Feb. 15, 1966 J. MARLEY 3,234,631

METHODS OF MANUFACTURING MAGNETIC DEFLECTION COILS AND YOKES

Original Filed Jan. 11, 1956 3 Sheets-Sheet 1

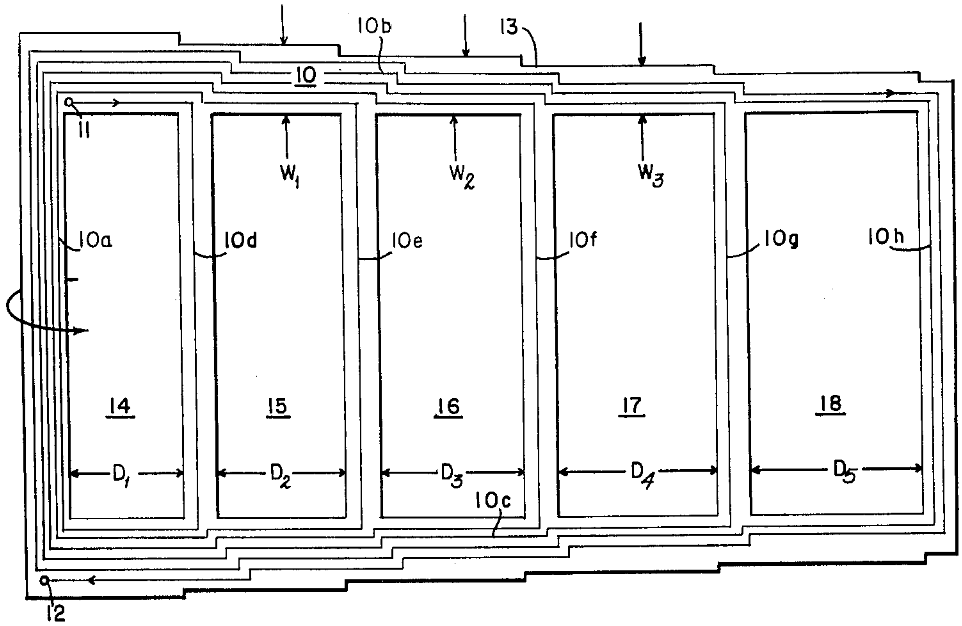

FIG.1

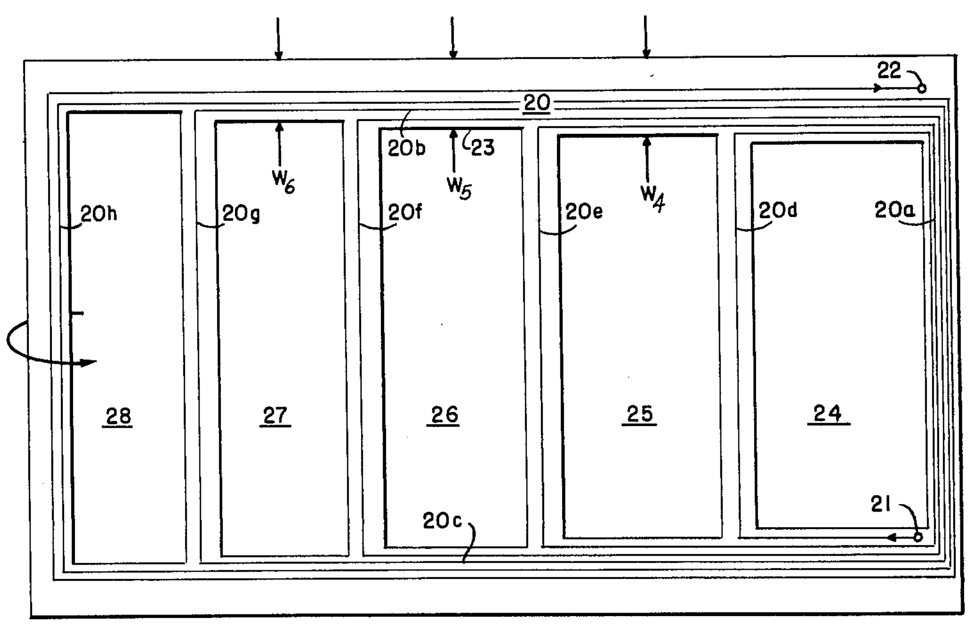

FIG.2

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METHODS OF MANUFACTURING MAGNETIC DEFLECTION COILS AND YOKES

Original Filed Jan. 11, 1956 3 Sheets-Sheet 2

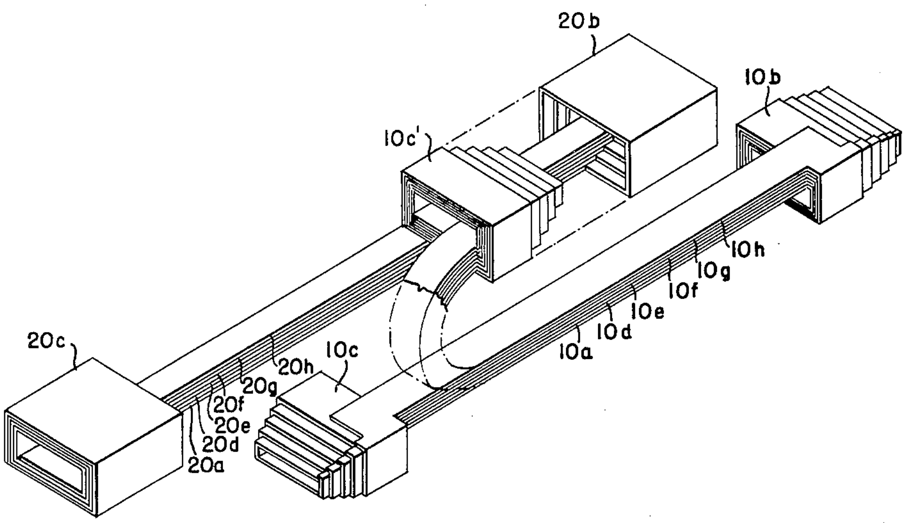

FIG. 3

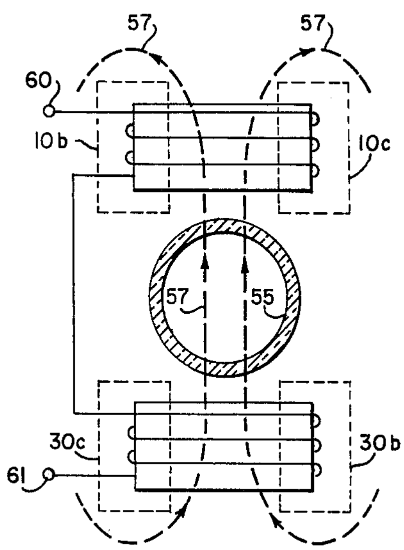

FIG. 6

METHODS OF MANUFACTURING MAGNETIC DEFLECTION COILS AND YOKES

