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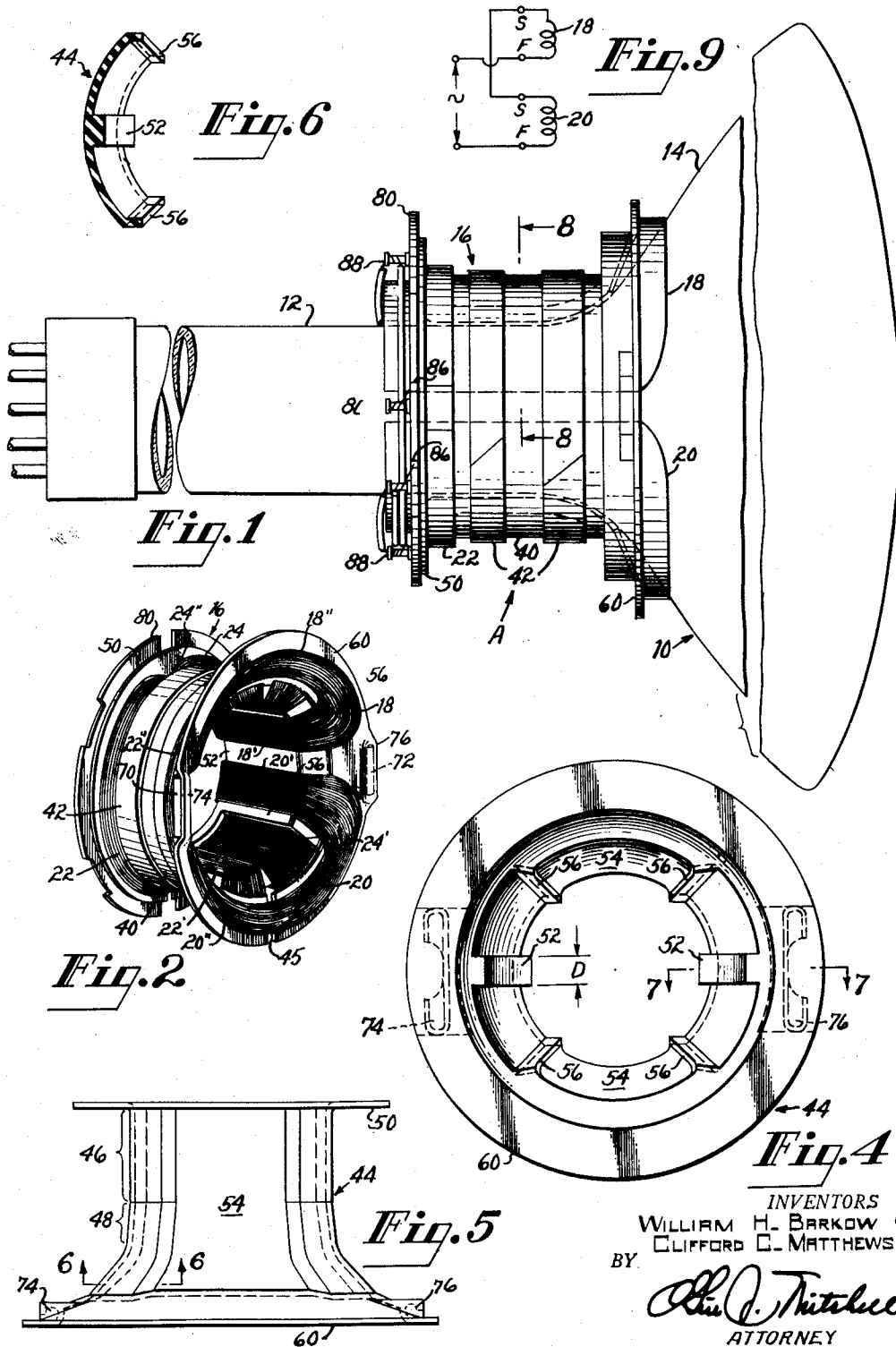
W. H. BARKOW ET AL

