United States Patent

[11] **3,622,927**

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[45] Patented **Nov. 23, 1971**

[54] **DEFLECTION YOKE**
17 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** **335/210,** 335/213
[51] **Int. Cl.** **H01f 7/00**
[50] **Field of Search** 335/210, 213; 313/76, 77

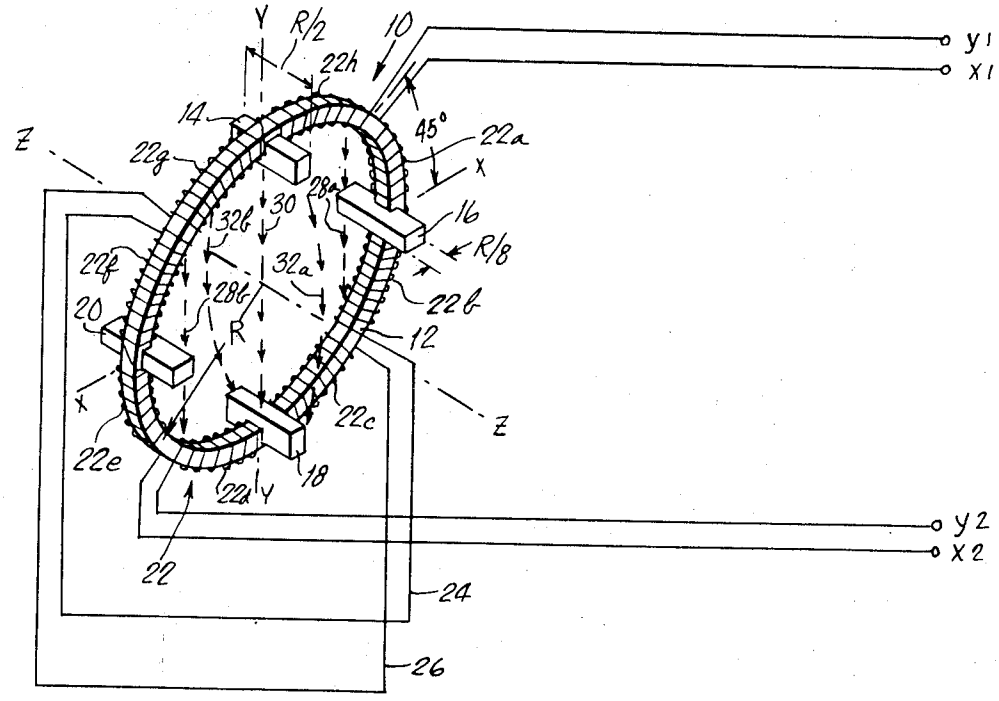
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Primary Examiner—G. Harris
Attorneys—Robert Scobey, Robert S. Dunham, P. E. Henninger, Lester W. Clark, Gerald W. Griffin, Thomas F. Moran, Bradlee Boal and Christopher C. Dunham

ABSTRACT: Several substantially circular deflection yoke structures for cathode-ray tubes are disclosed. Their common principal characteristics include means whereby the features of orthogonal (x, y) deflection axes are identical. This results in symmetry about the diagonal (45°) deflection positions as well as about the deflection axes. These structures each employ eight identical toroidally wound coil segments. Four coils, symmetrically placed on both sides of the x-axis, provide x-axis deflection. Four coils similarly located with respect to the y-axis provide y-axis deflection. Each coil occupies a 45° segment from its axis outwardly along an annular core piece.



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SHEET 1 OF 2

Fig. 1.