Original Filed Jan. 11, 1956 3 Sheets-Sheet 3

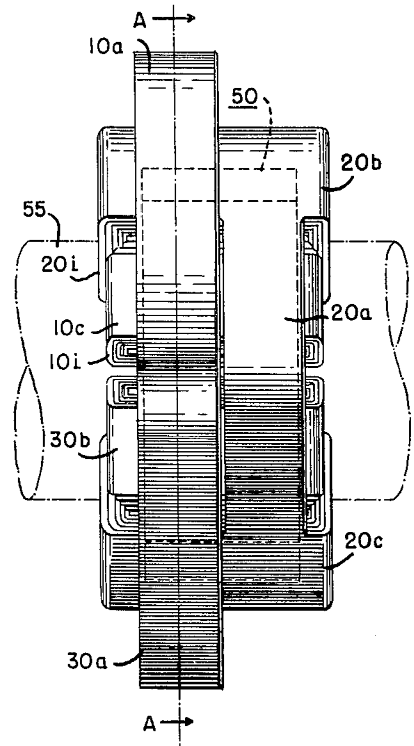

FIG.4

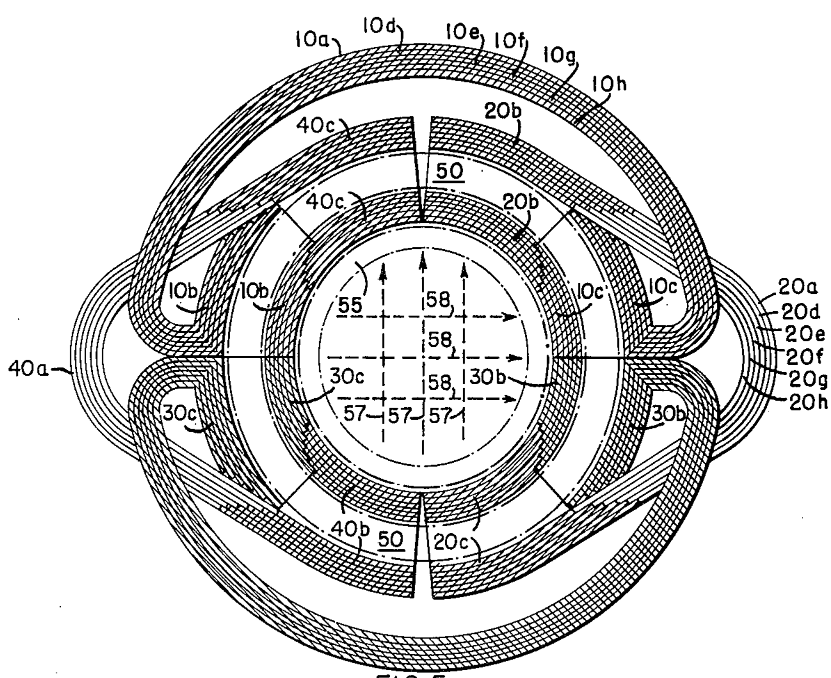

FIG.5

3,234,631

METHODS OF MANUFACTURING MAGNETIC DEFLECTION COILS AND YOKES

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Continuation of abandoned application Ser. No. 558,526, Jan. 11, 1956. This application June 15, 1960, Ser. No. 36,372
15 Claims. (Cl. 29—155.57)

This application is a continuation of application Serial No. 558,526, filed January 11, 1956, now abandoned, and entitled, "Method of Manufacturing Magnetic Deflection Coils and Yokes."

