Jan. 13, 1942. L. MAUERER 2,269,678

METHOD OF MANUFACTURING COIL STRUCTURES

Filed June 2, 1939 3 Sheets-Sheet 1

Fig. 1

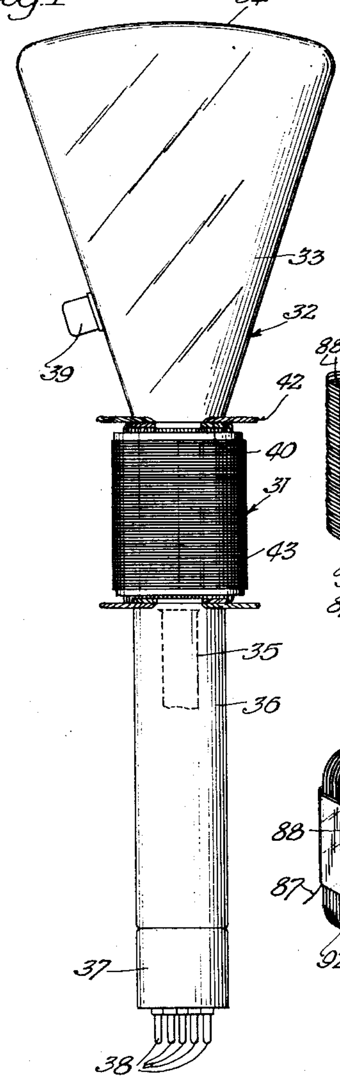

Fig. 2

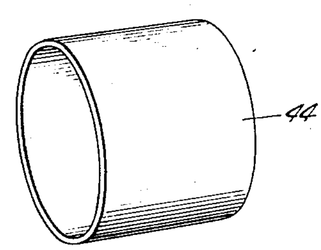

Fig. 3

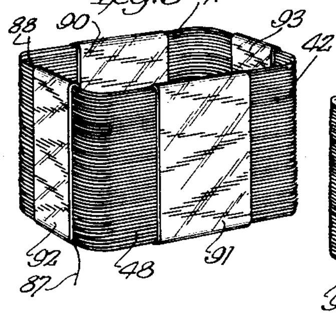

Fig. 4

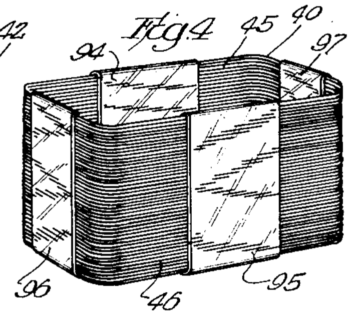

Fig. 5

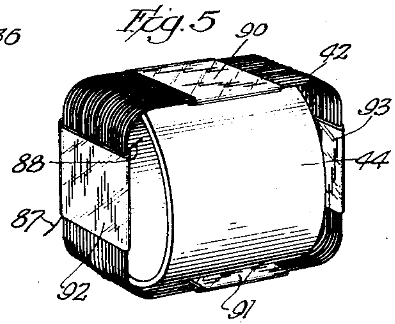

Fig. 7

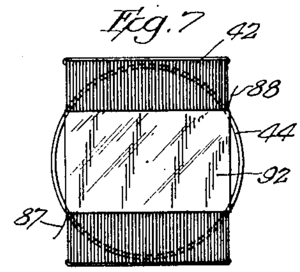

Fig. 8

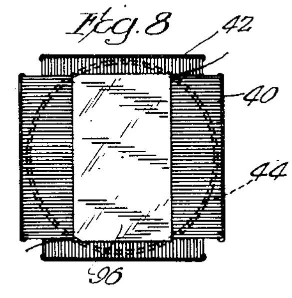

Fig. 6

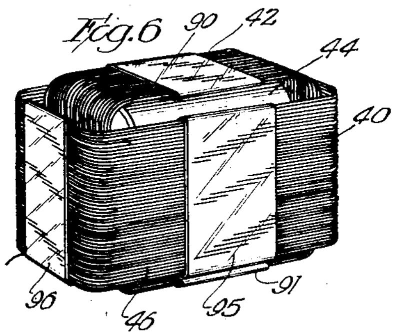

Fig. 9

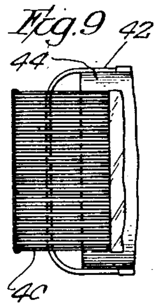

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Fig. 10

