Jan. 17, 1967 C. E. TORSCH 3,299,379

DEFLECTION YOKE

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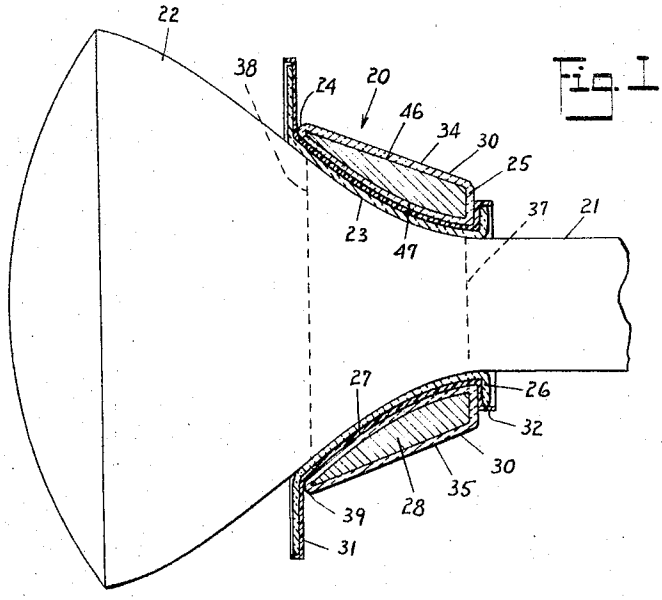


Fig. 1

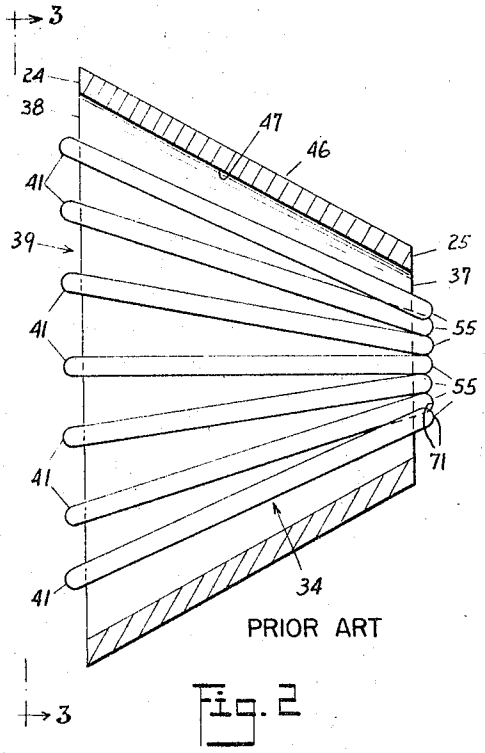
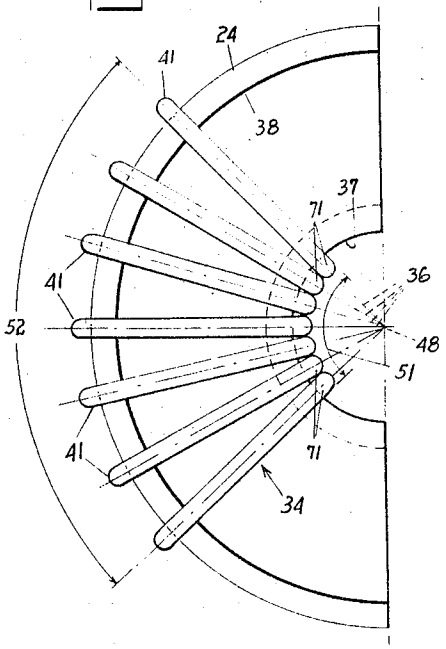


Fig. 2

Fig. 3 PRIOR ART



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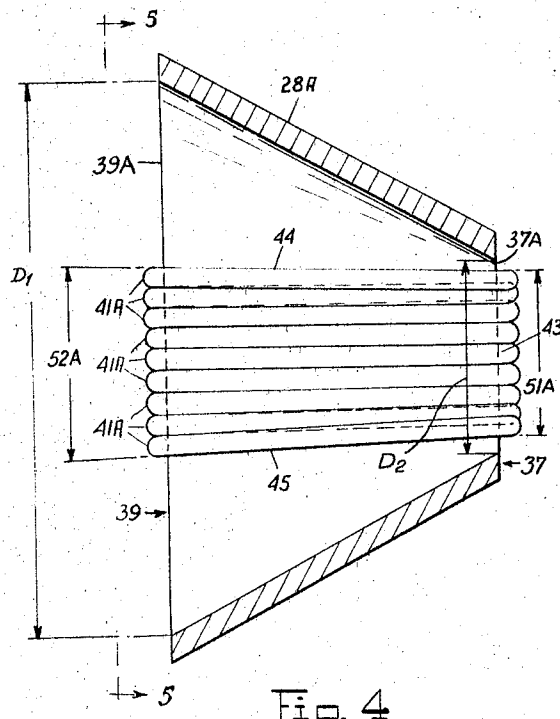


