

July 14, 1953

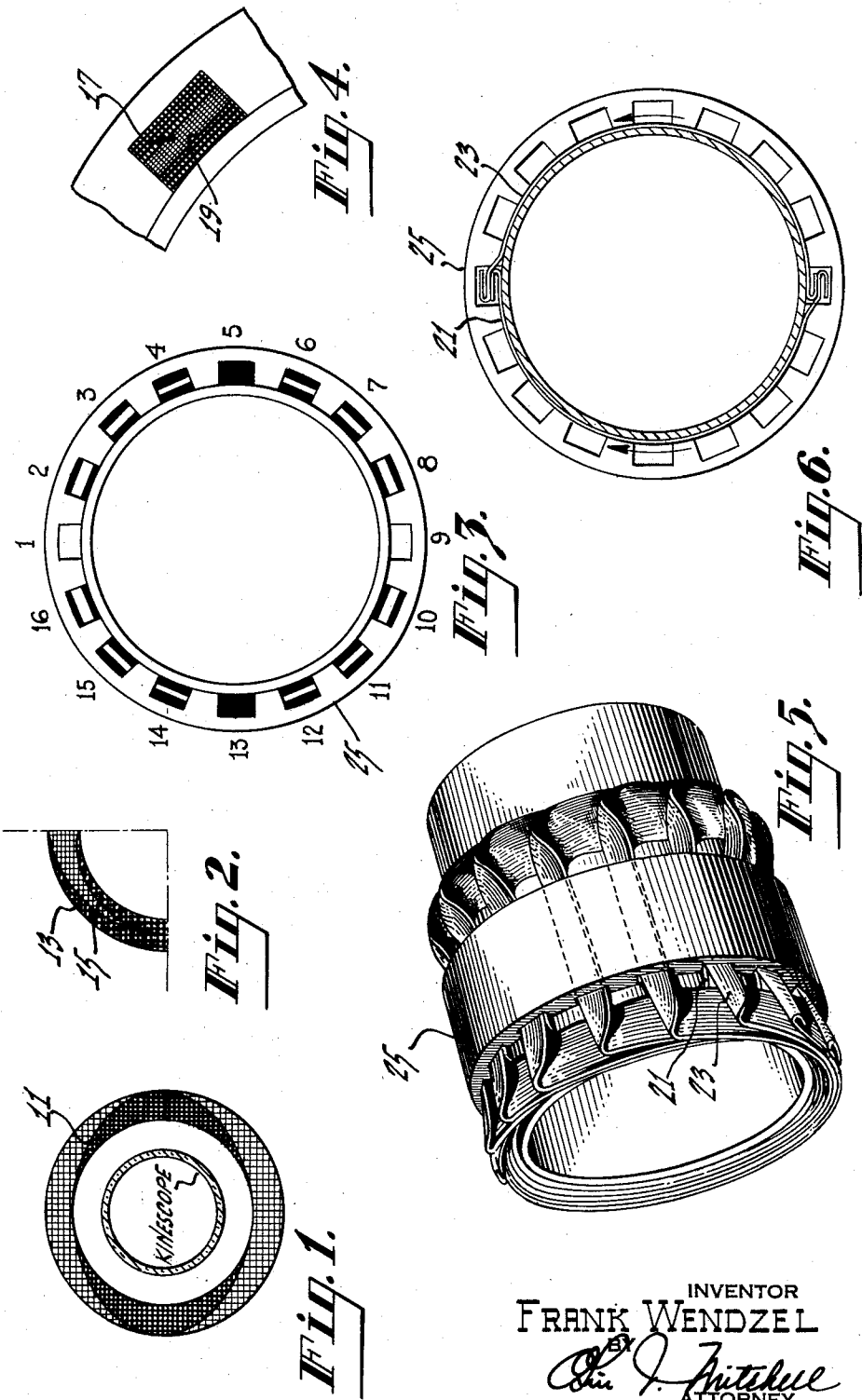
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2,645,735