2,901,650

ELECTROMAGNETIC DEFLECTION YOKE

Filed Jan. 27, 1956

2 Sheets-Sheet 1



INVENTORS
 WILLIAM H. BARKOW &
 CLIFFORD C. MATTHEWS
 BY
Chas. Q. Mitchell
 ATTORNEY

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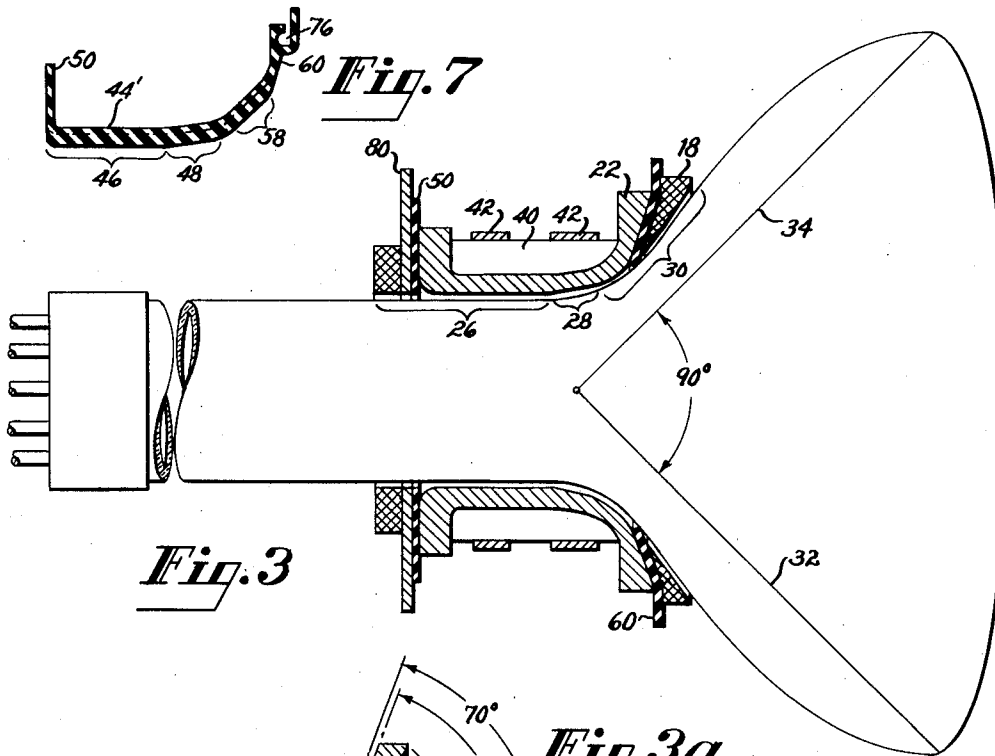
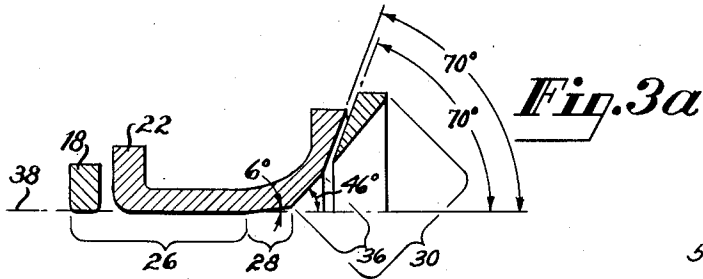
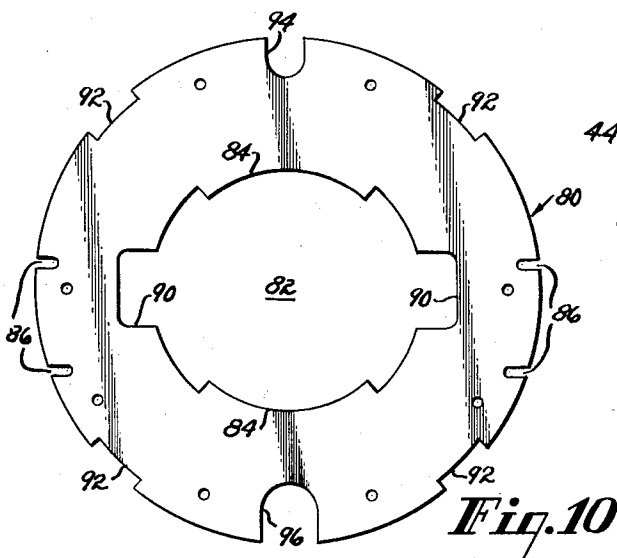
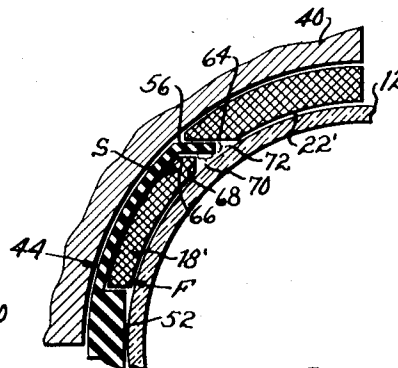
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ELECTROMAGNETIC DEFLECTION YOKE

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INVENTORS
WILLIAM H. BARKOW &
CLIFFORD C. MATTHEWS
BY
Clifford C. Matthews
ATTORNEY

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ELECTROMAGNETIC DEFLECTION YOKE

William Henry Barkow, Pennsauken, and Clifford Charles Matthews, Merchantville, N.J., assignors to Radio Corporation of America, a corporation of Delaware

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19 Claims. (Cl. 313-76)

The present invention relates to new and improved electromagnetic deflection apparatus for cathode ray tubes and, particularly, to a novel deflection yoke capable of producing wide angle deflection in a kinescope of the type employed in television receivers.

It has been found that problems which were of little, if any, moment in arrangements involving narrow deflection angles constitute important obstacles when an electron beam is to be deflected through a wide angle. For example, one problem is that of yoke sensitivity, in that it is necessary to attain a deflection field of sufficient strength to afford the requisite amplitude of deflection. At the same time, it is necessary to maintain control of the characteristics of the deflection field in such manner as to insure satisfactory shape of the pattern or raster scanned by the beam or beams in the tube and to insure against undue degradation of the focus of the scanning beam. In the case of commercial television receivers, the matter of unit cost is of importance, so that a deflection yoke must, in order for it to be commercially feasible, be of relatively simple construction and low cost, in addition meeting the operational requirements mentioned above.

It is, therefore, a primary object of the present invention to provide a new and improved electromagnetic deflection yoke capable of producing wide angle deflection, which yoke is of relatively simple construction and susceptible of production by mass production methods and at low cost.

One form of deflection yoke commonly used in conjunction with television receiver kinescopes is that comprising two pairs of coils shaped in general conformity with the cylindrical neck portion of the kinescope, the coils of one pair surrounding the coils of the other pair and being disposed substantially at right angles to the coils of the first pair, so that the deflection fields produced respectively by the two pairs are substantially normal. Such deflection yokes, in general, take one of two specific forms, namely, that in which the coils of one pair overlap, at least in part, the coils of the other pair and, secondly, the "interlocked" form in which the longitudinal conductors of one pair fit substantially within the "window" openings of the coils of the other pair, without overlap. For reasons to be explained at greater detail hereinafter, it has been found that coils of the interlocked variety are less expensive to produce than those of the overlapped type and it is to this latter yoke form which the present invention relates.

Insofar as the questions of deflection sensitivity and uniformity are concerned, it has been found that wide angle deflection may effected by extending the active or longitudinal conductors of the coils forwardly along the longitudinal axis of the tube (i.e., toward the screen or target), so that a portion of the coils surrounds a portion of the flared, bulbous part of the tube. Such an arrangement is disclosed in the copending application of J. K. Kratz et al., Serial No. 343,068, filed March 18, 1953, now Patent No. 2,821,671, in accordance with one aspect

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of which a deflection yoke is definable in two portions, one of which is relatively straight and extends substantially parallel to the longitudinal axis of the deflection yoke and the other of which is flared, deviating from the central axis of the yoke at the forward end of the yoke. The configuration of the flared section is such as to extend, effectively, the active conductors of the coils and, at the same time, to remove the end turns from the beam deflection region with the result that the ratio of the desired field flux to the undesired flux produced by the end turns is considerably increased, thereby both increasing the deflection sensitivity and the angle through which the electron beam may be deflected effectively to scan a substantially rectangular raster.

Heretofore, it has not been practicable to employ the relatively inexpensive interlocked coil form of deflection yoke for wide angle deflection of the order afforded by yokes of the types disclosed in the cited application.