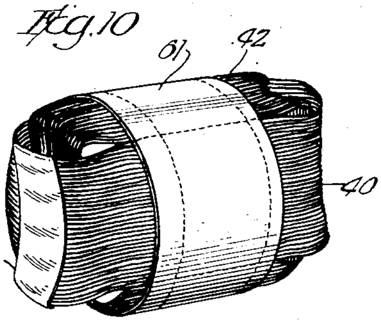


Fig. 11

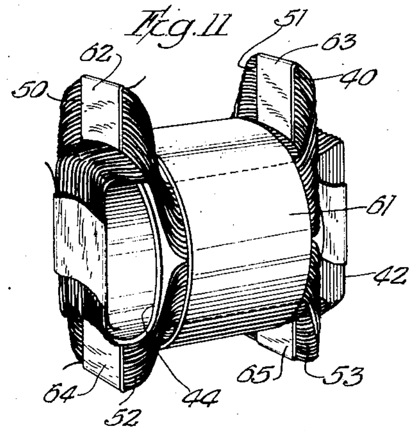


Fig. 12

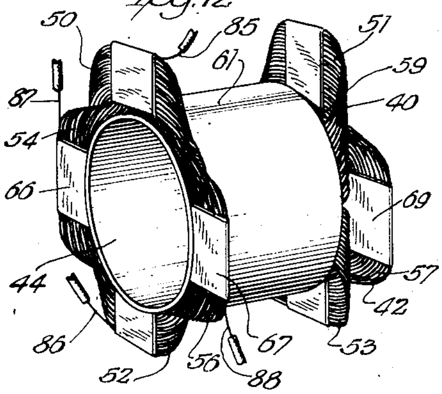


Fig. 13

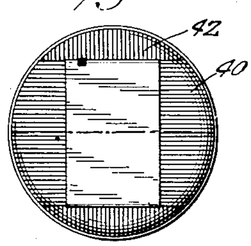


Fig. 14

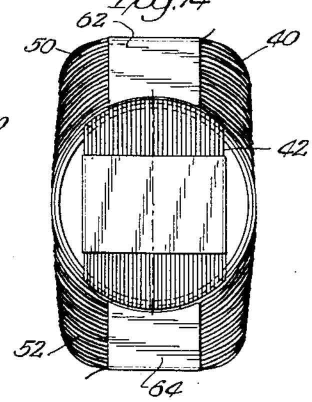


Fig. 16

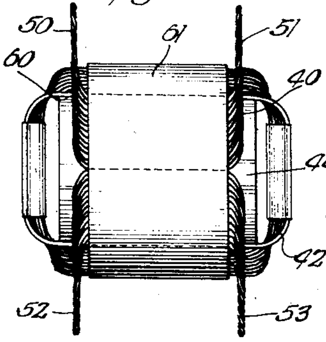


Fig. 17

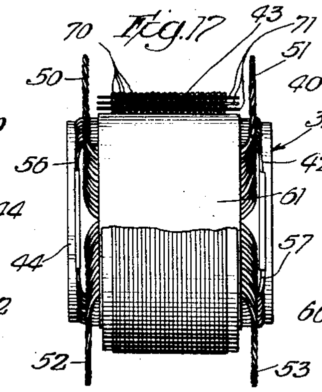


Fig. 15

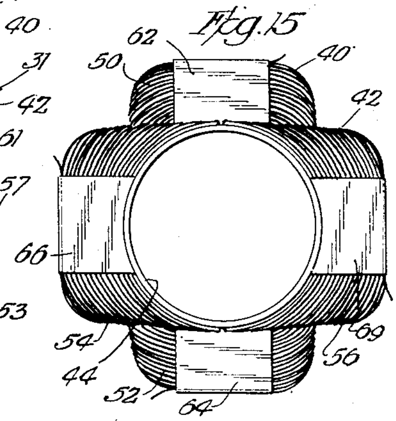
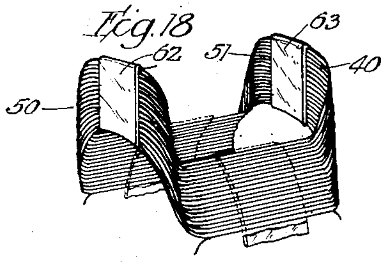


Fig. 18



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METHOD OF MANUFACTURING COIL STRUCTURES

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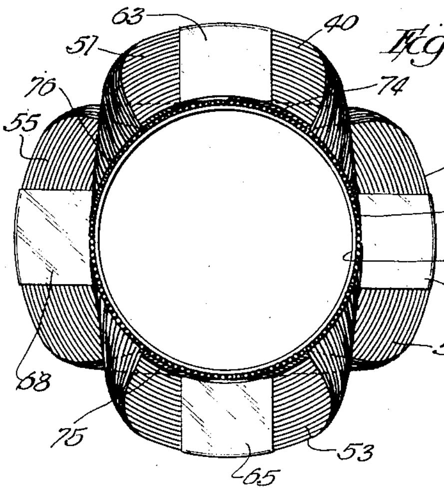