PRECISION DEFLECTING YOKE

Filed April 19, 1952

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

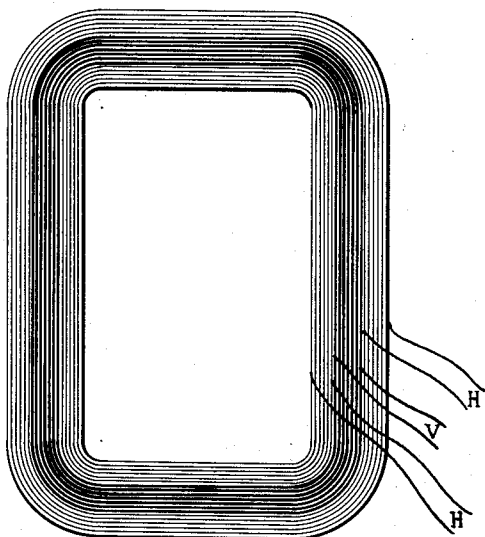


Fig. 7.

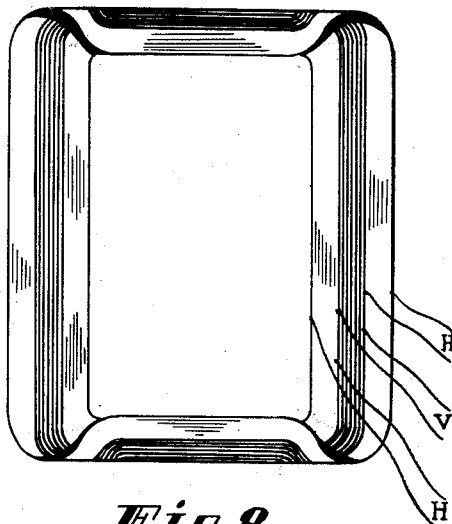


Fig. 8.

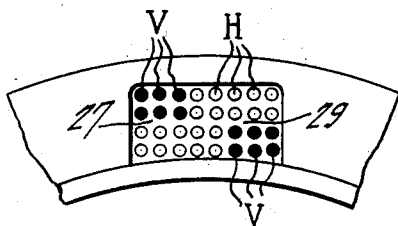


Fig. 9.

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PRECISION DEFLECTING YOKE

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13 Claims. (Cl. 313—76)

1

This invention relates to magnetic deflecting yokes and more particularly to deflecting yokes which provide a very precise deflection of the electron beam in a cathode ray tube.

In television and radar it has become the custom to deflect the electron beam in a cathode ray tube by means of a magnetic field produced by a winding of a yoke. Ordinarily two windings are provided in each yoke, such as might be used for vertical and horizontal deflection.

In television receiver practice each of the windings is usually made up of two coils which are shaped to conform to the curvature of a supporting structure which is normally in the form of a ring. The supporting structure has an opening through which a portion of a cathode ray tube may be passed. One of the two coils of the winding is placed about the supporting structure on one side of the opening and the other coil is placed about the supporting structure on the opposite side of the opening. The two coils of the other winding are similarly placed relative to one another but in positions which are respectively 90° from the coils of the first.

Each coil consists of two principal portions, namely, (1) the active conductors, which are positioned parallel to the longitudinal axis of the cathode ray tube and which are the most effective in setting up the main flux in the path of the electron beam in the cathode ray tube, and (2) the end turns, which connect together the active conductors and which are ordinarily formed arcuately about the neck of the cathode ray tube. Although the end turns do not produce a strong field in the path of the electron beam in the cathode ray tube, nevertheless, in precision deflection the end turns must be placed suitably to prevent the end turn field from causing a distortion in the main field of the deflecting yoke. To provide an electron beam with linear magnetic deflection and without disturbing the beam focus a field must be produced which has uniform flux density.

It has become normal practice first to wind each coil as a hank with no restraint on the location of each turn within the hank, then to bend the hank as necessary to conform to the curvature of the neck of the tube or supporting structure, and finally to separate the parallel portions of the hanks by means of small Bakelite spacers; however, this construction permits considerable variation in the location of the various wires in each coil and in the shape of the coils. There is, therefore, some variation in the performance of this type of yoke. This variation in

2

performance is not great and is readily accepted in entertainment television, but in some industrial and military applications it is intolerable. Where yoke deflection accuracy of 1 percent or better is required, it is essential that the variations in the yokes be held to very low values.