It is, therefore, another object of the present invention to provide a novel deflection yoke having interlocking coils and capable of affording wide angle deflection.

In accordance with an illustrative embodiment of the present invention, there is provided an electromagnetic deflection yoke for use with the cathode ray tube of the type having a generally cylindrical neck and a flared, bulbous portion. The yoke comprises generally a first pair of deflection coils, each coil having longitudinal conductors and end conductors defining a window opening, the coils of the first pair being arranged to face each other and being shaped, for a portion of their length, in generally cylindrical form of such diameter as to accommodate the neck of the tube and, for a succeeding portion of their length, flared in general conformity with the flared part of the tube. The yoke further includes a second pair of deflection coils, each having longitudinal and end conductors defining a window opening, the coils of the second pair being arranged to face each other and being shaped for a portion of their length in generally cylindrical form and of the same diameter as the cylindrical portion of the first pair of coils and, for a succeeding portion of their length, the second pair of coils are flared in general conformity with the flared part of the tube. The coils of the second pair are, in accordance with the invention, arranged around the coils of the first pair in such manner that the bundles of longitudinal conductors of the one pair of coils fit entirely within the window openings defined by the other pair of coils, so that the two pairs of coils are interlocked. According to a further aspect of the invention, the end conductors of the outer coils are flared outwardly an amount greater than the first-mentioned flare so that the end conductors of the first pair of coils may be accommodated in the interlocked arrangement.

The yoke of the present invention, while of simple construction and low cost, is effective to produce deflection of an electron beam or beams through wide angles of the order of 90°, which deflection is accomplished without any appreciable distortion of the scanning raster pattern or defocusing of the electron beam.

The yoke of the present invention further includes novel insulating means for electrically insulating the coils of the first pair (e.g., the horizontal deflection coils) from each other and from the coils of the second pair. By virtue of the novel construction of the insulating means, maximum efficiency of the volumetric space accorded the yoke is realized. Further, the structure of the insulating means facilitates assembly of the several elements of the core.

According to still another feature of the invention, the yoke includes a novel terminal board upon which the various leads and other deflection circuit components may be mounted for ease of electrical connection. The terminal board is, according to a feature of the inven-

tion, shaped to aid in the interlocking structure of the coils and is thus effectively keyed into the composite coil structure.

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 a wide elevational view of a deflection yoke in accordance with the invention, illustrating the yoke in position on a cathode ray tube kinescope which is shown in fragmentary form;

Figure 2 is a perspective view of the yoke of Figure 1;

Figure 3 is a vertical sectional view taken in the direction of arrow "A" in Figure 1;

Figure 3a is a diagrammatic illustration of certain angular relationships of the coils to be described;

Figures 4-7 are various views, to be described, of novel yoke insulating means according to the invention;

Figure 8 is a fragmentary sectional view taken along line 8-8 of Figure 1;

Figure 9 is a schematic diagram of the horizontal deflection coils; and

Figure 10 is an elevational view of a terminal board which forms a part of the composite yoke of the preceding figures.

Referring to the drawing and, particularly, to Figure 1 thereof, there is shown an electromagnetic yoke located in operative position on a cathode ray tube kinescope 10 which conventionally comprises a generally cylindrical neck portion 12 housing the usual electron gun structure (not shown). The neck 12 is joined to a flared or bulbous portion 14 of the tube, the end of which includes a target screen comprising a suitable electron-responsive material for emitting light in response to electron impingement. Such a tube is well known and need not be described in further detail. The deflection yoke, represented in its entirety by reference numeral 16, comprises a pair of horizontal deflection coils 18 and 20 and a pair of vertical deflection coils 22 and 24, only one of which is visible in the view of Figure 1. As will be noted from Figure 1, the front end of the yoke extends beyond the cylindrical neck 12 of the tube 10 and over a part of the flared portion 14 thereof.

The several coils making up the deflection yoke 16 are better seen in the perspective view of Figure 2 which illustrates the fact that the horizontal deflection coils 18 and 20 are made up of longitudinal conductors 18' and 20', respectively, and end conductors 18'' and 20'', respectively, such that the longitudinal and end conductors 18' and 18'' of the coil 18 define a generally rectangular window opening. Similarly, it will be appreciated that the longitudinal and end conductors of the coil 20 define a window opening of the same shape. The vertical deflection coils 22 and 24 will be understood as being formed, respectively, of longitudinal conductors 22' and 24' and end conductors 22'' and 24'', respectively. That is to say, the longitudinal conductors 22' and end conductors 22'' of the vertical deflection coil 22 define a window opening therebetween in the same manner as described in connection with the horizontal deflection coils. The same structure is true of the vertical deflection coil 24 which is substantially identical to the coil 22.

The cathode ray tube depicted in the drawing for illustrative purposes is of the type whose flared, bulbous portion is generally frusto-conical in shape, being joined to the cylindrical neck with a gradual curvature in the region of the joint. In accordance with the present invention, as stated briefly supra, the deflection yoke 16 is so constructed that it may be located, in part, forwardly of the neck of the tube in order that the longitudinal active conductors of the coils may be effective in the deflection of the electron beam through a wide angle, as will be explained more fully hereinafter. Specifically, and as may be seen from Figures 2, 3 and 3a, the longi-

tudinal conductors of the horizontal deflection coils 18 and 20 are substantially straight for a portion of their length so that they conform to the cylindrical neck portion of the tube. In a similar manner, the vertical deflection coils 22 and 24 are formed for a portion of their length into a cylindrical form of the same inner diameter as that of the horizontal deflection coils. The region within which the horizontal and vertical deflection coils are thus of circular cross section is represented by the bracket 26 in Figures 3 and 3a. Since, as stated, the neck of the tube flares outwardly at a slight angle in the region in which it is joined to the bulb portion 14, a corresponding portion of the length of the coils is similarly flared, as represented by the bracketed region 28. The remainder of the horizontal deflection coils forwardly of the region 28 (i.e., that part within the bracket 30) is flared outwardly frusto-conically to conform to the flare of the tube portion 14.