Fig. 4

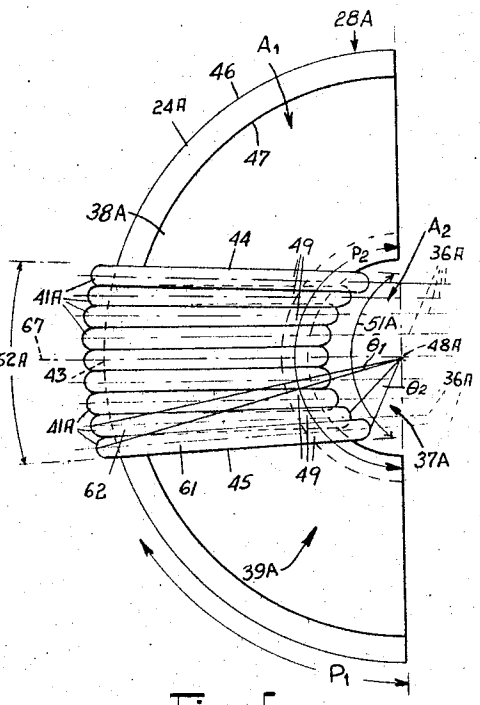
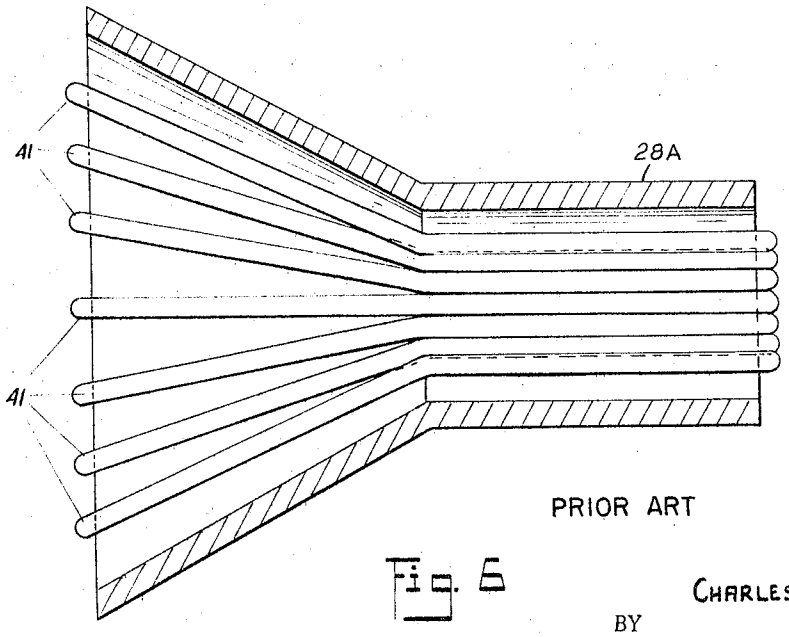


Fig. 5



PRIOR ART

Fig. 6

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DEFLECTION YOKE

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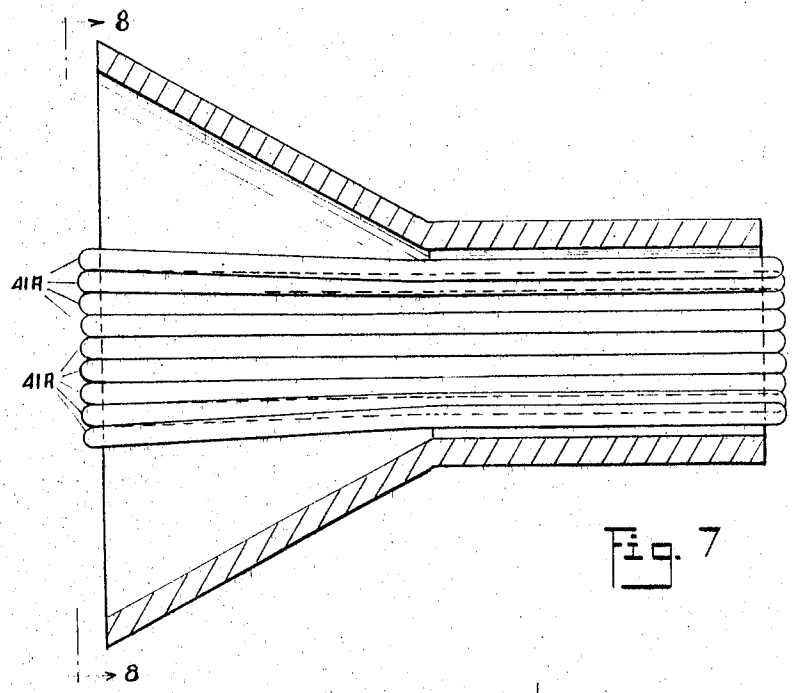