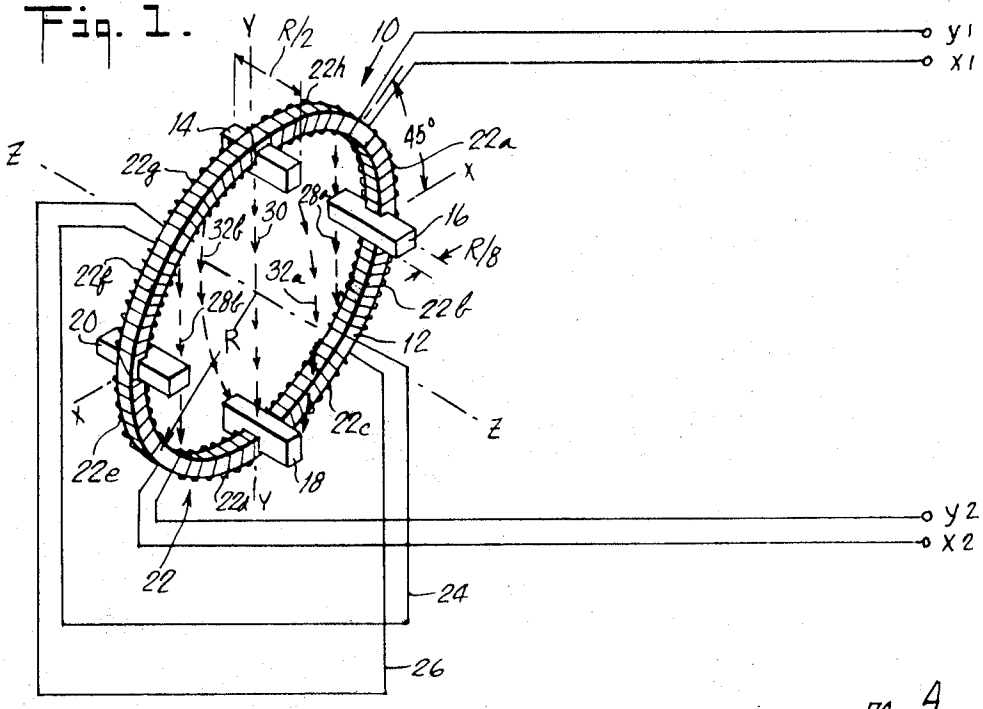


Fig. 2.

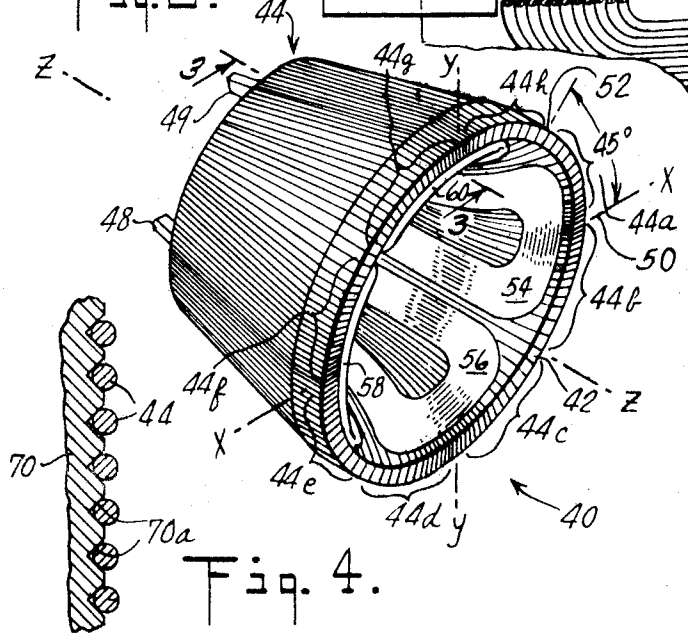


Fig. 4.

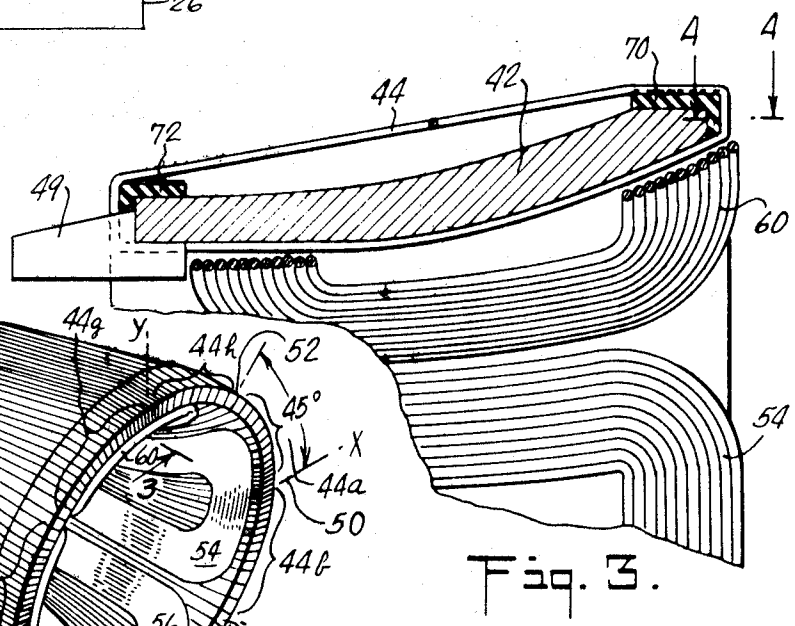


Fig. 3.

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Fig. 5.