Fig. 19

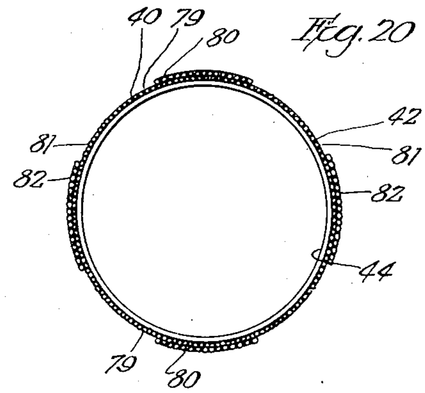


Fig. 20

Fig. 21

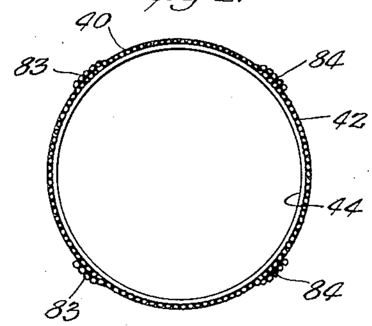
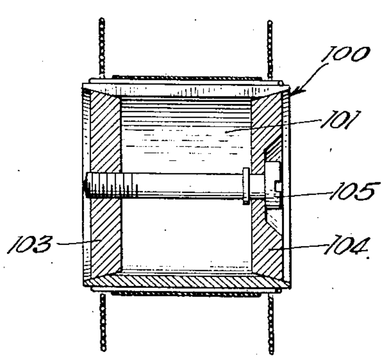


Fig. 22



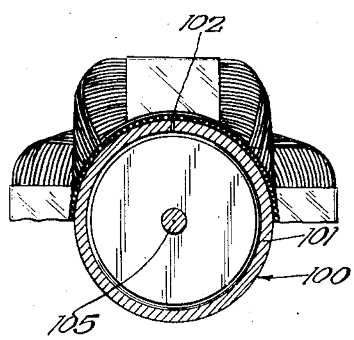
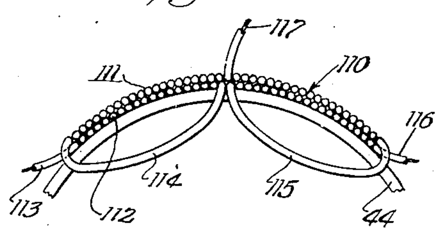


Fig. 23

Fig. 24



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Patented Jan. 13, 1942 **2,269,678**

UNITED STATES PATENT OFFICE

2,269,678

METHOD OF MANUFACTURING COIL STRUCTURES

Leopold Mauerer, Chicago, Ill., assignor to Jefferson Electric Company, Bellwood, Ill., a corporation of Illinois

Application June 2, 1939, Serial No. 277,044

10 Claims. (Cl. 29—155.5)

This invention relates to a method of manufacturing a coil structure, and more particularly it relates to the manufacturing of a coil assembly which is particularly well adapted to use as a scanning yoke utilized in television receiving apparatus in association with a cathode ray tube and in television cameras on the camera tube.

Although other uses may be or may become apparent for the coil assembly or method of manufacture disclosed herein, the illustrated adaptation thereof is particularly devoted to television apparatus.

Subject matter disclosed, but not claimed herein is claimed in my copending application Serial No. 399,315 filed June 23, 1941.

Another object of this invention is to provide a method of manufacturing a coil assembly, the coils of which have axially thin end sections so that the coil window lengths are long as compared to the available space for coils in the direction of the longitudinal axis thereof.

Another object of my invention is to provide a process of making a coil assembly including a plurality of coils, the magnetic axes of which are at right angles, and by which the coils are self-locating in their proper positions for such angular relations.

Another object of my invention is to provide a process of manufacturing a coil assembly comprehending prewound and subsequently assembled and deformed coils.

Another object of this invention is to provide a method of manufacturing a scanning yoke assembly for use with television apparatus including a cathode ray tube, which scanning yoke produces a magnetic field which is substantially uniform over the entire cross sectional area that is traversed by the beam in the tubes.

Another object of this invention is to provide a process of manufacturing a magnetic scanning yoke for television apparatus which enables the easy and consistent manufacture of such scanning yoke in production quantities.

Another object of my invention is to provide an improved method or process for the manufacture of coil assemblies which include a plurality of coils mounted with their magnetic axes in fixed and predetermined angular relation.

Another object of my invention is to provide an improved method or process for the manufacture of scanning yokes for television receiving apparatus.

Another object of my invention is to provide an improved method or process for the manufacture of coil assemblies which comprehends the use of pre-wound coils deformed in assembly; the size and deformation of the coils being such that the resulting assembly has desirable characteristics.

Other objects and advantages of this invention will be apparent from the following description and reference to the accompanying drawings wherein a preferred embodiment of my invention is clearly described and illustrated.