At this point, and in the interest of a more complete understanding of the operational characteristics of the yoke of the present invention, it should be noted that the longitudinal conductors of each coil are formed into a bundle such that the circumferential length of the bundle is relatively short and such that the radial thickness of each such bundle is generally constant, with certain exceptions to be noted hereinafter. As is known in the art, coils whose conductor bundles are thus "lumped," as opposed to the coils of the type whose active conductors are distributed over a greater arc, ordinarily produce a more distorted deflection field. In deflection yokes employed for relatively narrow deflection angles, this characteristic of lumped coils is of no great moment and becomes important only in the case of wide angle deflection, since the beam must then scan into the region physically closer to the conductors themselves, which region contains the more distorted field patterns. The usual result of lumped coils may be described with greater particularity as that of producing a pin-cushioned field, which, in turn, causes defocusing of the electron beam within the field. Flaring of the active conductors of the coils outwardly to conform to the tube envelope and, therefore, the angle through which the beam is deflected has the effect of moving the distorted or non-uniform field away from the extreme angular positions of the beam, so that the beam remains within the generally uniform field produced nearer the center of the yoke. These relationships may be better understood from the showing of Figure 3 wherein the lines 32 and 34 represent the extreme limits of deflection in the plane of the drawing, which limits define an angle of the order of 90°, as indicated.

As thus far described, it will be understood that the horizontal deflection coils 18 and 20 of the yoke fit snugly around the tube 10 in the regions indicated. Since the longitudinal conductors of the vertical deflection coils 22 and 24 are, for a portion of their length, formed into a cylindrical array of the same inner diameter as the horizontal coils and fit within the window openings of the latter coils, it will be understood that, for that portion, the vertical deflection coils are also in close proximity to the tube neck, thereby affording increased vertical deflection sensitivity over that available in an arrangement in which the vertical coils are outside the horizontal coils and overlap the horizontal coils. In accordance with the present invention, the longitudinal conductors of the vertical deflection coils are, in the region 28, flared outwardly through a slight angle and, in the region 36, flared outwardly through a greater angle equal to the angle of flare of the horizontal coils (which angle is, in turn, in general conformity with the frusto-conical flare of the bulb portion of the tube). The front end turns 22'' and 24'' of the vertical deflection coils are flared outwardly at an even greater angle from the axis of the yoke in order to accommodate the flare of

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the outer surface of the flared portion of the end turns of the horizontal deflection coils.

These angular relationships are best seen from the diagrammatic showing of Figure 3a which, for illustrative purposes, indicates the shapes of the horizontal and vertical deflection coils in the regions 26, 28, 30 and 36. That is, the horizontal and vertical coils are cylindrical in the region 26, as stated, so that they are parallel to a line 38 drawn parallel to the longitudinal axis of the yoke. It will be noted that the rear end turns of the two sets of coils are turned outwardly into planes which are substantially normal to the axis of the yoke in a conventional manner for the purpose of removing the undesired fringe flux produced by the rear end conductors from the tube neck. In the region 28, the longitudinal conductors of both the vertical and horizontal coils are flared slightly at an angle of 6° with respect to the reference line 38. In the region 30, the horizontal deflection coils are flared outwardly at an angle of 46° with respect to the reference line 38 in order that they may fit snugly against the bulb of the tube with which they are associated. The remaining portion of the longitudinal conductors of the vertical deflection coils is in the region 36 and is also flared at the angle 46° with respect to the reference line, so that the entire length of the longitudinal conductors of the vertical coils is in conformity with the tube. The remaining portion of the vertical coils constitutes their front end turns and is flared outwardly by an angle at least equal to the angle of flare of the outer surface of the horizontal deflection coils, which angle is indicated as 70° in Figure 3a.

It will, from the foregoing, be recognized that, despite the intricate shapes imparted to the horizontal and vertical deflection coils in order that wide angles of deflection in both horizontal and vertical planes may be realized, the coils of one pair are interlocked with the coils of the other so that the advantages of interlocked coils may be had. Such advantages include higher deflection sensitivity of the coils, for the same outer diameter of the coils and the same volume of wire, than is possible with overlapping coils, the reason for this advantageous aspect being that the conductors of neither of the sets of coils are spaced from the tube. Another advantage of the interlocked coils of the present invention is that there is less inter-coil capacity than exists in the case of overlapping coils, by reason of the fact that only a very small area of either set of coils faces the other set of coils. This reduced inter-coil capacity permits a shorter retrace time in the deflection scanning cycle, since the retrace time is determined, at least in part, by the natural resonant frequency of the inductance and capacitance of the coils. Moreover, and as has been explained, the described yoke is substantially free of the usual disadvantages heretofore attributed to interlocking coils.

At this point, certain additional advantages of the yoke described and illustrated thus far may be noted. By virtue of the fact that, as stated, the bundles of longitudinal conductors are "lumped" circumferentially of the tube as well as radially thereof, the fabrication of the coils is relatively simple and, therefore, less expensive than certain other forms of coils. Each of the bundles of conductors of the present coils subtend an arc of the order of 45°. As contrasted with coils whose conductors are distributed over a greater circumferential portion of the tube such that the conductors are subject to looseness with resultant short circuiting of one wire to another when the coils are rammed into their final shape, the lumped coils of the present yoke are sufficiently thick radially of the tube at all points that the likelihood of loose turns is substantially precluded. Moreover, by virtue of the relatively small arcuate dimensions of the conductor bundles of the interlocked coils, more uni-

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form packing of the conductors is possible than in the case of other forms of coils.

In order to increase the sensitivity of the deflection yoke by affording a relatively low reluctance return path for the flux produced by the longitudinal conductors of the coils 18, 20, 22 and 24, there is provided a magnetic core 40 shown in Figures 1, 2 and 3. The core 40 may be formed of a plurality of sections of a cylinder, four in number, for example, of such dimension as to fit snugly around the longitudinal conductors of the coils between the end turns of the vertical coils. While the outer surface of the assembled core sections may be cylindrical, the inner surface thereof is shaped in conformity with the outer surface of the yoke coils, that is, cylindrical for a portion of its length and flared outwardly in generally frusto-conical form for the remainder of its length. The core sections may be formed of any suitable magnetic material having high flux permeability, such as powdered ferrite, iron or the like. The several sections comprising the magnetic core may be simply held in place around the coils as by means of one or more strips of tape 42, of the pressure sensitive adhesive type, wrapped around the core sections.