Fig. 7

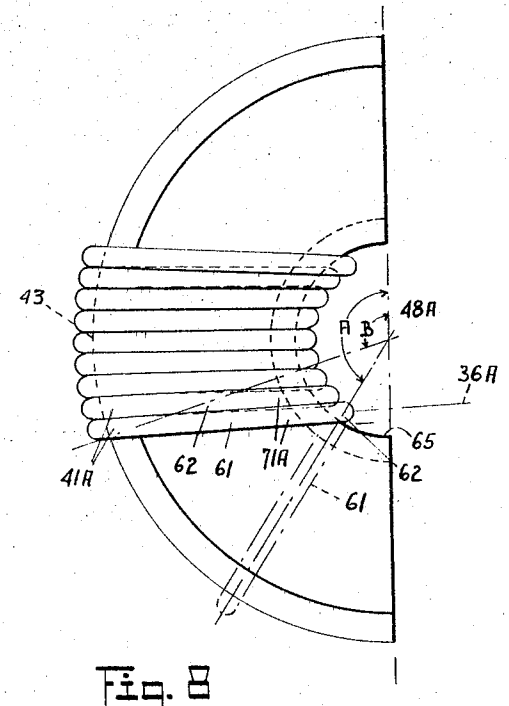


Fig. 8

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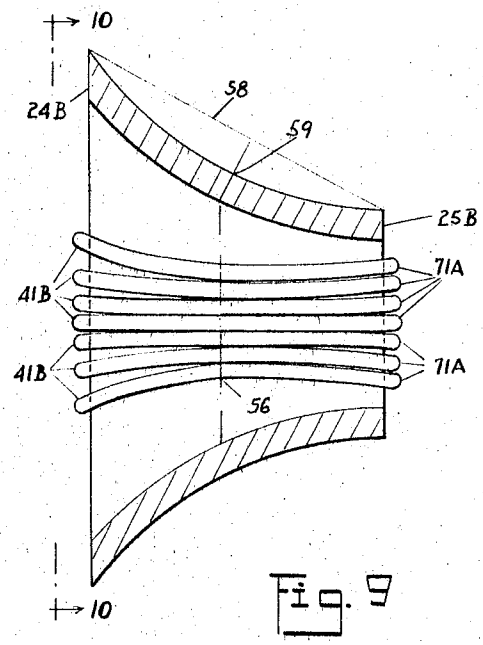


Fig. 9

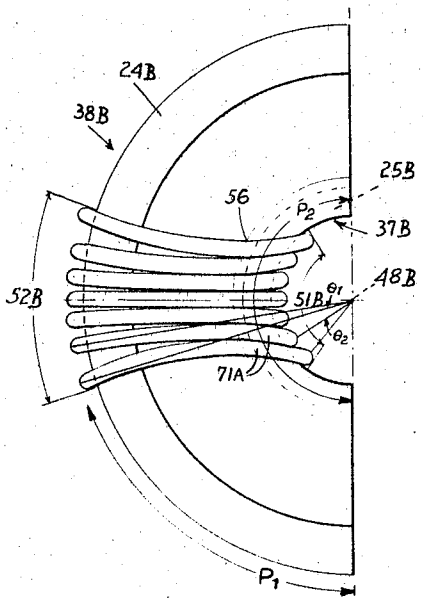
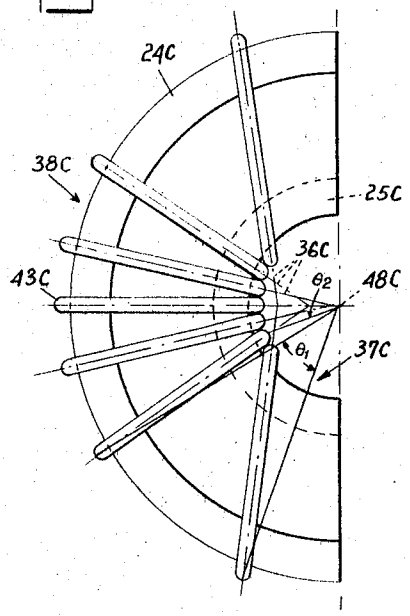