In the drawings:

Figure 1 is a side elevation showing an adaptation of a preferred embodiment of this invention to television apparatus;

Figures 2, 3 and 4 are perspective views of unassembled parts adapted to be assembled as and in accordance with a preferred embodiment of my invention;

Figure 5 is a perspective view indicating a step in the assembly of the parts shown in Figures 2 and 3;

Figure 6 is a perspective view indicating a step in the assembly of the parts shown in Figures 2, 3 and 4 and beyond the step shown in Figure 5;

Figures 7 and 8 are end views indicating the relation of the parts shown in Figures 5 and 6 respectively;

Figure 9 is a fragmentary side view indicating the relation of a portion of the assembled parts shown in Figure 6;

Figures 10, 11 and 12 are respective perspective views showing the steps of the assembly of, and in accordance with a preferred embodiment of my invention which succeed the steps indicated in Figures 5 and 6;

Figures 13, 14 and 15 are end views of the apparatus as it is shown in Figures 10, 11 and 12 respectively;

Figure 16 is a side elevation of the apparatus shown in Figure 11;

Figure 17 is a side elevation of an assembly embodying a preferred form of my invention and having a part thereof cut away to show details of construction;

Figure 18 is a perspective view of a part of the assembly shown in Figures 12, 15, 16 and 17;

Figure 19 is a sectional end view of a modified form of my invention;

Figures 20 and 21 are fragmentary sectional views indicating other modifications of my invention;

Figures 22 and 23 are sectional views indicating modified steps in the assembly of a device in accordance with my invention; and

Figure 24 is a fragmentary diagrammatic view illustrating modified winding connections for coils utilized in my invention.

In Figure 1 a scanning yoke **31** made in accordance with this invention is shown applied to a cathode ray tube **32**, in conjunction with which it is adapted to operate as a part of television receiving apparatus. The cathode ray tube **32** is one of the type commonly in use for the purpose specified having a glass envelope **33** and a fluorescent screen at one end, as at **34**. The tube **32** includes an electron gun, the end of which is indicated by dotted lines at **35**, and from which an electron beam is projected against the fluorescent screen at **34**. The wall **33** of the tube adjacent the fluorescent screen 34 flares outwardly to permit deflection of the electron beam over a greater fluorescent screen surface. A neck 36 of the envelope 33 encloses the electron gun 35 and extends a distance beyond the end of the gun. A base 37 is secured to the end of the neck 36 and has prongs 38 secured thereto to which the electrical connections are made to the internal elements of the tube. A terminal 39 is secured to the envelope for making electrical connection to a high voltage electrode or anode to the tube.

The scanning or deflecting yoke 31 preferably fits closely around the neck 36 of the envelope 33 and preferably extends from the end of the gun 35 to the portion of the envelope where the wall thereof commences to flare outwardly toward the end in which the fluorescent screen is located. This scanning or deflecting yoke 31 has two sets of deflecting coils 40 and 42. The deflecting coils 40 and 42 are so disposed with respect to each other that their magnetic axes are perpendicular. It is also preferable and particularly desirable that the longitudinal axes of the coils are parallel to the electron beam in its normal or undeflected position. The magnetic axes of the coils 40 and 42 extend across the neck 36 of the tube and are substantially perpendicular to the longitudinal axis of the tube as well as the normal or undeflected beam. In order to improve the magnetic efficiency of the scanning or deflecting yoke 31 it is particularly desirable that the high reluctance air path between the coils and the envelope is minimized. Also, a low reluctance magnetic flux path 43 closely surrounds the outer surfaces of the coils and extends circumferentially around the neck 36 of the tube. As will be more fully explained it is desirable that the window openings of the coils are as long as possible with respect to the space available for the scanning or deflecting coil assembly between the end of the electron gun 35 and the outwardly flaring portion of the envelope 33. This feature provides a greater effective length of the coils in the space available therefor. In addition to being desirable from the standpoint of magnetic efficiency that the distance between the coils 40 and 42 and the envelope 33 of the tube is minimized, it is also desirable that the air gap or leakage space between the low reluctance magnetic return path 43 and the envelope 33 is also minimized. This reduces the reluctance of the magnetic path over which there is possibility of control, since the magnetic path through the tube is fixed by the dimensions of the tube. The previously mentioned features of construction of the scanning or deflecting yoke 31, as well as the features of construction and assembly which provide a yoke consistent with the features, will be more fully understood in considering the detailed description of structure, method or process of manufacture and description which follows.

For more particular and detailed description of the structure of the scanning or deflecting yoke 31, more particular reference is made to Figures 2 to 18 inclusive. A form 44 of phenol fiber or other suitable insulating material provides a cylindrical support for the coils 40 and 42. The form 44 preferably has an internal diameter such that it fits snugly around the neck 36 of the cathode ray tube 32. Also, the wall of the form 44 is preferably thin so that the length of the flux path therethrough is minimized; although, of course, it must be sufficiently thick to provide a support having ample rigidity. In referring to the cylindrical characteristic of the form, it is understood that while a circular cylindrical form is preferable, the term "cylindrical" as used herein covers the more general aspect of the term and includes polygonal cylindrical forms.