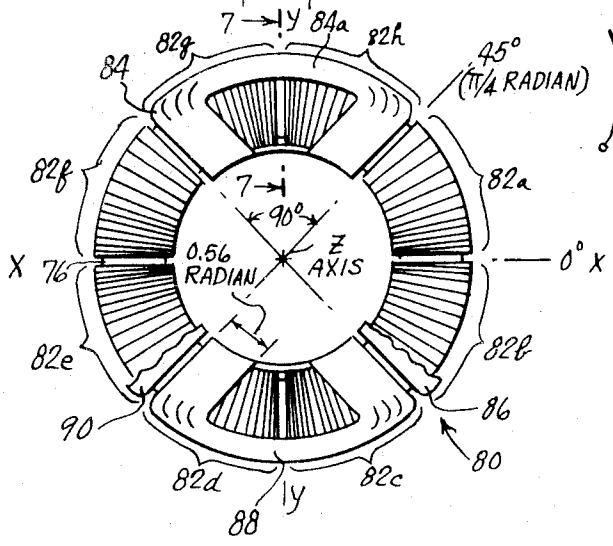


Fig. 6.

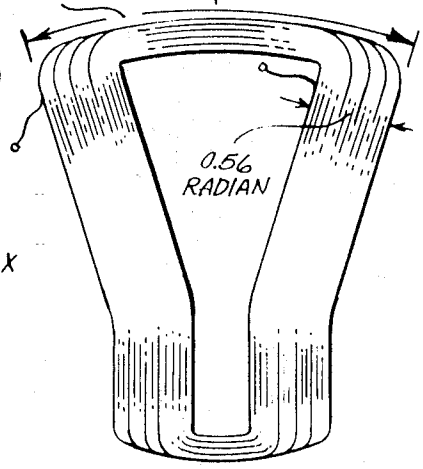
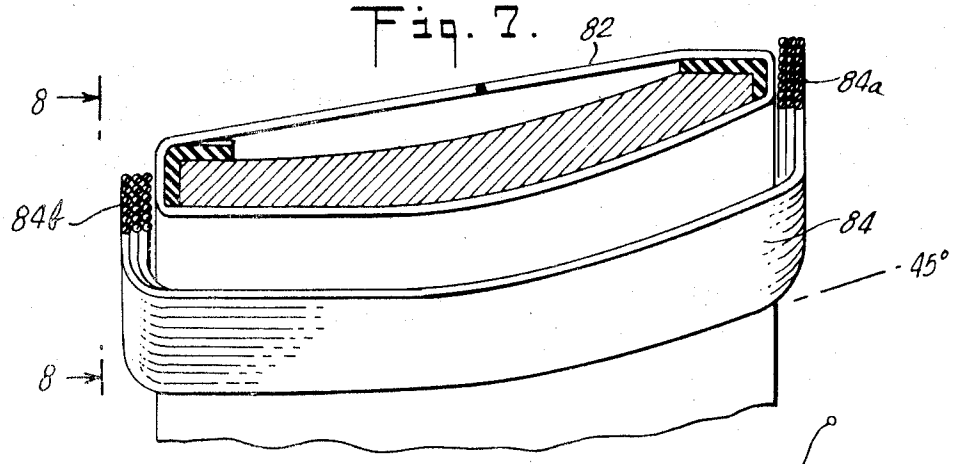


Fig. 7.



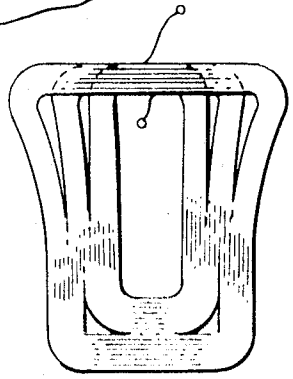


Fig. 9.

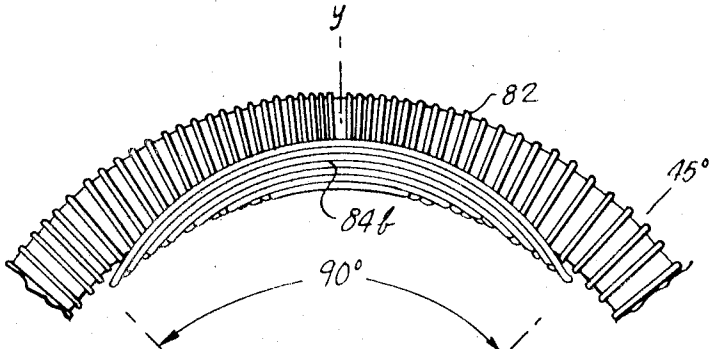


Fig. 8.

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DEFLECTION YOKE

In a first variation the coils have uniform turns distribution, and four-pole pieces (two on each axis) are mounted on the yoke core. The pole piece dimensions are chosen to provide best deflection field uniformity.