For certain applications nearly constant flux density in the air gap of the yoke is desirable to obtain precision deflection. There are many uses of cathode ray devices such as in certain industrial and military equipments where a relatively high order of precision is desired in the deflection of an electron beam. A "graphechon" is one example of such a cathode ray device. A "graphechon" is the particular type of storage tube disclosed in an article by L. Pensak titled "The Graphechon—A Picture Storage Tube" published in the RCA Review in Vol. X, March 1949 at page 59. A representative form of a graphechon consists essentially of two independent cathode ray guns and a target plate coated with a thin film of insulating material. The two guns can operate simultaneously, the one to record or "write" down the signals to be stored and the other to reproduce or "read" the written signals. The "reading" gun must scan precisely the same line which has been previously scanned by the "writing" gun. Without precise deflection or geometrical correspondence of the two cathode ray beams the "reading" gun can not accurately derive the desired signals.

Precise deflection of a cathode ray beam may be obtained in one direction by distributing the windings of a deflecting yoke in proportion to the cosine of the increasing central angle in the transverse plane of the neck of a cathode ray tube measured from a point on the neck of the cathode ray tube which embraces the thickest portion of the winding. Cosinusoidal distribution of the winding in a cathode ray deflecting yoke is described in U. S. Patent No. 2,395,736, "Deflecting Coils and Yoke and Method of Manufacturing Same," granted to G. L. Grundmann. A winding with cosinusoidal distribution is capable of producing flux, and hence deflection in only one direction, and therefore, to provide horizontal and vertical deflection it is necessary to add another winding. The second winding might simply be added to the deflecting yoke by placing it outside the first, but the interface between the two windings carrying different current causes a circumferential component of flux that is undesirable in precision deflection of electron beams since it produces irregularities in the main field in the air gap of the yoke.

One object of this invention is to provide an improved deflecting yoke for accurately deflecting an electron beam in cathode ray tubes and like devices in more than one direction.

Another object of this invention is to provide an improved deflecting yoke capable of producing a plurality of magnetic fields for deflecting an electron beam in more than one direction.

Still another object of this invention is to reduce the circumferential component of flux which is inherent in the juxtaposition of two windings carrying different currents.

A further object of this invention is to reduce the defocusing of an electron beam in a cathode ray tube.

A further aim of this invention is to reduce field irregularities produced by a cathode ray deflecting yoke.

In accordance with this invention, the magnetic deflecting yoke is composed of a plurality of interleaved windings each of which has a predetermined distribution of active conductors. For example, this distribution may be cosinusoidal.

The invention will, however, be better understood from the following description when considered in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring to the drawings:

Fig. 1 is a cross sectional view of two cosinusoidally distributed windings according to the prior art;

Fig. 2 is a quadrantal cross sectional view of two cosinusoidally distributed windings wherein one winding is interleaved with the other in accordance with this invention;

Fig. 3 is a cross sectional view of two substantially cosinusoidally distributed windings interleaved within slots of a supporting structure;

Fig. 4 is a fragmentary view of Fig. 3 drawn to an enlarged scale;

Fig. 5 is a perspective view of a deflecting yoke in accordance with this invention;

Fig. 6 is an end view of the yoke showing two coils disposed in two diametrically opposite slots in the supporting structure in accordance with this invention;

Fig. 7 shows a rectangular coil having a single turn layer composed of a number of convolutions of the vertical winding interleaved with a number of convolutions of the horizontal winding;

Fig. 8 illustrates a rectangular coil similar to that of Fig. 7 with opposite sides folded to form a double layer of active conductors; and

Fig. 9 is a cross sectional view of one of the slots in the supporting structure illustrated in Fig. 5 showing the position of the active conductors of the horizontal and vertical windings within one slot.