Fig. 10

Fig. 11



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3,299,379
DEFLECTION YOKE

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24 Claims. (Cl. 335—213)

The present invention relates to cathode ray tube deflection devices, and more particularly to novel toroidal electromagnetic deflection coils for use with cathode ray tubes.

During the operation of a cathode ray tube, the cathode ray beam is continually deflected so as to trace a pattern, known as a raster, on the tube screen. The deflection is caused by passing the beam through a time-varying magnetic field which emanates from deflection coils mounted about the tube neck.

In order to prevent deflection defocusing at the periphery of the raster, it is generally desirable that the field generated by the coils be uniform and more intense at the beam entry end of the deflection yoke. This condition is usually achieved by the use of deflection coils having a cosine distribution. However, where the cosine distribution is used in wide angle deflection, a further difficulty arises. Since, in wide angle deflection the radius of curvature of the screen is usually much greater than the average distance from the center of the yoke to the screen, the raster collapses at the edges so that it is shaped like a pincushion rather than being rectangular as desired.

This type of distortion is usually compensated for by the use of additional elements, known as anti-pin-cushion magnets, which are generally positioned on a non-magnetic frame attached to the deflection yoke near the flare of the picture tube. The magnets serve to pull or stretch the raster into the desired shape. Such an arrangement is not only costly, but in certain applications, such as in color three gun tube arrangements, the use of pin-cushion correction magnets is undesirable as it creates color blemishes.

Moreover, the prior art windings utilized large amounts of copper, required more space within the core for the copper, and simultaneously consumed more power.

Accordingly, it is an object of this invention to provide a novel type of deflection yoke winding and coil arrangement which in itself decreases the distortion of the raster at its periphery and thereby minimizes the need for pincushion magnets for correcting such image distortion.

A further object is to provide a novel type of winding to create a maximum flux density with favorable distribution in the yoke region with a minimum of copper for the winding and minimum power consumption.

Another object is to provide a novel winding which decreases the energy losses during the deflection process, and enables the internal diameter of the core structure to be narrowed, and which causes a decrease in the energy storage in the quadrature windings.

A further object is to develop a winding for use in color television yokes for decreasing pin-cushion distortion where is it undesirable to use anti-pin-cushion magnets due to their creation of color blemishes.

Briefly, the foregoing objects are accomplished by the use of a toroidal coil having windings thereon wound in a tilted manner. Referring now to the drawings:

FIG. 1 is a cross-sectional elevation of a yoke assembly taken at 45° to the axis of the horizontal and vertical flux;

FIG. 2 is a cross-sectional elevation view of a right conical core having a prior art radial winding thereon;

FIG. 3 is a front view of the assembly of FIG. 2;

FIG. 4 is a cross-sectional elevation view of a right conical core having a tilted winding thereon;

FIG. 5 is a front view of the assembly of FIG. 4;

FIG. 6 is a cross-sectional elevation view of a combined conical and cylindrical core having a prior art radial winding thereon;

FIG. 7 shows the core of FIG. 6, but with a tilted winding thereon;

FIG. 8 schematically shows a method of constructing a tilted winding;

FIG. 9 is a cross-sectional elevation of a curved-flare core having a tilted winding thereon;

FIG. 10 is a front view of the assembly of FIG. 9;

FIG 11 is a front view of a core segment having an inverse tilted winding thereon.

Deflection coils are either of saddle or toroidal shape. The toroidal coil is one which is wound axially of the core, circumscribing at least a portion of both the inside and outside thereof. The saddle type coil generally fits adjacent only one side of the core. A deflection yoke may use either saddle coils, toroidal coils, or a combination thereof. The present invention relates to yokes wherein at least one of the coils utilized is toroidal.

Referring again to the drawings, FIG. 1 shows a deflection yoke **20** mounted on the neck **21** of a cathode ray tube **22** adjacent the flared or bulb portion **23** of the tube. The yoke includes a pair of saddle-type horizontal deflection coils **26** positioned adjacent the neck of the tube, an insulator **27** placed about the horizontal coils, and a ferromagnetic core **28**, having a toroidal coil pair **30** wound thereon, placed about the insulator intermediate the front **31** and rear **32** flanged portions thereof.