As has been mentioned briefly and as will be understood, it is necessary, by reason of high voltages involved, to provide means for electrically insulating the horizontal deflection coils from each other and from the vertical deflection coils, the latter coils being normally at or near ground potential, while the pulse voltage across the horizontal coils may be of the order of 4000 volts. The yoke of the present invention includes novel means for performing the electrical insulating function, which insulating means further provides advantages in the assembly of the several elements of the yoke by insuring proper positioning of the elements. The insulating element is shown by itself in Figures 4-7, Figure 4 being a front elevational view and Figure 5 being a plan view thereof. The insulator, indicated in its entirety by reference numeral 44, may be generally described as a tubular member having a generally radial flange at each end. The insulator may be formed as one part or a plurality of parts which, together, form the tubular shape. If a unitary structure, the sleeve may be slit longitudinally as at 45. The tubular portion of the insulating member is generally cylindrical for a portion of its length as indicated by the bracketed region 46 (Figures 5 and 7). For the remainder of its length, the tubular part of the insulating member conforms to the various flares described in connection with Figure 3a for the coils and in a manner which will be described more fully hereinafter.

The radial flange 50 at the rear end of the insulating member 44 is adapted to be located between the outwardly turned end conductors of the horizontal and vertical deflection coils, as indicated in Figures 1 and 2. The tubular portion of the insulator 44 is further provided on its inner surface with a pair of diametrically opposed, radially extending ribs 52, the radial dimension of which is substantially equal to the radial thickness of the longitudinal conductors 18' and 20' of the horizontal deflection coils 18 and 20 so that, as may be seen in Figure 8, the longitudinal conductors are received in a pocket or recess defined by the ribs 52 and the body proper of the insulator. At this point, it may be noted that the radial thickness of the insulator body is substantially equal to the difference between the radial thicknesses of the longitudinal conductors of the vertical deflection coils and the horizontal deflection coils. The tubular portion of the insulator is further provided, at diametrically opposed locations and at right angles to the ribs 52, with window openings 54, the arcuate dimension of which is generally equal to the arcuate dimension of the two adjacent bundles of longitudinal conductors 22' and 24' of the vertical deflection coils. Stated otherwise, the window openings 54 in the insulating member 44 are of generally the same size as the window

openings defined by the longitudinal and end conductors of the horizontal deflection coils. Each of the window openings 54 is bordered along its longitudinal edges by a flange 56, which flanges run throughout the length of the window openings. These flanges 56 extend inwardly of the body of the insulator 44 to separate and insulate adjacent portions of the horizontal and vertical deflection coil conductors from each other, as best shown in Figure 8.

Before describing the details of the flanges 56, note will be made of the specific shapes of the portions of the tubular part of the insulator 44. The inner surface of each of the ribs 52 is shaped to conform to the inner surfaces of the horizontal deflection coils as described in connection with Figure 3a. That is, the section 46 is, as stated, cylindrical; the section 48 is flared outwardly a small amount, namely 6°; and the section 58 is flared still more and in the amount of 46°. It will thus be understood that the ribs 52 also conform on their inner surfaces to the contours of the tube 10 with which the yoke is associated. The contours of the inner surface of the main body portion of the insulator 44 conform substantially to the outer surface contours of the horizontal deflection coils. Finally, the outer surface of the body portion of the insulator 44 is contoured in conformity with its inner surface, as may be seen from the sectional view of Figure 7 wherein the inner surface of the body portion of the insulator is shown by the dotted line 44'. The flange at the front end of the insulator is represented in its entirety by the reference numeral 60 and serves to separate and, therefore, insulate the end conductors of the vertical deflection coils from the adjacent conductors of the horizontal deflection coils, as shown in Figures 1, 2 and 3. This part of the insulator is flared outwardly in an amount equal to the flare of the inner surface of the end turns of the vertical deflection coils, indicated by way of example as 70° in Figure 3a. In the interest of completeness of description, it may be noted that the insulator member 44 may be formed of any suitable insulating material such as a neoprene base rubber, an example of which is a composition manufactured by the Inland Manufacturing Co. and designated compound 4748-22.

Referring again to the flanges 56 which serve to insulate the longitudinal conductors of the horizontal coils from the adjacent conductors of the vertical coils, it will be seen from Figures 6 and 8 that the flanges 56 are parallel to the horizontal center line 62 at all locations along their length. Similarly, the adjacent surface 64 of the vertical deflection coils is parallel to the center line 62 as is the surface 66 of the horizontal deflection coils. The longitudinal conductor bundles of the horizontal deflection coils are shaped, in cross section, as shown in Figure 8 with a vertical surface 68 perpendicular to the surface 66. The flange 56 extends inwardly between the horizontal and vertical coil conductors by such an amount as to extend beyond the surface 66 of the horizontal coil by a distance 70. The thickness of the flange 56 is represented by the distance 72, the sum of the distances 70 and 72 constituting the insulation leakage path between the conductors of the horizontal and vertical coils in the region of the flange. This insulation leakage path is longer than the shortest straight line distance between the conductors of the two coils measured in the plane of the drawing of Figure 8 in order that the insulation path be greater than the straight line air gap distance. The fact that each of the surfaces 64 and 66 and the flanges 56 is parallel to the horizontal center line 62 further facilitates assembly of the parts of the yoke, as will be described additionally infra.

The dimension "D" (Figure 4) of each of the ribs 52 is also of importance in the construction and operation of the yoke of the present invention. That is to say, the thickness "D" constitutes a separation between the longitudinal conductors of one of the horizontal coils from