This invention relates to coils and, more particularly, to methods of manufacturing magnetic deflection coils and deflection yokes. Such yokes are utilized to deflect beams of electrons or similar electrical particles and are particularly useful in connection with cathode-ray tubes and the like.

Considering the case of a cathode-ray tube in more detail, it is conventional practice to place a plurality of deflection coils adjacent the neck portion of such cathode-ray tube in order to deflect the electron beam developed by such tube. Such deflection coils are frequently combined in an overlapping manner to form a complete deflection yoke. In operation, the coils of the yoke are energized by suitable electrical currents thereby causing the coils to develop magnetic deflection fields which in turn serve to deflect the electron beam thereby causing such beam to scan a display surface in a desired scanning pattern.

In order to obtain accurate control over the deflection of the electron beam, it is desirable to utilize deflection coils wherein the coil turns are accurately positioned relative to one another in a known manner. Also, in order to reduce manufacturing costs, it is desired that there should be a high degree of consistency between the operating characteristics of deflection coils of the same construction. This, again, requires that the coil turns be accurately positioned, otherwise manual adjustment of the coil turns may be necessary after the coil is formed in order to obtain deflection coils having the same operating characteristics. This desired accuracy of coil turn positioning could be readily achieved if some method were available for utilizing printed wiring techniques.

In order to develop magnetic deflection fields having a high degree of linearity, it is frequently necessary to utilize coils in which the turns are distributed in a nonuniform manner, that is, that the density of coil turns vary from one end of the coil to the other in a precise but nonuniform manner. Such nonuniformity of coil turn density compensates for other nonuniformities that would otherwise be present and thereby enables a uniform or undistorted deflection field to be produced. It would be desirable to have a method of coil manufacture which would readily enable such results to be obtained with a minimum of effort.

It is further desirable that a deflection yoke made up of a plurality of deflection coils be as compact as possible. This leads to increased power efficiency and decreased distributed capacitance in the yoke because the yoke structure then has a minimum of unused air spaces between the various coils. Also, the defocusing effects normally produced by the end turns of the coils are reduced because the end turns of adjacent windings are positioned more closely to one another thereby better enabling the end turn fields developed by one to cancel the end turn fields developed by the other.

It is an object of the invention, therefore, to provide new and improved methods of manufacturing deflection coils and yokes which achieve one or more of the foregoing advantages.

It is a further object of the invention to provide new and improved methods of manufacturing deflection coils having increased precision of coil turn positioning.

It is another object of the invention to provide new and improved methods of manufacturing deflection coils which readily lend themselves to printed circuit techniques.

It is a further object of the invention to provide new and improved methods of manufacturing deflection coils having a desired nonuniform density of coil turns.

It is an additional object of the invention to provide new and improved methods of manufacturing deflection yokes having reduced end turn effect, reduced distributed capacitance, and increased power efficiency.

In accordance with the present invention, there is made possible the method of manufacturing magnetic deflection coils by rolling a ladder coil so that the side pieces roll into two distinct cylindrical coils and all rung sections overlay each other and form one compact group interconnecting the cylindrical coils.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, the scope of the invention being pointed out in the appended claims.

Referring to the drawings:

FIG. 1 is a plan view of a ladder coil constructed in accordance with the present invention;

FIG. 2 is a plan view of an alternative form of ladder coil;

FIG. 3 is a perspective view of a pair of such ladder coils after undergoing further operations in accordance with this invention;

FIG. 4 is a side elevational view showing a complete deflection yoke constructed in accordance with the present invention;

FIG. 5 is a cross-sectional view taken on the section line A—A of FIG. 4, and

FIG. 6 is a symbolic electrical circuit diagram for explaining the operation of the FIG. 4 deflection yoke.

Referring to FIG. 1 of the drawings, there is shown one form of ladder coil for making magnetic deflection coils in accordance with the present invention. For the purpose of this specification the term "ladder coil" is defined as an electrical coil having the following characteristics:

(1) All conductors are physically arranged in a rollable sheet.

(2) Each individual turn is generally in the form of a rectangle.

(3) The complete coil resembles a common ladder in form with the turns forming two side pieces and at least three rung sections.

(4) Individual turns encircle one or more of the windows of the ladder form.

(5) The complete coil is capable of being rolled up into a spiral roll.

Also, a "rolled ladder coil" is defined as a ladder coil which has been rolled up so that the side pieces of the ladder coil roll into two distinct cylindrical coils and all rung sections overlay each other and form one compact group interconnecting the cylindrical coils (as will be explained in more detail).