As shown in FIG. 1, the toroidal coil pair comprises a pair of oppositely disposed coil halves **34** and **35**. Each coil half is wound axially of the core in a toroidal fashion and extends peripherally only along a portion of the core, as shown, for example, in FIG. 2.

In order to permit wide angle deflection, cores are generally flared, the cores being smaller in internal dimension at the rear, i.e. the beam entrance end **37** of the core and larger in internal dimension at the front, i.e. beam exit end **38** of the core. This flaring permits the front end **39** of each coil half to be positioned upon the bulb portion **23** of the tube thereby enhancing the wide angle deflection. The cores generally have a front face **24** and a rear face **25** which separate the outside surface **46** of the core from the inside surface **47**.

The flared cores may be in the shape of a regular cone as shown in FIG. 4, a combined cylinder and cone as shown in FIG. 6 or curved such as the circular flare shown in FIG. 9.

For purposes of clarity in explaining the present invention, the windings shown will be of much larger conductor diameter, and the turns fewer than might be the case in actual practice wherein more turns of finer wire may be utilized. In the past as shown in FIGS. 2 and 3, it has been the practice to wind toroids by winding each turn along the shortest axial distance, pulling the turn taut, and continuing to the next turn. Such procedure conformed to the natural shape of the core and utilized the least length of copper. As a result of this prior art turn alignment, the portions of the turns adjacent the front **38**, i.e. beam exit end, of the core were spread apart. This is shown by viewing the front end portions **41** of the coil half **34** of FIG. 2. This is also apparent from the front end view, FIG. 3, wherein it is shown that the turns of the prior art winding were radially disposed relative to the central axis so that the planar extensions **36** of the turns pass through the longitudinal central axis **48** of the core. Where such radially disposed windings were used in conjunction with cosine winding it was necessary to include large anti-pin-cushion magnets. It has been found that by using a novel substantially non-radial type of winding, the need for pin-cushion magnets has been decreased,

the winding inductance increased for the same number of turns, and the current through these turns decreased with a consequent increase in efficiency. The novel winding embodies the use of increased length of copper winding per turn, but permits the cross-section to be decreased and the number of turns to be decreased while still producing the same inductance and magnetic field as the radial winding. Thus, there is a saving in both initial cost and in the cost of operation.

A deflection coil winding is generally composed of a series of superimposed layers. For purposes of clarity and simplicity in explaining the type of winding embodying the present invention, only one layer, the first layer, will be described. It is to be understood that subsequent layers could be wound in the same manner with the width of the layers following conventional practice of a constant or gradient width.

FIG. 4 shows a preferred form wherein the novel windings are applied to a right conical core **28A**. A characteristic of the preferred form of novel winding is that at least one of the turns in each layer is radially disposed. In the preferred form, the radial turn or directrix illustrated by turn **43** in FIG. 4, is located intermediate the side edges **44** and **45** of each layer.

FIG. 5 is a front view of the right cone of FIG. 4 and illustrates the manner of tilt of the turns of FIG. 4. The side turns **49** on either side of the radially disposed directrix **43** are inclined or tilted so that their front end portions **41A** converge from the radial. As a result, as shown in FIG. 5, the extended planes **36A** of the side turns **49** pass beyond the central core axis **48A** rather than passing through the central core axis as is the case with radially disposed turns.

In the form shown, the directrix **43** is located in the middle of the layer and the side turns **49** are symmetrically disposed on either side of the directrix. It is to be understood that the directrix turn need not be in the exact center of the coil, but might be towards one edge so that more turns are located on one side of the directrix than on the other.

It is apparent from FIGS. 4 and 5 that the front end portions **41A** of the turns are positioned close together, rather than being spaced apart as was the case with the front end portions **41** of the radial windings of FIG. 3.

A further characteristic of the preferred form of the tilted winding is that the circumferential span **52A** of the front end of the coil may be closer in length to the length of the circumferential span **51A** of the rear end of the coil than the front peripheral span **52** is to the rear peripheral span **51** of the prior art radial winding of FIG. 3. In the maximum tilt, the front coil span **52A** is substantially the same as the rear coil span **51A**. Another way of stating this characteristic is that the ratio of the front coil span to the rear coil span of the tilted winding is nearer unity than the corresponding ratio of a radially disposed winding.