Referring to Fig. 1 there is illustrated a view of two magnetic deflecting windings each having a cosinusoidal distribution about the neck of a cathode ray tube showing only the parts lying in the cross sectional plane perpendicular to the longitudinal axis of the cathode ray tube. It is known that a single winding having a cosinusoidal distribution will produce a fairly uniform flux density within the circular area defined by the winding. The above cited U. S. patent granted to Grundmann teaches the use of two cosinusoidally distributed windings producing two magnetic fields mutually perpendicular to one another by placing one winding outside of the other as shown in Fig. 1. Such an arrangement of the windings produces fairly uniform flux

density within the air gap of the yoke. However, the single interface 11 between the two windings causes a circumferential component of flux due to the different currents in the respective windings. This circumferential component of flux causes a distortion in the magnetic field and, consequently, causes non-linear deflection and defocusing of the electron beam. This flux is inherent in the juxtaposition of the two windings and although it exists in present yokes it is not considered objectionable in the yokes used in entertainment television. Where precision is necessary, the effect of the adjacent windings in producing the unwanted circumferential flux may be nearly eliminated in accordance with this invention by interleaving one winding with the other as shown in Fig. 2. There are then two interfaces 13 and 15 which give two substantially equal circumferential fluxes which flow in opposite directions and are close enough to one another to effect nearly complete mutual cancellation. The effect of the interface is thereby sensibly eliminated.

The form of the yoke shown in fragmentary view in Fig. 2 may be slightly modified without departing from the principles of this invention. In order to rigidly hold the active conductors of a winding having a predetermined distribution in a given place the active conductors may be disposed in the slots of a supporting form by dividing each winding into a number of discrete coils and setting the active conductors of each coil in slots as shown in the cross sectional view in Fig. 3 or in U. S. Patent 2,155,514 "Deflecting Coil for Cathode Ray Tube" granted to Tolson and Maloff. A cross sectional view of the active conductors in one of the slots of the supporting structure showing the two interfaces 17 and 19 appears somewhat as shown in Fig. 4. The breaking up of the windings into a number of separate coils must be done with discretion in order to retain the advantages of the cosine distribution of the windings. Experience has shown that 16 slots in the supporting structure are satisfactory for a winding whose internal diameter is about five times the dimensions of the air gap space swept by the electron beam within the tube. The proportion of turns in the slots in one quadrant of the yoke illustrated in Fig. 3 is shown in the following table:

Table

Slot	Horizontal Winding	Vertical Winding
1	0	100
2	38	92
3	71	71
4	92	38
5	100	0

The slots in each of the other three quadrants of the yoke have a similar proportion of turns.

Another form of a yoke embodying the principles of this invention is shown in Fig. 5. The interleaving within the slot takes place about a slightly different axis from that shown in Figs. 2, 3 and 4. In Fig. 6 there is shown an end view of two of the coils 21 and 23 illustrated in Fig. 5 disposed in two diametrically opposite slots in the supporting structure 25 in accordance with this invention.

In order to provide cosinusoidally distributed horizontal and vertical deflecting windings which are interleaved one with the other, individual coils are formed in a single turn layer as illus-

5

trated in Fig. 7. In winding the coils, leads are brought out so that the first few turns H of each coil could be part of one winding, for example, the horizontal winding, the next few turns V could be part of the other winding, for example, the vertical winding and the last few turns H, equal in number to the first few could be part of the first winding. The end turns of this coil are bent into a semi-circle to conform to the curvature of the cathode ray tube or the supporting structure. The active conductors of the winding are folded longitudinally of the conductors to form double layers of conductors as shown in Fig. 8.

It will be observed that, after folding one of the active conductor sides of the coil, the group of turns shown by heavy lines in Figs. 7 and 8, for example, those associated with the vertical winding, which were previously interleaved with the other turns are now on one edge of the coil. When two such coils are placed together within one slot with the end turns encircling the tube in opposite directions, the combination of active conductors within the slot forms an interleaved group as shown in Fig. 9. The active conductors V of one winding are placed in diagonal corners of the cross sectional area of the slot and the active conductors H of the other winding are interposed therebetween providing two interfaces 27 and 29. Slots diametrically opposite one another contain the same number of active conductors associated with the vertical winding, and also, each of the two slots has the same number of active conductors associated with the horizontal winding. Therefore, the end turns connecting the active conductors in diametrically opposite slots cover an arc of 180°. However, in order to maintain symmetry, the end turns of each of the two coils cover an arc of 180° but in opposite directions as shown in Fig. 6. The coils for the other slots are formed in the same manner, merely varying the number of turns in each group in each coil in conformity with the table. When all the coils are properly formed, they are assembled as shown in Fig. 5.