In a second arrangement, the above pole piece and winding structure is provided at the rear of a yoke. The toroidal windings are shifted to cosine distribution at the front. Saddle-type coils are provided at the front in lieu of pole pieces to provide uniform field distribution.

In a third arrangement, the the toroidal coils have cosine distribution covering the region from 0° to 45° throughout their length. Four saddle-type coils are provided which extend for a complete yoke length. They substantially provide a cosine distribution in the region from 45° to 90°.

BACKGROUND OF THE INVENTION

This invention relates to magnetic deflection yokes used for deflecting electron beams.

The present invention is particularly directed to deflection yoke structures meeting strict resolution standards, i.e., in which the focused beam spot on a cathode-ray tube screen must be maintained at a small size.

Various approaches have been followed in the past in the design of deflection yoke structures. Many such structures involve cumbersome winding arrangements incapable of adequately precise control, or involve inherent beam distortion to an unacceptable degree. For example, one well-known basic yoke structure comprises a square core having a pair of toroidal windings on opposite core legs for each axis of deflection. The yoke symmetry and winding distribution can be controlled to a high degree. However, the beam distortion can be reduced only to a limit inherent in the square core shape. Conversely, the beam distortion may be reduced to zero for correctly proportional circular cores of annular structure. Toroidally winding a pair or pairs of coils on an annular core to provide deflection in the direction of one or both axes is well known. Accurate turns distribution is difficult, and coil overlapping is a feature of this yoke structure which introduces complexities. Saddle-type coil windings (in which the windings are located inside the core) are also well known. A pair of such coils is required to produce deflection along one axis. Highly accurate control of turns distribution in such coils is also difficult. Yokes using toroidal coils for one axis and saddle coils for the other have been used. Any of these arrangements due to nonsymmetry result in a difference in deflection characteristics with respect to the two axes.

It is accordingly a principal object of the present invention to provide unique and simplified deflection yoke structures.

Another object of the invention is to provide deflection yoke structures which are inherently highly symmetrical about several axes and which are highly accurate in the deflection of an electron beam.

A further object of the invention is to provide deflection yokes having identical horizontal and vertical axis structural characteristics, thereby to exhibit 45° (pi/4 radian) diagonal symmetry.

Another object is to provide simplified deflection yoke structures while at the same time tolerating little or no beam distortion.

BRIEF DESCRIPTION OF THE INVENTION

The invention involves the combined use of toroidal and/or saddle windings and/or pole pieces for one or both directions of deflection. In a first basic toroidal winding structure, eight distinct windings in the form of a complete annulus on a yoke core are employed. Each winding is located within an arc segment of 45° or pi/4 radian. Two windings adjacent each deflection axis are connected together to form four pairs of windings. One set of opposing pairs is utilized for x-axis deflection and the other set of opposing winding pairs for y-axis deflection. Four pole pieces are advantageously positioned on the core, each between the two windings of a pair of windings.

The pole pieces are dimensioned to produce additional central axis flux lines to achieve a substantially balanced deflection field. For a short yoke, the pole pieces may extend along the z (CRT beam) axis of the deflection yoke for a distance approximately equal to one-half of the yoke radius (R). The pole pieces may extend inwardly toward the z-axis for a distance of about one-eighth R. The individual winding segments of the toroidal winding may be uniformly wound in any conventional manner.

In a second deflection yoke structure having a substantial extent along the z-axis, the pole pieces and uniform windings are employed at the rear end of the yoke. The windings at the front end of the yoke are shifted to a turns distribution in accordance with a cosine function. In this case the cosine function for each coil segment varies from 0° to 45°, i.e. from 1.000 to 0.707. The variation of cosine function through 45° rather than through 90° simplifies the making of the windings.

Saddle windings are employed at the front of the yoke in conjunction with the toroidal winding segments, and may be formed with a cosine distribution of turns, or wound uniformly but in one or more lumped segments so as to achieve in effect a cosine distribution of turns for angles from 45° to 90°.

In a third variation no pole pieces are employed. The toroidal windings have cosine distribution throughout their length. As above, for each coil segment the cosine function varies from 1.00 (heaviest turns concentration) at the deflection axis of that coil to 0.707 at the 45° diagonal position. The next adjacent 45° arc is occupied by a coil segment of the orthogonal deflection axis, and so on. Four saddle-type coils which extend the full length of the yoke (z-direction) are mounted inside the yoke, and each adjacent to a toroidal coil pair of the orthogonal deflection axis. In this position they contribute the deflection field flux corresponding to angles from 45° to 90° and are provided with a turns distribution corresponding to the cosine function in the interval 45° to 90°. A pair of opposite saddle coils on one axis, in conjunction with the two opposed pairs of toroidal coil segments located on the orthogonal axis, provide the deflection for the latter axis.