The coils 40 and 42 are so disposed with respect to the form 44 that the sides 45 and 46 of the coil 40 and the sides 47 and 48 of the coil 42 are substantially parallel to the longitudinal axis of the form. This makes the longitudinal axes of the coils parallel to the longitudinal axis of the form and consequently makes the longitudinal axes of the coils parallel to the electron beam of the cathode ray tube when that beam is in its normal or undeflected position and the scanning or deflecting yoke 31 is properly mounted on the tube. The coil sides 45, 46, 47 and 48 are axially straight and sectionally conform to the outer surface of the form 44. The transverse disposition of the coils is such that their magnetic axes are perpendicular. Several advantages are gained by making the coils of such a width that the circumferential spread of the sides of one of the coils is substantially equal to the width of the window of the other of the coils. That is, by such design of the coils, each of the coil sides 45, 46, 47 and 48 of each of the coils circumferentially covers one fourth of the surface of the form 44. Some of the advantages which are attendant with this construction are:

(a) That the coils 40 and 42 when secured in position naturally and automatically space themselves in such positions that their magnetic axes are perpendicular;

(b) The windings are spread over the entire circumference of the form so that a maximum number of turns can be put into a minimum of radial space;

(c) The magnetic efficiency of the yoke is improved by minimizing the radial air space required by the coil sides;

(d) The distribution of the magnetic field is substantially uniform over the entire cross sectional area of the cathode ray tube which is traversed by the electron beam in that tube;

(e) Inconsistencies of manufacture of the yokes in quantity production are limited.

In the final assembled form of the yoke 31, the end turns of the coils 40 and 42 extend outwardly from and circumferentially around the ends of the form 44; half of the end turns of each coil extending around one side of the form 44; and the other half of the end turns of each coil extending around the opposite side of the form 44. As indicated in the drawings, half of the end turns of the coil 40, indicated at 50 and 51 extend around one side of the form 44 and the other half of the end turns of the coil 40, indicated at 52 and 53 extend around a portion of the form 44 diametrically opposite the end turns at 50 and 51. Likewise, the coil 42 has half of its end turns, as at 54, extending around one side of the form 44 and the other half of its end turns extending around and diametrically opposite side of the form 44 as at 56 and 57.

The end turns such as 50, 51, 52, 53, 54, 56 and 57 of the coils 40 and 42 are preferably so relatively disposed that they extend radially outwardly from the form 44 and have a section which is axially thin. The end turns of half of the turns of each of the coils extend around diametrically opposite halves of the form 44. The thin axial section of the end turns which is particularly desirable provides coil windows such as 59 and 60 which are axially long as compared to the over all axial length of the finished coils 40 and 42 and the over all length of the finished yoke. The ratio of axial window length to the yoke length should be high to provide windows which are as long as possible in the space available for the yoke. As indicated in Figure 1, the space available for the yoke is that between the end of the gun 35 and the part of the envelope which begins to flare outwardly. The magnetic fields of the coils are comparable in dimensions to the size of the window openings in the coils. Since more effective control of the electron beam of the cathode ray tube can be obtained with a given magnetic force by extending the length of the space over which the magnetic field acts upon the beam to deflect it, it is desirable from the standpoint of efficiency to increase the coil window lengths.

Although the coil assembly may be dipped in wax or some similar substance to help to hold the turns thereof in their assembled position, this procedure is not particularly necessary when the coils are assembled on a form such as 44. The coils 40 and 42 are held in position with respect to the form 44 by a wrapping of an adhesive tape such as 61 which may be a cellulose tape. Also to strengthen the end turns and better secure their positions, wrappings of an adhesive tape, such as cellulose tape, surround the end turns 50, 51, 52, 53, 54, 56 and 57, as at 62, 63, 64, 65, 66, 67 and 69 respectively.

As illustrated in Figure 17, the low reluctance magnetic flux path which surrounds the coils 40 and 42 preferably comprises a plurality of layers 70 of magnetic wire wrapped circumferentially around the coils and having the layers 70 separated by paper 71 or other suitable insulating material. The low reluctance path 43 provides a return path for the flux of the coils 40 and 42 that passes through the cathode ray tube 32 to effect deflection of the electron beam. Since the internal diameter of the form 44, and the consequent length of the air gap within the form 44, is determined by the diameter of the neck 36 of the cathode ray tube, the length of that portion of the flux path is determined. However, the magnetic efficiency of the yoke is improved by minimizing the space between the low reluctance path 43 and the inside of the form 44. By utilizing the entire outer surface of the form 44 for winding space and eliminating gaps between the windings a greater number of turns are wound in a given radial space to reduce the length of the air gap outside of the cathode ray tube and improve magnetic efficiency. It is important also, from the standpoint of minimizing the radial space required by coils 40 and 42, that the space factor of the windings themselves be kept high.