The ladder coil **10** illustrated has turns which progress continuously between the inner region represented, for example, by the terminal **11** and the outer region of the coil represented, for example, by the terminal **12**. In other words, the coil is made up of one continuous conductor, for example wire, which progresses in a continuous manner from the terminal **11** to the terminal **12**. As indicated in FIG. 1, the turns of this coil **10** are arranged so that the coil has a first end **10***a* and a pair of elongated sides **10***b* and **10***c* (which may be considered the side pieces of the ladder form) which are intermittently bridged by segments of a fraction of the total turns so that the width of the side pieces may vary in a progressive manner from one end of the coil to the other. The turn segments which intermittently bridge the two elongated sides **10***b* and **10***c* are represented by the groups **10***d*–**10***h*, inclusive, which together with group **10***a* may be considered the rung sections of the ladder form. The effect of thus intermittently bridging some of the turns is that the total number of turns carried by one of the side pieces, for example, the side **10***b*, continuously decreases from one end of the coil to the other. This, in turn, enables the width of the side piece to decrease in a like manner. This decrease in width is indicated by the successive dimensions W_1, W_2 and W_3 which, as appear in the drawings, may be caused to successively decrease by displacing each turn following a rung segment toward the inner region of the coil so as to maintain a substantially equal spacing of all turns from that region.

The coil **10** may be affixed to a sheet of flexible dielectric material **13** which, preferably, has a number of windows cut therein. The windows are rectangular areas where the dielectric material has been removed and are indicated by the areas **14**–**18**, inclusive.

The open areas of the coil between the rung segments **10***a* and **10***d*–**10***h*, inclusive, are made to coincide with the windows **14**–**18**, inclusive, in the dielectric sheet. The coil **10** may be formed by using a jig or board having a number of pins located therein at positions corresponding to the various corners of the coil. In this manner, the wire may be wound about the pins to form the desired coil **10**. When formed, the wire coil may be attached to the dielectric material by means of a suitable cementing material or, if desired, the dielectric backing material may be dispensed with and the coil turns bonded together by coating them with lacquer or some suitable plastic coating which, after it dries, serves to bond the turns together.

An alternative way of forming the coil **10** is to print the desired turns pattern onto the sheet of dielectric material by means of any of the various well known printed circuit or printed wiring techniques. This method is a particularly advantageous way of forming the coil as it is rapid and produces an accurate coil pattern.

Where a plurality of deflection coils are required to form a complete deflection yoke, it is desirable that alternate coils for such yoke have a slightly modified construction in order that these coils may nest with one another in a most compact manner. Accordingly, it is also desirable to utilize a ladder coil of the form shown in FIG. 2. This coil is similar to that of FIG. 1 in that the coil **20** of FIG. 2 is made up of a continuous wire or conductor pattern which progresses continuously between the inner region represented by the terminal **21** and an outer region represented by the terminal **22**. Also, the turns are arranged so that the coil **20** has a first end rung **20***a* and a pair of side pieces **20***b* and **20***c* which are intermittently bridged by the rung segments **20***d*–**20***h*, inclusive, respectively comprising segments of a fraction of the total turns. In this manner, the width of the side pieces **20***b* and **20***c* may vary in a progressive manner from one end of the coil to the other. The successive variations in width of, for example, the side piece **20***b* are represented by the successively decreasing dimensions W_4, W_5, and W_6. This may be accomplished by displacing each turn having a rung segment toward the outer region of the coil so as to maintain a substantially equal spacing of all turns from that region. As before, this coil pattern may be printed on a dielectric sheet **23** having windows or panels **24**–**28**, inclusive, cut therein. The coil pattern **20** of FIG. 2 differs from the pattern of FIG. 1 in that the variation in width of the side pieces **20***b* and **20***c* is produced by maintaining the

position of the outer edge of such side pieces constant while varying the positions of successive portions forming the inner edges.

Magnetic deflection coils in accordance with the present invention are constructed from the flat coils of FIGS. 1 and 2 by rolling up each flat coil about one end thereof into a spiral so as to form a rolled ladder coil. Considering, for example, the flat coil **10** of FIG. 1 this coil may be rolled up about the end **10***a* as indicated by the arrow. In this manner, the two side pieces **10***b* and **10***c* form two distinct cylindrical coils and all rung sections overlay each other and form one compact group interconnecting the symmetrical coils. This rolled up coil pattern is shown in FIG. 3 of the drawings, wherein the rolled forms of coils **10** and **20** of FIGS. 1 and 2 are indicated by the primary designations **10** and **20** with various attached suffixes. As there indicated, the side pieces **10***b* and **10***c* of the flat coil of FIG. 1 become the correspondingly designated cylindrical coils **10***b* and **10***c* of FIG. 3. FIG. 3 also shows the two distinct cylindrical coils **20***b* and **20***c* and the stack of rung segments which are formed when the coil pattern **20** of FIG. 2 is rolled up about, for example, the end **20***h* thereof. As is apparent from FIG. 3, the term "cylindrical" is not to be limited to the case of a right circular cylinder because as shown by the coils **10***b*, **10***c*, **20***b* and **20***c* of FIG. 3, the distinct cylindrical coils may be of rectangular cross-section.