the longitudinal conductors of the other of the horizontal coils. Since the coil conductors are lumped, a certain amount of separation is necessary since, if the coils were not thus spaced, the deflection field would be unduly pin-cushioned. While a certain degree of pin-cushioning of the deflection field is, as is known by those skilled in the art, ordinarily required for raster rectangularity, a pin-cushioned magnetic field produces spot distortion. Thus, the dimension "D," approximately 1/4" in the illustrative yoke of the present invention, serves to reduce the amount of pin-cushioning of the deflection field in order to prevent undue distortion of the beam shape or focus. Secondly, the ribs 52 serve to insulate the longitudinal conductors of the coil 18 from those of the coil 20. The coils 18 and 20 are, according to the invention, connected in series with each other in the manner disclosed in the copending U.S. application of Vonderschmitt et al., Serial No. 519,542, filed July 1, 1955, now abandoned, that is, with the "start" turns connected to each other and with the "finish" turns connected across the source of deflection voltage. This connection is shown schematically in Figure 9. For reasons of clarity, it is to be noted that, conventionally, deflection coils of the type in question are so wound that the start turn of a coil is at the internal portion of the rectangle formed by the coil when it is developed into a plane, while the finish turn of the coil is at the exterior part of such rectangle. It will thus be understood that the start turns are in the region indicated by the letter "S" in Figure 8 and that the finish turns are in the region indicated by reference character "F." Assuming, therefore, that the pulse voltage appearing across the horizontal coils is of the order of 4000 volts peak-to-peak, the entire voltage appears, in view of the starts-connection of the coils, across the rib 52. The thickness of the rib required for proper spacing of the longitudinal conductors of the horizontal coils for reasons of field distortion mentioned above is also sufficient to withstand the voltage across the horizontal coils. Only half of the horizontal deflection voltage appears at the start turns of its coils, so that the insulation leakage path furnished by the flange 56 constitutes sufficient insulation between the start turns of the horizontal coils and the conductors of the vertical deflection coils, which may be considered as being at ground potential.

According to another feature of the invention, means in the form of small permanent magnets associated with the deflection yoke are provided for aiding in the control of the shape of the raster pattern scanned by the beam or beams which are subjected to the deflection field of the yoke. Two such magnets 70 and 72 are provided, one on each side of the deflection yoke. The magnets 70 and 72 are, respectively, supported in pockets 74 and 76 molded on the rear surface of the flange 60 of the insulator 44. The magnets are bar magnets of any suitable type and may, for example, take the form of 1" long barium ferrite magnets having a circular or square cross section. In one embodiment, the magnets employed were 1/8" in diameter. The magnet 70 is located with its north pole extending upwardly, so that its flux aids the horizontal deflection windings 18 and 20 in deflecting the beam to the left as viewed in Figure 2. Conversely, the magnet 72 is oriented with its north pole extending downwardly, so that its flux aids the deflection coils 18 and 20 in deflecting the electron beam to the right as viewed in Figure 2. By virtue of the concentrated field produced by each of the permanent magnets, the deflection field which is a composite of the permanent magnet flux and the flux produced by the electromagnetic coils is rendered more pin-cushioned than the field produced by the coils alone. The strength of the magnets 70 and 72 determines the amount of the additional pin-cushioning of the field and should be selected to afford maximum rectangularity of the raster pattern scanned by the beam on the screen of the tube. Since the magnets 70 and 72 are supported directly in front of

the electromagnetic deflection coils by the insulator 44, the strength of the magnets need not be great, as will be understood from the fact that the magnets are thus rather close to the center of deflection of the beam.

In addition to their raster shape correcting function, the magnets also serve to increase the amplitude of horizontal deflection imparted to the electron beam in the tube, since, as stated, the flux of the magnets is in aiding relationship to the flux from the horizontal deflection coils. It will be recognized that the length of the permanent magnets determines the type of correction (i.e., the shorter the magnet, the more concentrated will be its field and, therefore, the more pin-cushioning introduced into the composite deflection field), while the cross section and the material of which the magnets are formed determine the amount of correction introduced by the magnets.

According to another feature of the invention, the yoke includes a novel terminal board 80, shown in Figures 1, 2, 3 and 10. Conventionally, deflection yokes are provided with a terminal board to which the start and finish leads of the two pairs of deflection coils are secured for electrical connection to each other and to the energizing circuits of the deflection system, including various yoke damping elements such as resistors and capacitors. The terminal board comprises a disk-like member of suitable rigid insulating material such as a phenolic resin and includes a central aperture 82 of sufficient diameter to accommodate the neck 12 of the cathode ray tube 10. Diametrically opposed portions 84 extend radially inwardly toward the center of the disk 80 and are of such arcuate size as to be received by the window openings of the horizontal deflection coils. The terminal board 80 is located between the upturned rear end turns of the horizontal and vertical coil pairs, as shown in Figures 1 and 3, with its radial extensions 84 passing into the windows of the horizontal deflection coils 18 and 20. Thus, the terminal board 80 is prevented from rotation with respect to the coils and is fixed against axial movement by the close fit between the upturned rear end turns of the horizontal deflection coils and the rear flange 50 of the insulating member. By reason of the self-locking action of the coils, insulator 44 and terminal board 80, the cementing of coils, terminal board and core members to each other which is normally resorted to in conventional yokes is obviated by the present structure. This feature permits the use of the tapes 42 for securing the sections of the core 40 about the coils. By virtue of the slight elasticity of such tapes and the fact that the core sections need not be cemented to the coils as in prior arrangements, the yoke may be expanded slightly to permit the yoke to be slipped over the socket end of the cathode ray tube.

Further in connection with the terminal board 80, it will be noted from Figure 10 that the outer edge of the board is slotted as at 86 to act as guides for the start and finish leads of the deflection coils which may then be soldered to the pin-type terminal posts 88. The soldering of the coil leads to the terminal 88 may be performed simply through dip-soldering techniques.

The terminal board 80 is also provided with two diametrically opposed slots 90 at right angles to the radial extensions 84. The slots 90 are of such dimensions as to permit passage therethrough of the upturned rear end turns of the horizontal deflection coils for ease of assembly of the yoke.

In the interest of completeness of description, it will be noted that the outer edge of the terminal board 80 is provided with a plurality of shallow notches 92 and a pair of deeper notches 94 and 96. The latter notches are provided to permit passage of leads around the terminal board, while the notches 92 are or may be employed in supporting the assembled yoke in a cap having axially extending fingers which are received by the notches 92. That is to say, the terminal board constitutes a rigid part

of the assembled yoke, capable of neither rotational nor axial movement. Thus, the yoke may be supported by means of a suitable cap which engages the notches 92 of the terminal board and which is itself, or through an intermediate member, mounted on the chassis upon which the tube is supported. Such simplified mounting of the yoke obviates the necessity for the usual mounting bracket normally secured to the yoke by a metal clamping ring around the core.