The invention will be more completely understood by reference to the following detailed description of representative embodiments thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a deflection yoke utilizing a toroidal winding and pole pieces in accordance with the invention;

FIG. 2 is a perspective view of another deflection yoke in accordance with the invention, including toroidal and saddle windings and pole pieces at the rear end of the yoke;

FIG. 3 is a sectional view to an enlarged scale of part of the deflection yoke of FIG. 2, taken along the section line 3—3 of FIG. 2;

FIG. 4 is a sectional view to an enlarged scale of part of the yoke shown in FIG. 3, taken along the section line 4—4 in FIG. 3; FIG. 5 is a front view of another deflection yoke in accordance with the invention;

FIG. 6 is a plan view of a saddle winding useful in the practice of the invention;

FIG. 7 is a sectional view to an enlarged scale of the deflection yoke of FIG. 5, taken along the section line 7—7 in FIG. 5;

FIG. 8 is an end view of a portion of the deflection yoke of FIG. 7, looking in the direction of the arrows 8—8 in FIG. 7; and

FIG. 9 is a plan view of a saddle winding in which the distribution of turns is in accordance with a cosine function and which is useful in the practice of the invention.

DETAILED DESCRIPTION

Referring to FIG. 1, a deflection yoke **10** in accordance with the invention is shown. The deflection yoke is suitable for relatively small beam deflections for beam centering purposes, or

for the positioning of a beam to a given position on a cathode-ray tube screen, for example. The deflection yoke is generally required to be short, i.e., to be of little dimension along the *z*-axis. Because of the small deflection angle which is generally involved, the magnetic field need not be distortionless. The deflection yoke **10** of FIG. **1** is of simple construction, while at the same time achieving a good field configuration.

The deflection yoke **10** comprises an annular core **12**, of magnetic material which is relatively thin, i.e., it does not extend substantially in the direction of the *z*-axis. The core **12** may be laminated, or it may be a single relatively thin ring of magnetic material. Four- pole pieces **14**, **16**, **18** and **20** are included, as shown. The pole pieces are also of magnetic material. The pole pieces are spaced 90°, or pi/2 radians, apart. The pole pieces **14** and **18** are located along the *y*-axis, while the pole pieces **16** and **20** are located on the *x*-axis. The pole pieces serve to achieve a substantially uniform distribution of flux in the yoke field. Their dimensions are dependent on the yoke parameters. For example, for the case illustrated where the yoke core is short compared to its diameter and the toroidal coils have uniform winding distribution, each pole piece may extend in a direction along the *z*-axis for a length approximately equal to one-half of the radius R of the core **12** and may extend inwardly for a distance R/8.

A toroidal winding **22** is wound about the core **12**, and consists of eight different 45° (or pi/4 radian) segments **22***a*, **22***b*, **22***c*, **22***d*, **22***e*, **22***f*, **22***g* and **22***h*. The segments **22***a* and **22***b* comprise another pair. Similarly, segments **22***e* and **22***f* comprise a third pair; and segments **22***g* and **22***h* comprise a fourth pair. It will be noted that the pole pieces are positioned between the two winding segments that constitute a toroidal pair. For example, the pole piece **16** is positioned between the two winding segments **22***a* and **22***b*, constituting the first toroidal winding pair mentioned above.

The first and third toroidal winding pairs (segments **22***a*, **22***b*, **22***e* and **22***f*) are employed for *x*-axis deflection, while the second and fourth toroidal winding pairs (segments **22***c*, **22***d*, **22***g* and **22***h*) are employed for *y*-axis deflection. Typically the first and third pairs of windings are connected together in series, as for example by conductor **24**, which connects together the winding segments **22***b* and **22***f*. Signals for *x*-axis deflection are applied to terminals *x*1 and *x*2, respectively connected to toroidal coil segments **22***a* and **22***e*. Similarly, signals for *y*-axis deflection are applied to terminals *y*1 and *y*2 respectively connected to winding segments **22***h* and **22***d*. The two opposing pairs of *y*-axis deflection coils are connected together by conductor **26** (connecting together toroidal winding segments **22***c* and **22***g*). Although a series connection of windings has been shown in FIG. **1**, it is possible to utilize parallel connections, so long as the direction of magnetic flux is as shown by the arrows in FIG. **1**, which will now be explained.