It will be noted that the variation in the number of turns included in the side pieces of the flat patterns of FIGS. 1 and 2 has produced a nonuniform distribution or density of the turns in each of the resulting rolled ladder coils **10** and **20** of FIG. 3. This nonuniform distribution is indicated by the stepped nature of these coils, the outer periphery of each of the distinct cylindrical coils **10***b* and **10***c* of rolled ladder coil **10** and the inner periphery of each of the distinct cylindrical coils **20***b* and **20***c* of the rolled ladder coil **20** progressively increasing along the length of each coil going toward the stacked rung segments. This distribution of coil turns may be made to follow a desired pattern so as to compensate for deflection field distortion that would otherwise result by suitably selecting the number of turns that are to be included in each rung thereof. It will be noted in this regard that the number of turns and rungs shown in the drawings of FIG. 1 and FIG. 2 are intended as representative only, as the actual number of either of which may be used may be many times that illustrated.

As indicated by the dimensions D_1–D_5, inclusive, of FIG. 1, it is necessary that the dimensions of the windows of flat coil **10** parallel to the side pieces **10***b* and **10***c* either increase or decrease, as the case may be, from one rung to the next in order to make up for the increased circumference which must be covered by these successive sections when the coil pattern is rolled up. This same dimensional variation also applies to the coil pattern **20** of FIG. 2.

Referring now to FIGS. 4 and 5 of the drawings, there is shown a representative form of magnetic deflection yoke which may be made by practicing the teachings of the present invention. By way of illustration, a type of magnetic deflection yoke suitable for use with a cathode-ray tube is shown and, to this end, a portion **55** of the neck of such a cathode-ray tube is indicated in phantom, that is, in dash-line form, in order to indicate the position of the deflection yoke relative to the cathode-ray tube. Four pairs of interconnected cylindrical coils (four individual rolled ladder coils) of the type described in connection with FIG. 3 are required to make up the complete deflection yoke. In order to properly nest the outer peripheries of the coils of two of these pairs, the inner peripheries of the coils of the remaining two pairs must continually increase along the lengths of the coils going toward the stacked rung sections. The increasing outer periphery type of rolled ladder coil may be formed by rolling ladder coil 10 of FIG. 1 about its end 10*a* as described or by rolling ladder coil 20 of FIG. 2 about its end 20*a*. Similarly, the decreasing inner periphery type of rolled ladder coil may be formed by rolling ladder coil 20 about its end 20*h* or by rolling ladder coil 10 about its end 10*h*. Of course, if either coil 10 or coil 20 is to be rolled about its end 10*h* or 20*h*, respectively, the widths of the side pieces would have to increase toward ends 10*a* or 20*a* rather than as shown in FIGS. 1 and 2. In FIGS. 4 and 5 two of the rolled ladder coils, the various parts of which are indicated by primary designations 10 and 30 with various attached suffixes have been formed by rolling up two ladder coils of the type shown in FIG. 1, and two additional rolled ladder coils, the parts of which are indicated by designations 20 and 40 with various attached suffixes, have been formed by rolling up two ladder coils of the type shown in FIG. 2. These rolled ladder coils are positioned on a ferromagnetic core 50 in an overlapping manner with the smallest outer perepheral portion of each distinct cylindrical coil of the rolled ladder coils of increasing outer periphery positioned adjacent the smallest inner peripheral portion of the overlapping distinct cylindrical coils of the rolled ladder coils of increasing inner periphery. This overlapping is best seen in the cross-sectional view of FIG. 5 which is a view taken on the section line A—A of FIG. 4.

As indicated in the drawings, the ferromagnetic core 50 is of the ring type, that is, of a type which completely encircles or rings the neck portion 55 of the cathode-ray tube. Each of the rolled ladder coils is positioned on the core 50 so that the turns making up each cylindrical coil thereof encircle the core. In order to obtain the preformed rolled ladder coils on the core 50, it is necessary that the core 50 be made of at least two segments or parts which may be separated from one another.

The manner in which the distinct cylindrical coils should be inserted into one another so as to produce the desired compact overlapping is shown by the phantom coil 10*c'* of FIG. 3 which represents the coil 10*c* in an altered position. The coil 10*c'* is inserted into the coil 20*b* so that the outside steps on the cylindrical coil 10*c'* may be neatly nested in the inner steps of the cylindrical coil 20*b*. The results of this overlapping when these coils are positioned on the core 50 is shown in FIG. 5, the coil 10*c'* there being referred to as 10*c*. The remainder of the rolled ladder coils are similarly positioned on the core 50 in this same overlapping manner. Thus is seen the reason for making two of the rolled ladder coils of the male type and the other two of the female type.

