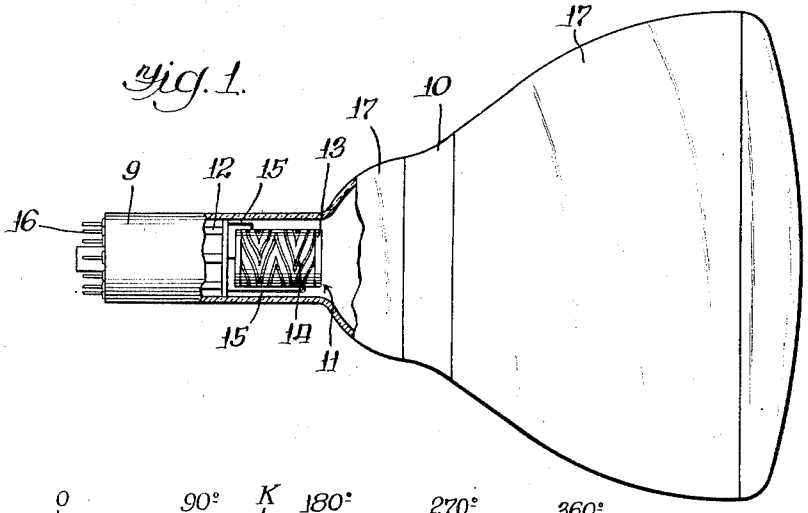
Nov. 13, 1956 K. SCHLESINGER ET AL 2,770,748

DEFLECTION SYSTEM

Filed June 15, 1953 2 Sheets-Sheet 1

Fig. 1.



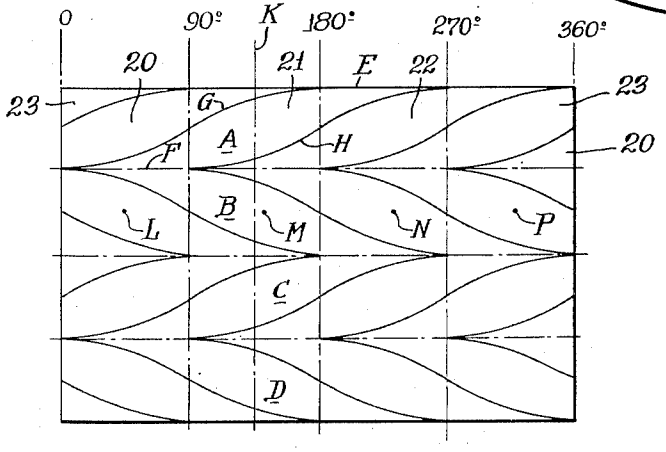


Fig. 2.

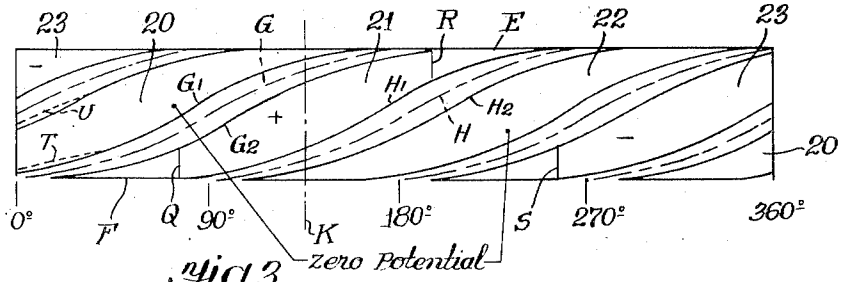


Fig. 3.