In particular, in FIG. **1** the various winding segments are poled so that the flux therefrom is in the direction of the arrows shown in FIG. **1**. In FIG. **1**, the arrows shown represent only magnetic flux involved in *x*-axis deflection, i.e., the flux from coil segments **22***a*, **22***b*, **22***e* and **22***f*. The flux flows downwardly (or upwardly) in the *Y*-direction to provide for suitable plus or minus *x*-axis deflection of the electron beam that passes through the deflection yoke **10**. The toroidal winding typically produces a field in which side flux lines **28***a* and **28***b* are stronger than central axis flux lines **30**. The pole pieces **14** and **18** provide for the flowing of additional flux lines **32***a* and **32***b*, which increases the central axis field to make it the same as the field which is off the central axis.

Similarly, pole pieces **16** and **20** are helpful in achieving a uniform flux for *y*-axis deflection and aid in increasing the strength of the field along the central (*x*) axis.

The strengths of the central axes fields may be adjusted, as noted above, through suitable variation of pole piece length and depth in order to achieve a substantially balanced deflection field and overcome the typically weaker fields along the central axes.

The structure of FIG. **1** is constructed in a simple fashion. The winding segments shown are uniform in distribution.

Another deflection yoke structure **40** is shown in FIG. **2**. The yoke includes, for example, a magnetic core **42**, shaped as shown and which extends a substantial distance along the *z*-axis. A toroidal winding **44** is employed about the core **42** and is composed of eight 45° segments **44***a*, **44***b*, **44***c*, **44***d*, **44***e*, **44***f*, **44***g* and **44***h*. The coil **44** corresponds to the coil **22** in FIG. **1**, and the individual winding segments may be similarly connected. Thus the winding segments **44***a* and **44***b* constitute a first pair; the segments **44***c* and **44***d* a second pair; the segments **44***e* and **44***f* a third pair; and finally, the segments **44***g* and **44***h* a fourth pair. A set of four-pole pieces is included, only two of which (**48** and **49** corresponding respectively to pole pieces **14** and **20** in FIG. **1**) are shown in FIG. **2**. The pole pieces are included only at the rear end of the deflection yoke **40**. These pole pieces serve the same function as the pole pieces shown and described above in connection with FIG. **1**. The toroidal winding **44** of the deflection yoke of FIG. **2** includes a uniform turns distribution at the rear end of the yoke adjacent the pole pieces. However, at the front end of the yoke, the turns distribution is shifted substantially in accordance with a cosine distribution. Since each winding segment occupies only a 45° sector, the cosine function varies from 1.000 (corresponding to 0°) to 0.707 (corresponding to 45°). Taking the zone **50** in FIG. **2** as a reference zone of 0° corresponding to *x*-axis deflection, the turns distribution of the winding segments **44***a* and **44***b* at this zone is the heaviest, and corresponds to the cosine function which is equal to 1.000. At the other end of the winding **44***a*, for example, (i.e., at the zone **52**) the turns distribution is the least dense, corresponding to the cosine function of 45°, which is 0.707. Thus the turns distribution at the front end of the deflection yoke, i.e., the density of turns for each winding, varies between the relative values 1.000 and 0.707. The turns density is the greatest along the *x*- and *y*-axes, and is the least along diagonals to these axes. It will be seen, therefore, that the toroidal winding is symmetrical with respect to 45° diagonal axes.

Four saddle-type windings **54**, **56**, **58** and **60** are also employed. Each saddle winding occupies a 90° sector and is positioned next to adjacent segments of a toroidal winding pair of the orthogonal deflection axis. For example, the saddle winding **54** (for *y*-axis deflection) is positioned next to windings **44***a* and **44***b* (for *x*-axis deflection) that are adjacent to each other and form parts of adjacent pairs. The saddle windings **56** and **60** are employed along with the toroidal winding segments **44***a*, **44***b*, **44***e* and **44***f* to provide for *x*-axis deflection. Similarly, the saddle windings **54** and **58** are employed, along with toroidal winding segments **44***c*, **44***d*, **44***g* and **44***h* for *y*-axis deflection. The saddle windings are ideally of cosine distribution corresponding to the cosine function in the range from 45° (for example at zone **52**) to 90°. In practice they may comprise one or more uniform lumped sections positioned to most nearly approximate this function or a desired degree of variation therefrom.