In the modified yoke construction shown in Figure 19, the coils 40 and 42 circumferentially cover the surface of the form 44, as in the previously described form. It is also common to the two forms of coils that the coil sides of one of the coils are of substantially the same width as, and fit into the window openings of the other coil. The difference in the structures is that the coil sides of the two coils are not of the same width in the form shown in Figure 19. That is, the coil sides 74 and 75 of the coil 42 are narrower than the coil sides 76 and 77 of the coil 40. This distribution of the coils on the surface of the form 44 gives a distribution of the windings and their magnetic fields which is comparable to the picture proportions that are commonly utilized in television apparatus, and the proportions of which are in the ratio of 3 to 4. In Figure 19 reference numerals similar to those previously used designate like parts; and in addition the numerals 55 and 68 designate respectively the end turns of the coil 42 and the tape surrounding those end turns, which did not appear in previously described figures.

In the modified structure disclosed in Figure 20 the coils 40 and 42 have a plurality of layers; the coil 40 having layers such as 79 and 80 and the coil 42 having layers such as 81 and 82. Although it is understood that the coils of any of the various forms disclosed may have either one or a plurality of layers, the particular form disclosed in Figure 20 has a part of the layers, such as the layers 79 of the coil 40 and the layers 81 of the coil 42, which are of substantially the same width as and fit into the window of the other coil to cover the entire circumference of the form 44. These layers 79 and 81 accomplish the spacing of the windings upon the form and the self-alignment and positioning of the coils 40 and 42. The other layers, such as 80 and 82 of the coils, are so distributed that they provide a desirable distortion of the magnetic fields of the coils. With the layers 80 and 82 distributed intermediate the edges of the coils 40 and 42 respectively, a type of distortion known in the art as "barrel distortion" is obtained. This particular type of distortion is utilized in compensating for a characteristic of some cathode ray tubes. This distortion would normally tend to cause the sides of the image pattern to bulge or be convexly distorted from the normal or undistorted pattern. Although the inherent spacing and alignment of the coils is not attendant with the spacing of the sides of each of the coils, one from the other, it is understood that other structural features of the yoke might be utilized with the coil sides spaced or separated on the form 44.

In the modified structure illustrated in Figure 21, the sides of one of the coils overlap the sides of the other coil as illustrated at 83 and 84 where the sides of the coil 40 overlap the sides of the coil 42. The overlapping of the coils in this manner provides a form of distortion which is known in the art as "pincushion distortion." This type of distortion is sometimes desirable to compensate for other variations and characteristics of the cathode ray tube.

In all of the forms of the yoke 31 thus far described the windings of the coils 40 and 42 are preferably continuous, but it is understood that the halves of the coils may be separately wound, assembled as described and later connected together. Connections to the coils 40 are made through suitable lead wires such as 85 and 86 which may be continuations of the winding; and connections to the coil 42 are made through lead wires 87 and 88.

With particular reference to the modified structure disclosed in Figures 22 and 23, it is pointed out that many of the features of design and construction are similar to those which have been set forth with regard to the preferred embodiment of this invention. The differences are principally concerned with the process and method of manufacture, and will be described in connection with that process or method.

Method or process of manufacture

In the preferred process or method of manufacture of scanning or deflecting yokes in accordance with this invention and the steps of which are shown in Figures 2 to 17 inclusive, a pair of coils having one or more closely wound layers are wound on forms or arbors and have substantially rectangularly disposed flat sides and ends, as shown in Figures 3 and 4. After being wound, the sides and ends of the coils are taped as at **90, 91, 92, 93, 94, 95, 96** and **97** with an insulating tape such as an adhesive cellulose tape. This tape aids in holding the coils together during the assembly thereof. The ends of the coil **42** are of such length that the cylindrical form **44** fits into the coil as shown in Figures 5 and 7 with the longitudinal axis of the form **44** substantially parallel to the sides **47** and **48** and the outside surface of the form **44** substantially in contact with the mid-portion or intermediate turns of the coil. The length of the sides **47** and **48** is such that a space is provided between the ends of the coil **42** and the ends of the form **44**, as shown in Figure 9. The sides **45** and **46** of the coil **40** are longer than the sides **47** and **48** of the coil **42**, and are preferably of such length that when the coil **40** is placed over the form **44** and the coil **42** as shown in Figures 6 and 8, a space is provided between the ends of the coils **40** and **42**, as shown in Figure 9. The lengths of the ends of the coil **40** are preferably substantially equal to the lengths of the ends of the coil **42**, so that when the coil **40** is placed over the form **44** and coil **42** with the magnetic or winding axes of the coils perpendicular, the mid-portion or mid-turns of the coil **40** substantially engage the outside diameter of the form **44**.