Since the terminal board is located between the flange 50 of the insulator member 44 and the rear end turns of the horizontal deflection coils, it affords additional insulation between the horizontal and vertical coils. Moreover, the presence of the terminal board in the stated location does not have the undesirable effect of reducing the sensitivity of the deflection yoke as would be the case if the board were in front of the rear end turns of the vertical deflection coils. The reason for this is that the sensitivity of the vertical deflection coils is closely related to the length of the magnetic core surrounding its conductors. Hence, the maximum sensitivity of the vertical coils is realized when the core extends, as in the instant case, throughout the length of the longitudinal conductors of the vertical coils. The slight reduction in the length of the core material presented to the horizontal deflection coils has only a negligible effect upon the sensitivity of the horizontal coils.

The manner in which the yoke of the present invention is assembled will now be described. First, the horizontal deflection coils 18 and 20 are inserted in the terminal board 80 by guiding the rear end turns of the coils through the slots 90, after which the coils may be turned to face each other. The extensions 84 of the terminal board are thus received by the window openings of the horizontal coils, fixing the coils in relation to each other. Second, the insulator 44 is placed around the horizontal deflection coils with the ribs 52 located between the longitudinal conductors of the two coils, so that the horizontal coils are then spaced from each other the required distance. The vertical deflection coils 22 and 24 then may be placed around the horizontal deflection coils and the insulator and are automatically guided into place by the horizontal flanges 56 of the insulator and the parallel surfaces 64 of the vertical coils. Thus, the vertical coils may be slid into place by movement along a single straight line path, whereupon they are maintained in their correct position by the flanges 56 of the insulator. The several sections of the core 40 may then be located around the assembled coils and insulator and secured by the tapes 42, thereby completing the assembly of the yoke, with the exception of the soldering of the coil leads to the terminals 88, as described.

From the foregoing, it will be recognized that the deflection of the yoke of the present invention constitutes a relatively simple and inexpensive arrangement in which adequate insulation is afforded with a minimum use of space for insulating material, thereby permitting maximum utilization of the space between the neck of the tube and the core so that maximum sensitivity is obtained.

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

1. In combination with a cathode ray tube having a generally cylindrical neck and a flared bulbous portion, an electromagnetic deflection yoke which comprises: a first pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening, said coils of said first pair being arranged to face each other and with their longitudinal conductors being shaped, for a portion of their length, in generally cylindrical form of such diameter as to accommodate said tube neck and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube; a second pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window

4. An electromagnet deflection yoke for use with a cathode ray tube having a generally cylindrical neck and a flared bulbous portion, said deflection yoke comprising a first pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening, said coils of said first pair being arranged to face each other and being shaped, for a portion of their length, in generally cylindrical form of such diameter as to accommodate such tube neck and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube; a second pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening therebetween, said coils of said second pair being arranged to face each other and being

6. An electromagnetic deflection yoke for use with a cathode ray tube having a generally cylindrical neck and a flared bulbous portion, said deflection yoke comprising: a first pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening, said coils of said first pair being arranged to face each other and being shaped, for a portion of their length, in generally cylindrical form of such diameter as to accommodate such tube neck and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube; a second pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening therebetween, said coils of said second pair being arranged to face each other and being shaped for a portion of their length in generally cylindrical form and of said diameter and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube, said second pair of coils being arranged around said first pair with the longitudinal conductors of one pair fitting entirely within the window openings of the other pair; and insulating means for insulating said coils of said first pair from each other and said coils of said first pair from said coils of said second pair, said insulating means comprising a generally semi-cylindrical sleeve member, a portion of whose length is flared in conformity with the flare of said second pair of

coils located around said first pair of coils and having openings in general registry with the window openings of the coils of said first pair, said sleeve member having a longitudinal, inwardly extending rib located for separating one coil of said first pair from the other coil of said first pair.

7. An electromagnetic deflection yoke for use with a cathode ray tube having a generally cylindrical neck and a flared bulbous portion, said deflection yoke comprising: a first pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening, said coils of said first pair being arranged to face each other and with their longitudinal conductors being shaped, for a portion of their length, in generally cylindrical form of such diameter as to accommodate such tube neck and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube; a second pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening therebetween, said coils of said second pair being arranged to face each other and being shaped for a portion of their length in generally cylindrical form and of said diameter and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube, said second pair of coils being arranged around said first pair with the longitudinal conductors of one pair fitting entirely within the window openings of the other pair, said longitudinal conductors of said first and second pairs of coils being arranged in bundles of generally constant radial thickness.

8. An electromagnetic deflection yoke for use with a cathode ray tube having a generally cylindrical neck and a flared bulbous portion, said deflection yoke comprising: a first pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening, said coils of said first pair being arranged to face each other and with their longitudinal conductors being shaped, for a portion of their length, in generally cylindrical form of such diameter as to accommodate such tube neck and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube; a second pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening therebetween, said coils of said second pair being arranged to face each other and being shaped for a portion of their length in generally cylindrical form and of said diameter and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube, said second pair of coils being arranged around said first pair with the longitudinal conductors of one pair fitting entirely within the window openings of the other pair, said longitudinal conductors of said first pair of coils being arranged in bundles of generally constant radial thickness, each such bundle being of such circumferential dimension as to subtend an arc of substantially less than 90°.

9. An electromagnetic deflection yoke for use with a cathode ray tube having a generally cylindrical neck and a flared bulbous portion, said deflection yoke comprising: a first pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening, said coils of said first pair being arranged to face each other and being shaped, for a portion of their length, in generally cylindrical form of such diameter as to accommodate such tube neck and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube; a second pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening therebetween, said coils of said second pair being arranged to face each other and being shaped for a portion of their length in

generally cylindrical form and of said diameter and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube, said second pair of coils being arranged around said first pair with the longitudinal conductors of one pair fitting entirely within the window openings of the other pair, said longitudinal conductors of each of the coils of said first and second pairs being arranged in bundles of generally constant radial thickness, the surfaces of the bundles of said first pair of coils which are adjacent to bundles of said second pair of coils being parallel to a plane passed through the longitudinal axis of said yoke between the cores of said first pair.