In order to keep the accumulated end turns of all the coils from building up into too thick a pile, it is desirable to make the end turns of each coil in a thinner, wider, more ribbon-like form than the active conductor sides as shown in Figs. 5 and 6.

Various alterations may be made in the present invention without departing from the spirit and scope thereof. For example, the rectangular coils may be of the layer-type having a number of layers. A coil of several layers could be used so long as its thickness is held small enough to permit the folding operation. Furthermore, the active conductors could be placed in the slots without first forming the layer-type rectangular coils. Also more than one pair of interfaces could be produced within each slot of the supporting structure. It is to be understood that the supporting structure may be of a non-metallic material. Alternatively, it may be made of a metallic substance, either permeable or non-permeable as required. It is desired that any and all such alterations be considered within the purview of the present invention as defined by the herein-after appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A cathode ray deflecting yoke comprising, two windings energizable and disposed relative to one another in a manner to deflect a cathode

6

ray in two different directions, said windings having portions which are mutually coextensive and said mutual coextensive portions being formed so that one winding is interleaved with the other to create a plurality of interfaces, whereby substantially the same number of equal and opposite circumferential components of flux is produced.

2. A cathode ray deflecting yoke comprising, a vertical deflecting winding and a horizontal deflecting winding, each of said windings having its conductors distributed to conform to a cylindrical surface such that the maximum number of conductors of each winding are disposed at points 180° apart, the number of conductors decreasing progressively from said maximum points in proportion to the cosine of the increasing central angle of a circle formed by a transverse plane of said cylindrical surface measured from one of said maximum points, and wherein said vertical and horizontal windings are interleaved.

3. A deflecting yoke to deflect the electron beam in a cathode ray tube comprising, two windings and a ring having a plurality of parallel slots, each winding composed of a plurality of discrete coils having diametrically opposite portions disposed within said ring in those of said slots which are diametrically opposite, said coils of each winding arranged to encircle a portion of said tube such that the number of conductors in each slot progressively decreases substantially proportionally to the cosine of the increasing central angle in a transverse plane of said ring measured from the slot having the maximum number of conductors, and wherein said windings are interleaved with each other to create a plurality of interfaces wherever both of said windings are located in the same slot.

4. A magnetic deflecting yoke for producing a uniform deflecting field in a plurality of directions for the deflection of a cathode ray beam in a cathode ray tube comprising, a plurality of active conductors arranged to encircle the neck of said tube, a portion of said conductors associated with each direction of deflection so distributed that the number of conductors of said portions is a maximum at points approximately 180° apart, the number of conductors of said portions decreasing progressively in either direction from said 180° points to a minimum at points angularly spaced respectively approximately 90° from said 180° points, said progressive decrease in said number of conductors being proportional to the cosine of the increasing central angle in a transverse plane of said tube neck measured from one of said 180° points and wherein said portions of said conductors are interleaved with each other to create a plurality of interfaces.

5. A magnetic deflecting yoke for producing a uniform deflecting field in a horizontal and vertical direction for the deflection of a cathode ray beam in a cathode ray tube comprising, a plurality of active conductors arranged to encircle the neck of said tube, a portion of said conductors associated with said horizontal deflection and the remaining portion of said conductors associated with said vertical deflection, said conductors of each portion so distributed that the number thereof is a maximum at points approximately 180° apart, the number of said conductors decreasing progressively in either direction from said points to a minimum at points angularly spaced respectively approximately 90° from said 180° points, said progressive decrease in number of conductors being proportional to the cosine of the increasing central angle in a transverse plane

of said tube neck measured from one of said 180° points and wherein said horizontal deflection portion of said conductors is interleaved with said vertical deflection portion of said conductors to create a plurality of interfaces between the conductors and said horizontal portion of said vertical portion.