As has been previously explained, the winding length of the coils **40** and **42** in one preferred embodiment of this invention, are preferably substantially equal and preferably substantially equal to one fourth of the circumference of the outer surface of the form **44**. When windings of this preferred length are secured to the form **44** and made to radially conform to the surface thereof by the tape **61**, as shown in Figure 10, the edges of the windings **40** and **42** abut each other and thereby inherently space the coils with their winding and magnetic axes perpendicular. Under the conditions outlined the coil sides of one coil are of substantially the width of, and fit into the window of the other coil. The deformation of the coils **40** and **42** is effected by wrapping the tape **61** thereon, as shown in Figure 10, or by a suitable clamp, so that the coils conform to the contour of the form **44**. There is a consequent deformation of the ends of the coils, as is also shown in Figure 10.

As the next step in the construction of the coil assembly, the end turns of the coil **40** are split or divided into two substantially equal parts or groups of turns. These substantially equal parts or groups of turns at each end of the coil **40** are deformed as shown at **50, 51, 52** and **53** in Figure 11, so that they extend outwardly and around diametrically opposite sides of the form **44**. This deformation of the ends of the coils is accomplished with the least possible deformation of the sides thereof, so that the sides remain substantially straight over practically their entire length, and particularly over the length thereof adjacent the coil windows. After the deformation of the end turns of the coil **40**, the end turns of the coil **42** are similarly divided and deformed. The end turns of the coil **42** partially overlap the end turns of the coil **40** and extend substantially outwardly and around diametrically opposite sides of the form **44** and intermediate the deformed ends of the coil **40**, as shown in Figure 12. The end turns of both of the coils **40** and **42** are deformed in such a way that their dimension or section in a direction parallel to the axis of the form **44** is thin. To accomplish the thin axial section of these turns the radial dimension is increased. This thin axial section provides a greater effective window length for a given over all length of a coil and increases the ratio of window length to over all coil length.

After the assembly with respect to the form and the deformation thereof is described, a low reluctance magnetic return path for the flux of the coils is provided. Although this flux path may be provided in a variety of ways, such as by providing a laminated ring core or by wrapping iron or steel ribbon thereon, the preferred embodiment thereof comprises the wrapping of a plurality of layers of soft iron or other low reluctance magnetic wire over the surface of the coils between the ends thereof, as shown at **43** in Figure 17. The layers of wire indicated at **70** are preferably separated by insulating material such as paper during the winding thereof, and as indicated at **71** in Figure 17.

The steps in the process of the manufacture of the modified forms of coil assemblies shown in Figures 19 to 21 inclusive are similar to those described with reference to Figures 2 to 17 inclusive. In the form shown in Figure 19, the winding lengths of the coils **40** and **42** are not equal. However, the winding length or coil width of one coil is such that the sides of one coil fit into the windows of the other coil and the two coils together circumferentially cover the outer surface of the form **44**. In the form shown in Figure 20, one or more layers of the coils **40** and **42** that are adjacent the outer surface of the form **44** act as spacing or locating layers for the coils to inherently effect the perpendicular displacement of the coils, and the narrower layers indicated at **80** and **82** provide desired distortion of the magnetic fields of the coils. In the form indicated in Figure 21 an additional step of insuring the right angular or perpendicular relation of the coils is necessary when they are secured to the form **44**.

As illustrated in Figures 22 and 23, a collapsible arbor **100** may be utilized in place of the form **44**. This collapsible arbor comprises a substantially cylindrical arbor member **101** which may be made of metal or other suitable material that preferably has some resilience and which is split at **102** to permit expansion and contraction of the arbor. Wedges **103** and **104** fit into the ends of the arbor member **102** and are drawn into the ends by a screw **105** to expand the arbor to the proper diameter at the beginning of the assembly of the yoke structure. The steps of the assembly when the collapsible arbor **100** is used are similar to those previously described and in which the form **44** was made a part of the complete coil assembly. Also, a collapsible arbor may be utilized in connection with the various forms of coils illustrated and described. However, when the collapsible arbor **100** is utilized in the assembly of the coils, the assembled coil structure is dipped into a hot wax or other suitable material which solidifies upon cooling; and after such dipping and cooling the arbor **100** is collapsed and removed from the assembly. The wax or other material, when solidified, aids in holding the parts of the coil in their proper assembled relation. This type of coil, although possibly some-what more difficult to manufacture, has the advantage of improved magnetic efficiency by virtue of the reduction of the air space between the coils and the surface of the cathode ray tube, due to the elimination of the form 44.