10. An electromagnetic deflection yoke for use with a cathode ray tube having a generally cylindrical neck and a flared bulbous portion, said deflection yoke comprising: a first pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening, said coils of said first pair being arranged to face each other and being shaped, for a portion of their length, in generally cylindrical form of such diameter as to accommodate such tube neck and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube; a second pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening therebetween, said coils of said second pair being arranged to face each other and being shaped for a portion of their length in generally cylindrical form and of said diameter and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube, said second pair of coils being arranged around said first pair with the longitudinal conductors of one pair fitting entirely within the window openings of the other pair, said longitudinal conductors of each of the coils of said first and second pairs being arranged in bundles of generally constant radial thickness, the surfaces of the bundles of said first pair of coils which are adjacent to bundles of said second pair of coils being parallel to the same plane.

11. An electromagnetic deflection yoke for use with a cathode ray tube having a generally cylindrical neck and a flared bulbous portion, said deflection yoke comprising: a first pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening, said coils of said first pair being arranged to face each other and being shaped, for a portion of their length, in generally cylindrical form of such diameter as to accommodate such tube neck and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube; a second pair of electromagnetic deflection coils, each such coil having longitudinal conductors and end conductors defining a window opening therebetween, said coils of said second pair being arranged to face each other and being shaped for a portion of their length in generally cylindrical form and of said diameter and, for a succeeding portion of their length, flared in general conformity with the flared portion of such tube, said second pair of coils being arranged around said first pair with the longitudinal conductors of one pair fitting entirely within the window openings of the other pair, and means connecting the start turns of said coils of said first pair to each other such that said coils are in series-aiding relationship.

12. An electromagnetic deflection yoke which comprises: a first pair of coils, each comprising a plurality of turns arranged in the form of longitudinal conductors and transverse end conductors defining a window opening, a second pair of coils of similar configuration arranged around the coils of said first pair, the longitudinal conductors of one coil pair being interlocked in the window openings of the other pair, the end conductors of both pairs being turned generally radially outwardly at the same end; a terminal board comprising a disk-like

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member of insulating material having a central aperture of sufficient size to accommodate the longitudinal conductors of said first pair of coils, said disk-like member being located between said end turns of said first pair of coils and the end turns of said second pair of coils.

13. An electromagnetic deflection yoke which comprises: a first pair of coils, each comprising a plurality of turns arranged in the form of longitudinal conductors and transverse end conductors defining a window opening, a second pair of coils of similar configuration arranged around the coils of said first pair, the end conductors of both pairs being turned generally radially outwardly at the same end; a terminal board comprising a disk-like member of insulating material having a central aperture of sufficient size to accommodate the longitudinal conductors of said first pair of coils, said disk-like member being located between said end turns of said first pair of coils and the end turns of said second pair of coils.

14. An electromagnetic deflection yoke which comprises a first pair of coils, each comprising a plurality of turns arranged in the form of longitudinal conductors and transverse end conductors defining a window opening, a second pair of coils of similar configuration arranged around the coils of said first pair, the end conductors of both pairs being turned generally radially outwardly at the same end; a terminal board comprising a disk-like member of insulating material having a central aperture of sufficient size to accommodate the longitudinal conductors of said first pair of coils, said disk-like member being located between said end turns of said first pair of coils and the end turns of said second pair of coils, said disk-like member having portions extending inwardly of said aperture, said inwardly extending portions extending into the window openings of said first pair of coils.

15. A deflection yoke for a cathode ray tube, said yoke comprising: first and second pairs of coils, each coil having longitudinal conductors and transverse end conductors defining a window opening therebetween, the coils of said first pair being formed into a tubular shape and the coils of said second pair being formed into a tubular shape and arranged around the coils of said first pair such that the longitudinal conductors of one pair fit substantially within the window openings of the other coil pair, said longitudinal conductors of the coils of said first and second pairs being arranged in bundles of generally constant radial thickness, the surfaces of the bundles of conductors of the coils of said first pair which are adjacent to bundles of said second pair of coils being parallel to the same plane.

16. Insulating means for an electromagnetic deflection yoke of the type made up of first and second pairs of coils, each of which has longitudinal and end conductors defining a window opening, the coils of one pair being arranged around the coils of the other pair and the longitudinal conductors of one pair being located substantially entirely within the window openings of the other coils, said insulating means comprising: means defining a tubular sleeve of insulating material, said sleeve having first and second radially inwardly extending ribs on diametrically opposed sides of its inner surface and

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diametrically opposed openings at locations substantially at right angles to the locations of said ribs, said window openings being of substantially the same size as the window openings of such coils.

17. Insulating means for an electromagnetic deflection yoke of the type made up of first and second pairs of coils, each of which has longitudinal and end conductors defining a window opening, the coils of one pair being arranged around the coils of the other pair and the longitudinal conductors of one pair being located substantially entirely within the window openings of the other coils, said insulating means comprising: means defining a tubular sleeve of insulating material, said sleeve having first and second radially inwardly extending ribs on diametrically opposed sides of its inner surface and diametrically opposed openings at locations substantially at right angles to the locations of said ribs, said window openings being of substantially the same size as the window openings of such coils, and an outwardly directed flange at each end of such tubular sleeve.

18. Insulating means for an electromagnetic deflection yoke of the type made up of first and second pairs of coils, each of which has longitudinal and end conductors defining a window opening, the coils of one pair being arranged around the coils of the other pair and the longitudinal conductors of one pair being located substantially entirely within the window openings of the other coils, said insulating means comprising: means defining a tubular sleeve of insulating material, said sleeve having first and second radially inwardly extending ribs on diametrically opposed sides of its inner surface and diametrically opposed openings at locations substantially at right angles to the locations of said ribs, said window openings being of substantially the same size as the window openings of such coils, said sleeve having flanges along the longitudinal edges of said window openings, which flanges are parallel to each other.

19. Insulating means for an electromagnetic deflection yoke of the type made up of first and second pairs of coils, each of which has longitudinal and end conductors defining a window opening, the coils of one pair being arranged around the coils of the other pair and the longitudinal conductors of one pair being located substantially entirely within the window openings of the other coils, said insulating means comprising: means defining a tubular sleeve of insulating material, said sleeve having first and second radially inwardly extending ribs on diametrically opposed sides of its inner surface and diametrically opposed openings at locations substantially at right angles to the locations of said ribs, said window openings being of substantially the same size as the window openings of such coils, and an outwardly directed flange at each end of such tubular sleeve, one of said flanges having a pocket formed therein adjacent to its outer edge for receiving a permanent magnet.

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