FIG. **3** shows some further details of the deflection yoke structure of FIG. **2**. The core **42** is annular, as shown, and may be cylindrical or arcuate in section to provide an annulus of greater diameter at the front end, and an annulus of lesser diameter at the rear end. Thus the core **42** is suitable for a wide-angle deflection yoke. The pole pieces are positioned at the rear end of the yoke, as noted above, where the off axis beam deflection is generally negligible. It is for this reason that the distribution of turns of the toroidal winding at the rear end may be made uniform, with pole pieces employed to render the magnetic field substantially uniform. This results in shorter windings. An annular spacer **70** is positioned about the core **42** at the front end of the deflection yoke, as shown in FIG. **3**, while an annular spacer **72** is similarly positioned at the rear end of the yoke. The spacer **70** is advantageously grooved, as at **70***a*, as shown in FIG. **4**, to accommodate selected ones of individual turns of the toroidal winding **44**. The spacer **72** may be similarly grooved. The winding **44** may be composed of one or more layers, preferably bank wound in sequence. As noted above, since each toroidal winding segment extends for only

45°, the turns distribution shifts simply from 1.000 to 0.707, simplifying the winding procedure. If 90° coil segments were employed, the distribution of turns would have to shift from 1.000 to 0.000. The individual turns of the winding are wound tightly around the core **42** and fall directly into the correct groove positions in the spacers **70** and **72**, making a simple, continuous, smooth winding, the accuracy of which depends primarily on the end spacers. The end spacers in turn may be fabricated, for example, in a mold with highly accurate groove formations, thus to provide for extremely accurate positioning of the individual turns of the toroidal winding **44**, and to provide the uniform turns distribution at the rear end of the yoke and the cosine function turns distribution at the front end. It should be noted that the distribution of turns at the front end may be shifted from the cosine distribution, as desired, to provide minimum beam spot distortions based on design detail variations and other requirements of the deflection yoke structure and CRT assembly.

The saddle windings are advantageously positioned against the toroidal winding segments, as shown in FIGS. **2** and **3**, and may be adhered in position by conventional cementing techniques. The rear ends of the saddle windings are just in front of the front ends of the pole pieces, while the front ends of the saddle windings extend to the front end of the deflection structure.

As noted, the saddle and toroidal winding segments may be connected in series or in parallel, as desired, so long as the correct flux direction and correct turns relationships, as required, are maintained.

FIGS. **5** and **7** show another deflection yoke structure similar to that of FIGS. **2** and **3**, in which, however, the pole pieces of FIGS. **2** and **3** have been eliminated. Such a deflection yoke structure is suitable for applications requiring very high resolution (zero beam distortion) in which it is necessary that the yoke have complete circular symmetry about the *z*-axis. The deflection yoke structure is designated **80**, and includes a toroidal winding **82** that is constituted of eight segments **82***a*, **82***b*, **82***c*, **82***d*, **82***e*, **82***f*, **82***g* and **82***h*. In this case, however, the distribution of turns at both the front and the rear ends of the deflection yoke structure is in accordance with a cosine function (see FIGS. **5** and **8**). Thus both the front and rear ends of the toroidal winding **82** include a turns distribution the same as that described for the front end of the winding **44** in FIG. **2**. Four saddle windings **84**, **86**, **88** and **90** (corresponding respectively to saddle winding **60**, **54**, **56** and **58** in FIG. **2**) are employed in the deflection yoke system of FIG. **5**. Thus the coils for *x*-axis deflection are **84**, **82***a*, **82***b*, **88**, **82***e* and **82***f*, connected preferably in series. However, parallel or any desired combination of these connections which provides the correct magnitude and direction of flux components from the various coils may be used for *x*-axis deflection. Similarly, the coils for *y*-axis deflection are **86**, **82***c*, **82***d*, **90**, **82***g* and **82***h*, which may be connected in series and/or parallel relationship, as desired.

As shown in FIG. **7**, the saddle winding **84** extends the full length of the deflection yoke (compare with the saddle winding **60** shown in FIG. **3**, which is not as long as the yoke). The end turns of the saddle winding **84**, designated **84***a* and **84***b*, are brought around the outside front and rear surfaces of the deflection yoke structure. This is true with respect to all of the saddle windings **86**, **88** and **90**, shown in FIG. **5**.

In the arrangement of FIGS. **5** and **7**, the saddle windings **84**, **86**, **88** and **90** should ideally provide a turns distribution that is in accordance with a cosine function through angles 45° to 90°. A coil comprising several groups of turns each positioned according to the cosine distribution provides a very close approximation. Construction of such a coil is illustrated in FIG. **9**. However, in practice it has been found that even for very high resolution, the saddle windings need not be wound exactly in accordance with a cosine distribution. A single flat cross section coil of uniform distribution, as shown in FIG. **6**, may be employed in the structure of FIGS. **5** and **7**. To achieve optimum distribution, the outside boundary of the winding (corresponding to the end portion **84***a* in FIG. **5**) should occupy a full 90°, or pi/2 radians sector (see also FIG. **6**), while the width of a half portion of the winding should be equal to about 0.56 radian, as shown in FIGS. **5** and **6**. This dimension may be readily adjusted to provide for minor variations in the yoke distribution as required by specific cathode-ray tube requirements. Such a saddle winding construction produces negligible beam distortion for an electron beam spot size of the order of 1 mil in diameter.