A still further characteristic of the preferred form of the tilted winding is that azimuthal angle θ_1 which is measured at aperture **39A**, between a longitudinal axis of the wire of the winding **49** at corresponding inner segments of turns which are wound successively in the general direction of coil winding advancement, has a lesser value than a corresponding azimuthal angle θ_2, which is measured at aperture **37A** between said longitudinal axis of said same segments of said same turns. The azimuthal angles θ_1 and θ_2 are illustrated in FIG. 5.

The inner surface **38A** at the beam exit end **39** of the core has a diameter **D1** at aperture **39A** and which defines a circular cross section area **A1** at the aperture **39A** in a plane perpendicular to the axis **48A**. At the opposite end of the core, the inner surface **38A** at the beam entry end **37** of the core, has a diameter **D2** which is less than **D1** and defines a circular cross section area **A2** at the aperture **37A** at the beam entry end **37** which is correspondingly less than the value of the cross sectional area **A1** at aperture **39A**. Since the cross sectional area **A1** is greater than cross sectional area **A2**, the perimetrical dimension or circumference, **P1**, of the inner surface **38A** of the core will be greater at the beam exit end **39** than at the corresponding perimetrical dimension **P2** measured at the beam entry end **37**.

FIG. 6 illustrates the prior art radial type of winding on a combined cylinder and cone type of core.

FIG. 7 illustrates a tilted winding on such a core. The front view for FIG. 7 is the same as FIG. 5.

FIG. 8 illustrates one way of making a tilted winding. A turn **61**, shown in dotted lines may be placed approximately 150 radial degrees with reference to the vertical, as shown at angle A of FIG. 8. Then, using the juncture **62** of the turn with the rear inside edge **65** of the core as a pivot point, the turn is pivoted while adding more wire thereto, so as to enlarge the turn, until the projected plane **36A** of the turn passes beyond the central axis **48A**. For example, the turn **61** may be rotated until the front end portion **41A** of the turn **61** is rotated until it is only 105°, with reference to the vertical as shown by angle B in FIG. 8. The next wire **62** is then laid so that the turns are touching at the front end portions **41A** and at the rear end portions **71A**. As the winding progresses, one of the turns **43** is so positioned that its planar extension will pass through the central axis thereby forming a directrix. The turns on the other side of this directrix are then aligned symmetrically to the first laid turns with the projected planes of the turns extending beyond the central axis.

It is to be understood that in actual practice more turns than one may be radial. However, it is preferred that at least more than half of the turns of each layer should be tilted.

Where the core has a front face **24**, **24A** and **24B**, as shown in FIGS. 3, 5 and 10, respectively, the difference between the radial windings of FIG. 3 and the tilted windings of FIGS. 5 and 10 is most apparent where the plane projection of turns method of comparison is utilized.

It is to be noted that where a curved core is machine wound, an additional characteristic of the novel tilted winding may appear. As shown in FIGS. 9 and 10 the rear end portions **71A** of the turns are spread apart slightly as compared to the rear end portions **71** of the prior art radial winding of FIGS. 2 and 3. However, unlike the radial arrangement, the length of the front span **52B** of the coil approaches the length of the rear span **51B**, and in some cases is substantially the same. A further characteristic of the machine wound curved core arrangement is that the turns converge intermediate the front and rear ends of the coil, thereby giving the coil a slightly inwardly bowed appearance. Thus the narrowest span of the wires is no longer located adjacent the rear end of the core, but at a point intermediate the front and rear ends of the coil. The point of narrowest span, the intermediate span **56**, is generally located at or near the point of greatest curvature of the flare. For example, where the curved core has a circular flare as shown in FIG. 9, and a chord **58** is drawn intermediate the ends of the circular segment, then the smallest span will be located at or near the greatest sagittal distance **59** of the circular segment from the chord. As a result, inductance is increased adjacent an important point in the path of the electron beam through the magnetic field.

In a modification such as shown in FIG. 11, it may be desirable to tilt the windings so that the side turns on either side of the directrix **43C** are tilted outwardly away from the directrix such that the projections **36C** of the planes of the tilted turns pass inside the central core axis **48C** as shown in FIG. 11. In this form, the advantage of increased mutual inductance at the front end of the coil is lost. However, in the inverse type of tilt, the color convergence of the yoke may be improved. In such case, instead of using anti-pin-cushion magnets to overcome pin-cushioning, it may be necessary to modulate the nor-

mal fixed value of peak-to-peak current through the horizontal or vertical coils.