6. A cathode ray deflecting yoke comprising, a vertical deflecting winding and a horizontal deflecting winding, each of said windings having its conductors distributed to conform to a cylindrical surface such that the maximum number of conductors of each winding is disposed at points 180° apart, the number of conductors decreasing progressively from said maximum points in substantial proportion to the cosine of the increasing central angle of a circle formed by a transverse plane of said cylindrical surface measured from one of said maximum points, and wherein all the conductors of one of said windings are adjacent to each other and are interleaved with the conductors of the other of said windings to create a plurality of interfaces between said windings.

7. A deflecting yoke to deflect the cathode ray beam in a cathode ray tube comprising, two windings and a ring having a plurality of parallel slots, each winding composed of a plurality of discrete coils having diametrically opposite portions disposed within said ring in slots which are diametrically opposite, said coils of each winding arranged to encircle a portion of said tube such that the number of conductors of each winding in each slot progressively decreases substantially proportionally to the cosine of the increasing central angle of said ring measured from the slot having the maximum number of conductors, and wherein the cross sectional area of each of said slots is substantially a rectangle having disposed in diagonal corners a substantially equal number of conductors of one of said windings, the conductors of the other of said windings being interposed between said diagonally disposed conductors.

8. A deflecting yoke to deflect the electron beam in a cathode ray tube comprising, two windings and a ring having a plurality of parallel slots, said windings composed of a number of discrete layer-type rectangular coils of a predetermined thickness, said coils having conductors associated with one of said two windings interposed between conductors associated with the other of said two windings, each of said coils having two opposite sides folded longitudinally of the conductors to form layers of conductors of twice the predetermined thickness, one folded side of each of two of said coils being disposed in one of said ring slots and the other folded sides of said two coils being disposed in the diametrically opposite ring slot, the other two sides of one of said two coils being arcuately formed so as to define with its folded sides substantially one half of a cylindrical surface, and the other two sides of the other of said two coils being arcuately formed so as to define with its folded sides substantially the other half of said cylindrical surface, and wherein the conductors associated with each of said windings are so distributed in said ring that the number thereof is a maximum in

slots approximately 180° apart, the number of said conductors of each winding in each slot decreasing progressively in either direction from said slots of maximum number in substantial proportion to the cosine of the increasing central angle in the transverse plane of said ring measured from one of said slots of maximum number of conductors.

9. A deflecting yoke as defined in claim 8 wherein said one winding is a vertical deflecting winding and said other winding is a horizontal deflecting winding.

10. A deflecting yoke as defined in claim 8 wherein, said slots are placed in the internal portion of said ring.

11. A deflecting yoke as defined in claim 10 wherein, said ring is composed of a metallic substance.

12. A deflecting yoke as defined in claim 8 wherein, said layer-type rectangular coils have a single turn layer.

13. A deflecting yoke to deflect the electron beam in a cathode ray tube comprising, a horizontal deflecting winding, a vertical deflecting winding, and a metallic ring having a plurality of parallel slots disposed within the internal portion of said ring, said deflecting windings composed of a number of discrete rectangular coils having a single turn layer, said coils having conductors associated with said vertical winding interposed between conductors associated with said horizontal winding, each of said coils having two opposite sides folded longitudinally of the conductors to form a double layer of conductors, one folded side of each of two of said coils being disposed in one of said ring slots and the other folded sides of said coils being disposed in the diametrically opposite ring slot, the other two sides of one of said two coils being arcuately formed so as to define with its folded sides substantially one-half of a cylindrical surface, and the other two sides of the other of said two coils being arcuately formed so as to define with its folded sides substantially the other one-half of said cylindrical surface and wherein the conductors associated with each of said windings are so distributed in said ring that the number thereof is a maximum in slots approximately 180° apart, the number of said conductors of each winding in each slot decreasing progressively in either direction from said slots of maximum number in substantial proportion to the cosine of the increasing central angle in a transverse plane of said ring measured from one of said slots of maximum number of conductors.

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