SUMMARY

Various deflection yoke structures embodying the present invention have been shown and described. Toroidal windings (45°) with and without pole pieces and with and without saddle windings have been disclosed. All the structures may be easily and accurately fabricated. Negligible beam distortion can be achieved. They all may provide exactly similar structures on both *x*- and *y*-axes and 45° diagonal symmetry. Variations intermediate in both angle and coil combinations to those shown will be obvious. Their use in combination with various prior known yoke arrangements is also obvious.

The invention should not be limited to the embodiments shown, but should be taken to be defined by the following claims.

1. A deflection yoke providing a magnetic field suitable for beam deflection, comprising in combination: toroidal coils symmetrically wound in a first plurality of angular segments adjacent to a first axis of deflection for contributing to the magnetic field in a given direction to deflect the beam in the direction of said first axis of deflection, and means positioned substantially totally within a second plurality of angular segments, each angular segment of said second plurality of angular segments constituting the complement of a corresponding one of said angular segments of said first plurality of angular segments, said means contributing to the magnetic field in said given direction to render said field substantially uniform throughout said yoke.

2. A deflection yoke in accordance with claim **1**, in which the toroidal coils have substantially linear distribution within 45° angular segments.

3. A deflection yoke in accordance with claim **1**, and having substantial length, wherein said means comprises pole pieces at one end and saddle coils having portions thereof at the other end to control the deflection field distribution.

4. A deflection yoke in accordance with claim **1**, in which said means comprises a pair of pole pieces whose dimensions are proportioned to control the field distribution of said magnetic field component.

5. A short deflection yoke in accordance with claim **4**, in which the toroidal coils are positioned at radius R with respect to a beam axis, and in which each pole piece extends for a distance approximately equal to R/2 in a direction substantially parallel to said beam axis.

6. A deflection yoke in accordance with claim **5**, in which each pole piece includes a dimension in a direction toward said beam axis approximately equal to R/8.

7. A deflection yoke in accordance with claim **1**, and having substantial length, in which the toroidal coil turns have a distribution function which is shifted from front to rear along the yoke length.

8. A deflection yoke in accordance with claim **7**, in which the turns of each coil at one end of the yoke are uniformly distributed, and the turns of each coil at the other end are distributed in proportion to the cosine of the angle of any turn from a reference position.

9. A deflection yoke in accordance with claim **1**, in which the toroidal coils adjacent to the first axis of deflection comprise four toroidal coil segments wound on an annular magnetic core.

10. A deflection yoke in accordance with claim **9**, including a pair of saddle coils positioned opposite each other and centered orthogonally to said deflection axis, each saddle coil occupying a pair of said complementary angular segments.

11. A deflection yoke in accordance with claim 9, having a second axis of deflection substantially perpendicular to said first deflection axis, and including four additional toroidal coil segments symmetrically wound in complementary angular segments adjacent to said second deflection axis.

12. A deflection yoke in accordance with claim 11, including two pairs of pole pieces, the pole pieces of each pair being positioned substantially opposite each other on a corresponding deflection axis.

13. A deflection yoke in accordance with claim 11, in which said means positioned substantially totally within complementary angular segments comprises two pairs of saddle coils, the coils of each pair being positioned substantially opposite each other on a deflection axis.

14. A deflection yoke in accordance with claim 1, having a desired angular turns distribution which is provided by said toroidal coils within their angular segments and by saddle coils within the complementary angular segments.

15. A deflection yoke in accordance with claim 14, in which the desired angular turns distribution is proportional to the cosine of the angular position of a coil turn referred to the deflection axis.

16. A deflection yoke in accordance with claim 14, in which at least one of the saddle coils comprises a lumped coil of uniform distribution positioned to most closely approximate the desired distribution function.

17. A deflection yoke in accordance with claim 16, in which each toroidal coil segment is 45°, each saddle coil occupies a 90° segment and comprises a single coil of uniform turns distribution which subtends an angular segment of about 0.56 radian adjacent the corresponding toroidal coil segments.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,622,927 Dated 23 Nov. 1971

Inventor(s) Clayton A. Washburn

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, Line 28 after "comprise", "another pair" should be deleted and substitute therefor --one toroidal winding pair; the segments 22c and 22d comprise another pair.--

Signed and sealed this 19th day of September 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334