It is to be understood that the word core, as used in the claims, could be a magnetic core, a non-magnetic core, or an air core. A support may be used for winding the toroid, the turns may be glued, and the support either retained as part of the core, or removed. Where the core is air, the reference axis then becomes the longitudinal central axis of the coil which would be in the same position as the core axis 48A and 48B illustrated. Where the core is present, then the longitudinal, or central coil axis is the same as the longitudinal central core axis.

It is to be noted from FIGS. 5, 10 and 11 that the the planar extensions of the tilted turns are non-coplanar with the central core axis, i.e. the planar extensions pass obliquely of the central core axis.

Whereas it is preferred that at least a pair of coil halves angularly disposed about the core be utilized with each coil half having the tilted configuration it may be possible to use a tilted winding on only one coil half.

I claim:

1. A deflection coil for use in cathode ray beam deflection yokes including a series of turns of wire toroidally disposed on the core with at least some of the turns being tilted so as to be non-radially aligned on the inner surface of the core relative to the longitudinal central axis of the coil.

2. A deflection coil according to claim 1, wherein the tilted turns are so positioned that the imaginary planar extensions thereof, when viewed from the front end of the coil, pass obliquely with respect to the longitudinal central axis of the coil.

3. A deflection coil according to claim 1, wherein the tilted turns are so positioned that the imaginary planar extensions thereof, when viewed from the front end of the coil, intersect the longitudinal central axis of the coil.

4. A deflection coil according to claim 3, wherein said tilted turns include more than half of the turns of the coil.

5. A deflection coil according to claim 4, including at least one turn, intermediate the side edges of the coil, said one turn being radially disposed so that the imaginary planar extension of the turn, when viewed from the front end of the coil, passes through the longitudinal central axis of the coil.

6. A deflection coil according to claim 1, wherein the coil includes a front end and a rear end, and wherein the portions of the turns of wire adjacent the front end of the coil, when viewed from the front end of the coil, are substantially contiguous throughout substantially their entire length adjacent the said front end of the coil.

7. A deflection coil for use in cathode ray beam deflection yokes, said coil having a front end and a rear end, a series of turns of wire toroidally wound from the front end to the rear end, the coil being curved about a longitudinal central axis, the inner diameter of the front end being greater than the inner diameter of the rear end with the peripheral span of the front end being substantially the same as the peripheral span of the rear end.

8. A deflection yoke for use on a cathode ray beam deflection tube, including a hollow core, at least one coil, said coil including a series of turns of wire toroidally disposed axially of the core with at least some of the turns being tilted so as to be non-radially aligned on the inner surface of the core relative to the longitudinal central axis of the core.

9. A deflection yoke according to claim 8, wherein the tilted turns are so positioned that the imaginary planar extensions thereof, when viewed from the front end of the core, pass obliquely with respect to the longitudinal central axis of the core.

10. A deflection yoke according to claim 9, wherein the tilted turns are so positioned that the imaginary planar extensions thereof, when viewed from the front end of the coil, intersect beyond the longitudinal central axis of the core.

11. A deflection yoke according to claim 9, wherein said tilted turns include more than half of the turns of the coil.

12. A deflection yoke according to claim 8, wherein at least one of the tilted turns is so positioned that a plane passing through the central axis of the core and through the point of juncture of the rear end of the turn with the inside rear edge of the core is at a greater angle relative to the vertical than is a plane passing through the central axis of the core and through the point of juncture of the front end of the turn with the inside front edge of the core.

13. A deflection yoke according to claim 12, wherein at least half of the turns of the coil are so tilted.

14. A deflection yoke for use on a cathode ray beam deflection tube including a hollow core, at least one coil, said coil including a series of turns of wire wound axially of the core in a toroidal fashion with at least some of the turns being positioned so that the turns are wound axially of the core in paths which are longer than the shortest axial toroidal path for the turn.

15. A deflection yoke for use on cathode ray tubes including a hollow core, said core being flared in a curved fashion, a coil including a series of turns wound axially of the core in a toroidal fashion, the coil having a front peripheral span, a rear peripheral span and an intermediate peripheral span, the intermediate peripheral span being less in length than either the front peripheral span or the rear peripheral span.

16. A deflection coil according to claim 1, wherein the coil includes a front end, a middle portion and a rear end and wherein the width of the middle portion is less than the width of the front or rear ends of the coil.