In the fragmentary diagrammatic view of Fig. 24, connections for the coils are illustrated which effect a reduction of the distributed capacity of the coils. One side of a multi-layer coil 110, which may correspond to either of the coils 40 or 42, has layers 111 and 112. The layer 112, which is preferably the inner layer of the coil, is cut or opened at substantially the middle, so that it is divided into two halves. A lead 113 at one outer end of the layer 112 provides connecting lead for the coil. The other end of the half of the layer 112 to which the lead 113 provides a connection, is connected through a lead 114 to one end of the layer 111. The other end of the layer 111 is connected through a lead 115 to the inner end of the other half of the layer 112; and a lead 116 provides a second connecting lead for the coil. Where desirable, a mid-tap to the coil is provided by a lead 117 connected to the midturn of the coil. It is the purpose of connections such as those illustrated in Fig. 24 to reduce the potential difference between adjacent turns and to thereby reduce the distributed capacity of the coil. When the low reluctance or high permeability flux path is utilized with the coil, as indicated in Fig. 17, it is preferable that the inner layer 112 be the one that is divided, because the resultant capacity will be lower with the divided layer separated from the magnetic material.

While the forms and embodiments of my invention which have been described and illustrated herein are to be preferred, it is understood that many modifications may be made without departing from the spirit and scope of the invention, and it is not desired or intended that the invention is limited to the precise details set forth but rather the invention shall include all changes coming within the scope of the appended claims.

What is claimed is:

1. The method of making a coil assembly which comprises the steps of winding a pair of coils of substantially equal width with substantially rectangular disposed flat sides and ends and with the sides of one shorter than the sides of the other, placing a cylindrical form within the shorter coil with the axis of the form parallel to the coil sides, placing the longer coil over the shorter coil and form in such relation thereto that the sides are parallel to the axis of the form and the sides of one coil are adjacent the openings between the sides of the other, deforming the coil sides to the cylindrical contour of the form and securing them in such position, and deforming the ends outwardly around the form.

2. The method of making a coil assembly which comprises the steps of winding a pair of coils of substantially equal width with substantially rectangularly disposed flat sides and ends and with the sides of one shorter than the sides of the other, placing a cylindrical form within the shorter coil with the axis of the form parallel to the coil sides, placing the longer coil over the shorter coil and form in such relation thereto that the sides are parallel to the axis of the form and the sides of one coil are adjacent the openings between the sides of the other, deforming the coil sides to the cylindrical contour of the form and securing them in such position, dividing the ends into substantially equal portions, and deforming said portions of each of the coils outwardly around opposite sides of the form.

3. The method of making a coil assembly which comprises the steps of winding a pair of coils having end and side portions with the sides of one longer than the sides of the other and the width of the sides of one dependent upon and determined by the distance between the sides of the other, placing a cylindrical form within the shorter coil with the axis of the form substantially parallel to the side portions, placing the longer coil over the form and shorter coil with the end portions of one coil substantially perpendicular to and between the end portions of the other, deforming the sides to the cylindrical contour of the form, dividing the end portions of each coil into parts and oppositely deforming the parts.

4. The method of making a coil assembly which comprises the steps of securing prewound coils to a form in such relation that the edges of the coils abut and the coil sides conform to the contour of the form, and deforming the ends of the coils so that they extend around the form and the directions of their maximum dimensions are transverse to the form.

5. The method of making a coil assembly which comprises the steps of winding coils of predetermined dimensions on forms, deforming the coils to conform to a predetermined contour, separately deforming other portions of the coils to said predetermined contour with a thin longitudinal sectional dimension, and winding low reluctance material around a portion of the outer surface of the assembled coils.

6. In the process of making a coil assembly, the steps comprising, winding a pair of coils on arbors of different sizes, placing the coils symmetrically with their winding axes perpendicular, deforming portions of the coils to conform to the contour of a form and securing the coils in the deformed positions, and subsequently deforming other portions of the coils to circumvent the contour of said form.

7. In the process of making a deflecting yoke, the steps comprising, winding cylindrical coils having side and end portions and windows on arbors, placing the coils symmetrically over a form with their winding axes perpendicular, deforming the side portions of the coils to the contour of a form and securing the coils in the deformed symmetrical positions, and deforming the end portions of the coils to circumvent said form.

8. In the process of making an assembly of coils having windows, the steps comprising, winding coils in a predetermined cylindrical form, and deforming the ends of the coils to circumvent a predetermined cylindrical contour and have a high ratio of window length to over all coil length.

9. In the process of making a coil assembly, the steps comprising, winding coils in a predetermined cylindrical shape with substantially straight sides and ends, and subsequently deforming the sides and dividing and deforming the ends to conform to a single cylindrical form.

10. In the process of making a coil assembly, the steps comprising winding a coil about a winding axis so that the section of the winding sides is substantially straight, deforming the sides to conform to a cylindrical section, and dividing and deforming the ends to conform substantially to the said cylindrical section of the sides.

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