As is apparent from FIG. 5, the portions of each of the cylindrical coils which are located inside the core 50 fit neatly together with very little unused space remaining, whereas the portions of the coils which are located outside of the core 50 do not fit together quite so neatly. In this regard, it should be remembered that its is only the coil portions located inside the core 50 which are active in deflecting the electron beam produced by the cathode-ray tube 55. This is because the outer coil portions are shielded from the electron beam by the ferromagnetic core 50. Thus, it will be recognized that the locations of the coil portions which are outside the core 50 are not critical as far as deflection of the electron beam is concerned. As is indicated in FIG. 4, the positions of the compact groups of rung sections indicated by the numbers 10*a*, 20*a* and 30*a* are chosen so as not to conflict with one another.

In order to obtain all of the rolled ladder coils on the core 50 in the indicated overlapping manner, it is preferable that at least two of the compact groups of rung sections, for example, the groups having the outer rung sections designated by the numbers 20*a* and 40*a*, be made extra long in length so that after all four of the rolled ladder coils have been properly inserted into one another there is enough room left over so that the pieces of the core 50 may be inserted within the overlapped coils. After the individual rolled ladder coils have been overlapped and the core pieces inserted into the center regions thereof, the yoke structure may then be suitably clamped together in a rigid manner, for example, by tightening a metallic band or strap around the circumference of the entire yoke structure.

A typical way of interconnecting the coil pairs for actual operation in deflecting the electron beam is indicated by the symbolic diagram of FIG. 6. This diagram is intended to be purely symbolic and is not intended to represent either the actual or equivalent circuit of the deflection yoke but, nevertheless, serves to enable one to readily understand how the yoke operates. More particularly, the symbolic coil portions 10*b*, 10*c*, 30*b* and 30*c* of FIG. 6, correspond to the correspondingly designated portions of the coils of FIG. 5, which are located inside the core 50. The remainder of the coil wiring of FIG. 6 represents that portion of the coil wiring of FIG. 5 which is located outside of the core 50. In this manner, from FIG. 6, is may be seen that the coil portion 10*b*, 10*c*, 30*b* and 30*c* produce a pair of series-adding magnetic fields which serve to produce a vertical component of magnetic flux which is indicated by the dashed lines 57. This component of flux causes the electron beam to be deflected in a horizontal direction. Where, for example, the cathode-ray tube 55 is used in a television receiver, the terminals 60 and 61 of the coil pairs indicated in FIG. 6 are connected to suitable supply circuits of the television receiver for enabling suitable deflection currents to be supplied to these windings. In a similar manner, though not shown in FIG. 6, it may be seen that the coil portions 20*b*, 20*c*, 40*b* and 40*c* which are located inside of the core 50 may be connected and supplied with suitable deflection currents for producing a horizontal magnetic field, the flux lines of which are represented by the dashed lines 58 of FIG. 5. In this manner, the deflection yoke of FIG. 5 may, for example, be used in a television receiver to produce the desired scanning raster of the electron beam. Of course, where desired, only the coils necessary for deflecting the electron beam in one direction need be included in the yoke structure if deflection in one direction is all that is required of such a yoke structure.

From the foregoing description of the various portions of the invention, it will be apparent that the ladder coils of FIGS. 1 and 2 are such that highly accurate deflection coils and deflection yokes may be produced by the use thereof. More particularly, such ladder coils readily lend themselves to printed circuit techniques thus rendering construction of such deflection coils and deflection yokes rapid and economical. Also, by permitting the coil portions located inside the core to be neatly and compactly overlapped, the construction of deflection coils and yokes in accordance with the present invention, results in increased linearity of the resultant deflection fields, increased power efficiency, and reduced distributed capacitance.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. The method of manufacturing magnetic deflection coils by rolling a ladder coil so that the side pieces roll into two distinct cylindrical coils and all rung sections overlay each other and form one compact group interconnecting the cylindrical coils.

2. The method of manufacturing magnetic deflection coils by rolling a ladder coil having a predetermined nonuniform turns arrangement so that the side pieces roll into two distinct cylindrical coils and all rung sections

overlay each other and form one compact group interconnecting the cylindrical coils.

3. The method of manufacturing magnetic deflection coils by rolling a ladder coil having predetermined nonuniform rung spacings so that the side pieces roll into two distinct cylindrical coils and all rung sections overlay each other and form one compact group interconnecting the cylindrical coils.

4. The method of manufacturing magnetic deflection coils by rolling a ladder coil having predetermined nonuniform turns arrangement and rung spacings so that the side pieces roll into two distinct cylindrical coils and all rung sections overlay each other and form one compact group interconnecting the cylindrical coils.

5. The method of manufacturing magnetic deflection coils by forming a ladder coil and rolling this coil so that the side pieces roll into two distinct cylindrical coils and all rung sections overlay each other and form one compact group interconnecting the cylindrical coils.

6. The method of manufacturing magnetic deflection coils by forming a printed circuit ladder coil and rolling this coil so that the side pieces roll into two distinct cylindrical coils and all rung sections overlay each other and form one compact group interconnecting the cylindrical coils.