17. A deflection coil according to claim 1, wherein the tilted turns are so positioned that the imaginary planar extensions thereof, when viewed from the front end of the coil, intersect between a confronting inner face of the coil and the longitudinal central axis of the coil.

18. A deflection yoke according to claim 8, wherein the tilted turns are so positioned that the imaginary planar extensions thereof, when viewed from the front end of the coil, intersect between a confronting inner face of the core and the longitudinal central axis of the core.

19. A deflection yoke according to claim 18, wherein the tilted turns include more than half of the turns of the coil.

20. A deflection yoke for a cathode ray tube comprising: a core of ferromagnetic material having a length, an annular outer surface, an annular inner surface, said inner surface defining a cavity extending longitudially through said core from a first aperture at one extreme of said length to a second aperture at another extreme of said length, a horizontal deflection coil and a vertical deflection coil, one of said deflection coils having a plurality of wire turns wound about said core, each of said wire turns circumscribing said inner and outer surfaces and having a segment extending through said cavity, said one deflection coil having turns of wire which are wound successively in the general direction of coil winding advancement separated by a first azimuthal angle θ_1 at said first aperture and separated by a corresponding second azimuthal angle θ_2 at said second aperture, said first and second azimuthal angles having the relation

$$\theta_2 > \theta_1$$

where θ_1 and θ_2 are measured in degrees.

21. A deflection yoke for a cathode ray tube comprising: a core of ferromagnetic material having a length, an annular outer surface, an annular inner surface, said inner surface defining a cavity extending longitudinally through said core from a first aperture having a cross sectional area A_1 at one extreme of said length to a second aperture having a cross sectional area A_2 at another extreme of said

length, a horizontal deflection coil and a vertical deflection coil, one of said deflection coils having a plurality of wire turns wound about said core, each of said wire turns circumscribing said inner and outer surfaces and having a segment extending through said cavity, said one deflection coil having turns of wire which are wound successively in the general direction of coil winding advancement separated by a first azimuthal angle θ_1 at said first aperture and separated by a corresponding second azimuthal angle θ_2 at said second aperture, said first and second cross sectional areas and said azimuthal angles having the relation

$$A_1 > A_2$$

$$\theta_2 > \theta_1$$

where A_1 and A_2 are measured in square inches and θ_1 and θ_2 are measured in degrees.

22. A deflection yoke for a cathode ray tube comprising: a core of ferromagnetic material having a length, a longitudinal axis, an outer annular surface, an inner annular surface, said inner surface defining a cavity extending longitudinally through said core from a first aperture at one extreme of said length to a second aperture of another extreme of said length, said outer surface having linear perimetrical dimensions p_1 and p_2 measured in a plane perpendicular to said axis at points along said surface corresponding to said first and second apertures respectively, a horizontal deflection coil and a vertical deflection coil, one of said deflection coils having a plurality of wire turns wound about said core each of said wire turns circumscribing said inner and outer surfaces and having a segment extending through said cavity, said one deflection coil having turns of wire separated which are wound successively in the general direction of coil winding advancement by a first azimuthal angle θ_1 at said first aperture and separated by a corresponding second azimuthal angle θ_2 at said second aperture said first and second perimetrical dimensions and said first and second azimuthal angles having the relation

$$p_1 > p_2$$

$$\theta_2 > \theta_1$$

where p_1 and p_2 are measured in inches and θ_1 and θ_2 are measured in degrees.

23. A deflection yoke for a cathode ray tube comprising: a core of ferromagnetic material having a length, an outer circular surface, an inner circular surface said inner surface defining a cavity extending longitudinally through said core from a first aperture at one extreme of said length to a second aperture at another extreme of said length, said outer circular surface having diameters D_1 and D_2 at positions along the length of said core corresponding to said first and second apertures respectively, a horizontal deflection coil and a vertical deflection coil, one of said deflection coils having a plurality of wire turns wound about said core, each of said wire turns comprised of segments circumscribing said inner and outer surfaces and having a segment extending through said cavity said one deflection coil having corresponding segments of turns of wire which are wound successively in the general direction of coil windings advancement separated by a first azimuthal angle θ_1 at said first aperture and separated by a corresponding second azimuthal angle θ_2 at said second aperture, said diameters D_1 and D_2 and said first and second azimuthal angles having the relation

$$D_1 > D_2$$

$$\theta_2 > \theta_1$$

where D_1 and D_2 are measured in inches and θ_1 and θ_2 are measured in degrees.

24. The apparatus of claim 23 wherein said one deflection coil having a plurality of wire turns consists of said vertical deflection coil.

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