570$ and said inner surface of said first pair of coils being a surface of revolution of a parabola defined by the equation $y=.74x^2+.625$, where x and y are the loci of points on said parabola in a system of rectangular coordinates.

9. An electromagnetic deflection yoke for deflecting an electron beam in a cathode ray tube, which yoke comprises a first pair of deflection coils, each coil being made up of a plurality of turns of a conductor such that it has longitudinal and end bundles of turns, said coils being arranged to face each other, the inner surfaces of said coils being a surface of revolution of a parabola; a second pair of coils arranged around said first coils in such manner that a magnetic field produced by the longitudinal conductor turns of said first coils is substantially normal to a field produced by the corresponding conductor turns of said second pair of coils, the coils of said second pair being shaped in substantial conformity with the coils of said first pair, the inner dimensions of said first pair of coils being of minimum value so that the inner surface of said first pair of coils is spaced in a minimum distance from the beam of such tube in its maximum deflected position.

10. An electromagnetic deflection yoke for a cathode ray tube, which yoke comprises a first pair of deflection coils, each coil being made up of a plurality of turns of a conductor such that it has longitudinal and end bundles of turns, said coils being arranged to face each other, the inner surfaces of said coils being a surface of revolution of a parabola; a second pair of coils arranged around said first coils in such manner that a magnetic field produced by the longitudinal conductor turns of said first coils is substantially normal to a field produced by the corresponding conductor turns of said second pair of coils, the coils of said second pair being shaped in substantial conformity with the coils of said first pair, said second pair of coils having a lower total electrical resistance than that of said first pair of coils.

11. An electromagnetic deflection yoke for a cathode ray tube, which yoke comprises a first pair of deflection

coils, each coil being made up of a plurality of turns of a conductor such that it has longitudinal and end bundles of turns, said coils being arranged to face each other, the inner surfaces of said coils being a surface of revolution of a parabola; a second pair of coils arranged around said first coils in such manner that a magnetic field produced by the longitudinal conductor turns of said first coils is substantially normal to a field produced by the corresponding conductor turns of said second pair of coils, the coils of said second pair being shaped in substantial conformity with the coils of said first pair, said coils of said first pair having a substantially constant turns distribution throughout the length of such longitudinal bundles of conductor turns, said parabola being defined by the equation $y=ax^2+C$, where x and y are the loci of points on said parabola in a system of rectangular coordinates and C is a constant.

12. An electromagnetic deflection yoke for a cathode ray tube, which yoke comprises a first pair of deflection coils, each coil being made up of a plurality of turns of a conductor such that it has longitudinal and end bundles of turns, said coils being arranged to face each other, the inner surfaces of said coils being a surface of revolution of a parabola; a second pair of coils arranged around said first coils in such manner that a magnetic field produced by the longitudinal conductor turns of said first coils is substantially normal to a field produced by the corresponding conductor turns of said second pair of coils, the coils of said second pair being shaped in substantial conformity with the coils of said first pair, said first and second pairs of coils each having substantially uniform turns distributions throughout their lengths, said parabola being defined by the equation $y=ax^2+C$, where x and y are the loci of points on said parabola in a system of rectangular coordinates and C is a constant.

13. An electromagnetic deflection yoke for a cathode ray tube, which yoke comprises a first pair of deflection coils, each coil being made up of a plurality of turns of a conductor such that it has longitudinal and end bundles of turns, said coils being arranged to face each other, the inner surfaces of said coils being a surface of revolution of a parabola; a second pair of coils arranged around said first coils in such manner that a magnetic field produced by the longitudinal conductor turns of said first coils is substantially normal to a field produced by the corresponding conductor turns of said second pair of coils, the coils of said second pair being shaped in substantial conformity with the coils of said first pair, said coils of said first pair being so wound as to produce a magnetic field of such shape as to effect substantially uniform focus of an electron beam passing therethrough and said coils of said second pair being wound so as to produce a magnetic field whose shape is more greatly pincushioned than the field of said first pair of coils.

14. An electromagnetic deflection yoke for a cathode ray tube, which yoke comprises a first pair of deflection coils, each coil being made up of a plurality of turns of a conductor such that it has longitudinal and end bundles of turns, said coils being arranged to face each other, the inner surfaces of said coils being a surface of revolution of a parabola defined by the equation $y=ax^2+C$, where x and y are the loci of points on said parabola in a system of rectangular coordinates and C is a constant; a second pair of coils arranged around said first coils in such manner that a magnetic field produced by the longitudinal conductor turns of said first coils is substantially normal to a field produced by the corresponding conductor turns

of said second pair of coils, the coils of said second pair being shaped in substantial conformity with the coils of said first pair; and core forming means of magnetic material surrounding the longitudinal conductor turns of said first and second coil pairs.

15. An electromagnetic deflection yoke for a cathode ray tube, which yoke comprises a first pair of deflection coils, each coil being made up of a plurality of turns of a conductor such that it has longitudinal and end bundles of turns, said coils being arranged to face each other, the inner surfaces of said coils being a surface of revolution of a parabola; a second pair of coils arranged around said first coils in such manner that a magnetic field produced by the longitudinal conductor turns of said first coils is substantially normal to a field produced by the corresponding conductor turns of said second pair of coils, the coils of said second pair being shaped in substantial conformity with the coils of said first pair, said coils of said first pair being so wound as to produce a magnetic field of such shape as to effect substantially uniform focus of an electron beam passing therethrough and said coils of said second pair being wound so as to produce a magnetic field whose shape is more greatly pincushioned than the field of said first pair of coils; and a permanent magnet mounted on each side of said first pair of coils in such manner that the flux of each magnet aids the flux produced by said first pair of coils.

16. An electromagnetic deflection yoke casing for use with a yoke of the type comprising two pairs of normally arranged coils surrounded by a core of magnetic material which fits between the end turns of said coils, which casing comprises: a shell of insulating material, said shell being made up of a plurality of sections of a generally cylindrical member; means for securing said shell around such core near one end of said shell; and means for supporting a terminal board within said shell at a location beyond one end of said yoke.

17. An electromagnetic deflection yoke casing for use with a yoke of the type comprising two pairs of normally arranged coils surrounded by a core of magnetic material which fits between the end turns of said coils, which casing comprises: a shell of insulating material, said shell being made up of a plurality of sections of a generally cylindrical member; means for securing said shell around such core near one end of said shell; and means for supporting a terminal board within said shell at a location beyond one end of said yoke; a pair of permanent ring magnets; and means for supporting said magnets at the end of said shell remote from its first-named end.

18. A cathode ray tube having a generally cylindrical neck portion and a bulb portion extending therefrom along a single axis, said bulb portion having an outer surface which is a surface of revolution of a parabola whose equation is $y=.62x^2+.570$, where x and y are the loci of points on said parabola in a system of rectangular coordinates.

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