7. The method of manufacturing a magnetic deflection yoke by placing four rolled ladder coils on a yoke core in nesting relationship.

8. The method of manufacturing a magnetic deflection yoke from a group of two rolled ladder coils of increasing outer periphery and two rolled ladder coils of increasing inner periphery by placing the said coils on a yoke core in nesting relationship with the smallest outer peripheral portions of one type of rolled ladder coil adjacent the smallest inner peripheral portions of the other type.

9. A method of manufacturing a magnetic deflection coil having a predetermined nonuniform turns distribution, comprising: forming a flat rectangular coil having two longitudinal sides and two shorter transverse sides, the turns of said coil being arranged to bridge the longitudinal sides thereof at progressively increased spacings from the first transverse side so as to form a series of groups of turns of which one transverse leg of each group is common to the first transverse side and the other transverse leg is progressively further spaced therefrom, thus progressively reducing the number of turns in each longitudinal side of said coil extending from its first transverse side to its second transverse side and causing a corresponding progressive reduction in the width of each longitudinal side; and rolling said flat coil about one of its transverse sides so that said groups of turns wind about each other and said two longitudinal sides form two distinct cylindrical coils which are interconnected by all said transverse legs in overlaid relationship; whereby the variation in width of each of said longitudinal sides of said flat coil causes the number of turns of each of said cylindrical coils to be distributed along the length thereof in accordance with said predetermined turns distribution.

10. A method of manufacturing a magnetic deflection yoke, comprising: forming two flat rectangular coils respectively having two longitudinal sides and two shorter transverse sides, the turns of each coil being arranged to bridge the longitudinal sides thereof at progressively increased spacings from its first transverse side so as to form a series of groups of turns of which one transverse leg of each group is common to the first transverse side and the other transverse leg is progressively further spaced therefrom, thus progressively reducing the number of turns in each longitudinal side of each of said coils extending from its first transverse side to its second transverse side and causing a corresponding progressive reduction in the width of each longitudinal side; rolling the first of said flat coils about its first transverse side and the second of said flat coils about its second transverse side so that said groups of turns of each flat coil wind about

each other and the two longitudinal sides thereof form a pair of distinct annular cylindrical coils which are interconnected by all of the transverse legs of the same flat coil in overlaid relationship, the outer periphery of each of the pair of cylindrical coils formed from said first flat coil and the inner periphery of each of the pair of cylindrical coils formed from said second flat coil progressively increasing along the length thereof; and nesting the cylindrical coils of increasing outer periphery respectively within the cylindrical coils of increasing inner periphery with the smallest outer peripheral portions adjacent the smallest inner peripheral portions.

11. A method of manufacturing a magnetic deflection yoke, comprising: forming two flat rectangular coils respectively having two longitudinal sides and two shorter transverse sides, the turns of each coil being arranged to bridge the longitudinal sides thereof at progressively increased spacings from its first transverse side so as to form a series of groups of turns of which one transverse leg is progressively further spaced therefrom, thus progressively reducing the number of turns in each longitudinal side of each of said coils extending from its first transverse side to its second transverse side and causing a corresponding progressive reduction in the width of each longitudinal side; progressively transversely displacing the turns in each longitudinal side of each of said flat coils with respect to the opposite longitudinal side thereof in accordance with the progressive reduction in the width of those sides following successive ones of said transverse legs, said displacement being toward the opposite longitudinal side in the case of said first flat coil and away from the opposite longitudinal side in the case of said second flat coil; rolling the first of said flat coils about its first transverse side and the second of said flat coils about its second transverse side so that said groups of turns of each flat coil wind about each other and the two longitudinal sides thereof form a pair of distinct annular cylindrical coils which are interconnected by all of the transverse legs of the same flat coil in overlaid relationship, the outer periphery of each of the pair of cylindrical coils formed from said first flat coil and the inner periphery of each of the pair of cylindrical coils formed from said second flat coil progressively increasing along the length thereof in the direction toward the other coil of the same pair; and nesting the cylindrical coils of increasing outer periphery respectively within the cylindrical coils of increasing inner periphery with the smallest outer peripheral portions adjacent the smallest inner peripheral portions.

12. A method of manufacturing a magnetic deflection yoke, comprising: forming two flat rectangular coils respectively having two longitudinal sides and two shorter transverse sides, the turns of each coil being arranged to bridge the longitudinal sides thereof at progressively increased spacings from its first transverse side so as to form a series of groups of turns of which one transverse leg of each group is common to the first transverse side and the other transverse leg is progressively further spaced therefrom, thus progressively reducing the number of turns in each longitudinal side of each of said coils extending from its first transverse side to its second transverse side and causing a corresponding progressive reduction in the width of each longitudinal side; progressively transversely displacing the turns in each longitudinal side of each of said flat coils with respect to the opposite longitudinal side thereof in accordance with the progressive reduction in the width of those sides following successive ones of said transverse legs; rolling the first of said flat coils about its first transverse side and the second of said flat coils about its second transverse side so that said groups of turns of each flat coil wind about each other and the two longitudinal sides thereof form a pair of distinct annular cylindrical coils which are interconnected by all of the transverse legs of the same flat coil in overlaid relationship, the outer periphery of each of the pair of cylindrical coils formed from one of said flat coils and

the inner periphery of each of the pair of cylindrical coils formed from the other of said flat coils progressively increasing along the length thereof; and nesting the cylindrical coils of increasing outer periphery respectively within the cylindrical coils of increasing inner periphery with the smallest outer peripheral portions adjacent the smallest inner peripheral portions.

13. A method of manufacturing a magnetic deflection coil having a predetermined nonuniform turns distribution, comprising: forming a flat rectangular coil having two longitudinal sides and two shorter transverse sides, the turns of said coil being arranged to bridge the longitudinal sides thereof at progressively increased spacings from the first transverse side so as to form a series of groups of turns of which one transverse leg of each group is common to the first transverse side and the other transverse leg is progressively further spaced therefrom, thus progressively reducing the number of turns in each longitudinal side of said coil extending from its first transverse side to the second transverse side thereof and causing a corresponding progressive reduction in the width of each longitudinal side; progressively transversely displacing the turns in each longitudinal side of said flat coil with respect to the opposite longitudinal side thereof in accordance with the progressive reduction in the width of those sides following successive ones of said transverse legs; and rolling said flat coil about one of its transverse sides so that said groups of turns wind about each other and said two longitudinal sides form two distinct annular cylindrical coils which are interconnected by all said transverse legs in overlaid relationship, the progressive displacement of the turns in each longitudinal side of said flat coil causing the periphery of one of the walls of each of said annular cylindrical coils to progressively increase along the length thereof in accordance with said predetermined turns distribution.

14. A method of manufacturing a magnetic deflection coil having a predetermined nonuniform turns distribution, comprising: forming a flat rectangular coil having two longitudinal sides and two shorter transverse sides, the turns of said coil being arranged to bridge the longitudinal sides thereof at progressively increased spacings from the first transverse side so as to form a series of group of turns of which one transverse leg of each group is common to the first transverse side and the other transverse leg is progressively further spaced therefrom, thus producing a progressive stepped reduction of the number of turns in each longitudinal side of said coil following successive ones of said transverse legs and causing a corresponding progressive stepped reduction in the width of each longitudinal side; progressively transversely displacing the turns in each longitudinal side of said flat coil toward the opposite longitudinal side thereof in accordance with the progressive reduction in the width of those sides following successive ones of said transverse legs; and rolling said flat coil about its first transverse side so that said groups of turns wind about each other and said two longitudinal sides form two distinct annular cylindrical coils which are interconnected by all said transverse legs in overlaid relationship, the progressive

stepped reduction and displacement of the turns in each longitudinal side of said flat coil causing a progressive stepped increase of the outer periphery and of the number of turns of each of said annular cylindrical coils in the same direction along its length in accordance with said predetermined turns distribution.

15. A method of manufacturing a magnetic deflection coil having a predetermined nonuniform turns distribution, comprising: forming a flat rectangular coil having two longitudinal sides and two shorter transverse sides, the turns of said coil being arranged to bridge the longitudinal sides thereof at progressively increased spacings from the first transverse side so as to form a series of groups of turns of which one transverse leg of each group is common to the first transverse side and the other transverse leg is progressively further spaced therefrom, thus producing a progressive stepped reduction of the number of turns in each longitudinal side of said coil following successive ones of said transverse legs and causing a corresponding progressive stepped reduction in the width of each longitudinal side; progressively transversely displacing the turns in each longitudinal side of said flat coil away from the opposite longitudinal side thereof in accordance with the progressive reduction in the width of those sides following successive ones of said transverse legs; and rolling said flat coil about its second tranverse side so that said groups of turns wind about each other and said two longitudinal sides form two distinct annular cylindrical coils which are interconnected by all of said transverse legs in overlaid relationship, the progressive stepped reduction and displacement of the turns in each longitudinal side of said flat coil causing a progressive stepped increase of the inner periphery and of the number of turns of each of said annular cylindrical coils in the same direction along its length in accordance with said predetermined turns distribution.

References Cited by the Examiner

UNITED STATES PATENTS

1,647,474	11/1927	Seymour	29—155.5
2,237,651	4/1941	Bruche	317—76 XR
2,395,736	2/1946	Grundmann	29—155.57
2,441,960	5/1948	Eisler	29—155.5
2,632,864	3/1953	Hunter	313—76 XR
2,748,324	5/1956	Lord	317—200
2,961,747	11/1960	Lyman	310—207 XR
2,986,667	5/1961	Tirico	317—200 XR
3,002,260	10/1961	Shortt et al.	336—200 XR
3,011,247	12/1961	Hanlet	29—155.61 XR
3,015,152	1/1962	Marley	317—200 XR

FOREIGN PATENTS

640,618	7/1950	Great Britain.

OTHER REFERENCES

"Electronics," January 1939 (Television Deflection Circuits), pages 19 and 20.

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