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Nov. 13, 1956 K. SCHLESINGER ET AL 2,770,748

DEFLECTION SYSTEM

Filed June 15, 1953 2 Sheets-Sheet 2

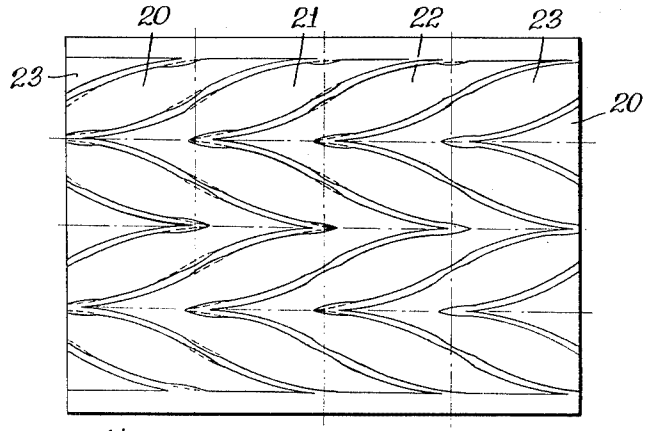
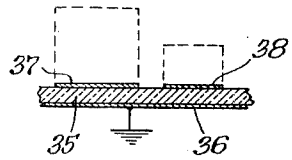


Fig. 11.

Fig. 8.



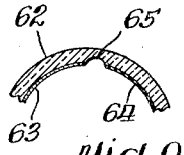


Fig. 9.

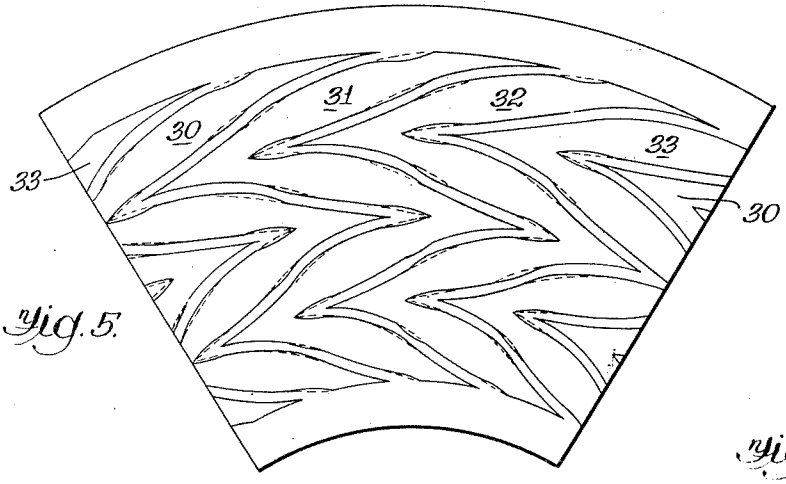


Fig. 5.

Fig. 6.

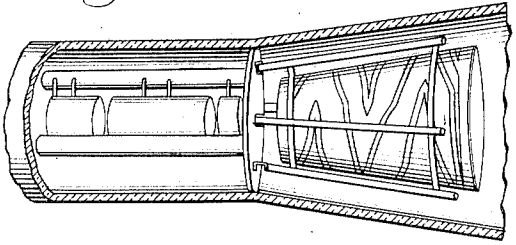
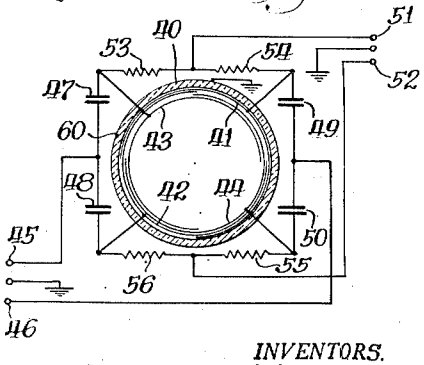


Fig. 7.



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United States Patent Office 2,770,748 Patented Nov. 13, 1956

2,770,748

DEFLECTION SYSTEM

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Application June 15, 1953, Serial No. 361,472

8 Claims. (Cl. 313—78)

This invention relates generally to electrostatic deflection systems and more particularly to such systems for use with cathode ray tubes to provide simultaneous bi-directional deflection of the beam thereof.

The system of the instant application is an improvement over the systems disclosed and claimed in Patents 2,617,076 and 2,617,077, issued November 4, 1952, and application Serial No. 275,070, filed March 6, 1952, now Patent #2,681,426, all covering inventions of Kurt Schlesinger. Although the systems disclosed in the above patents have been used satisfactorily, in these systems which are applicable to circular structures, spaces of varying widths are provided between the electrodes and this both reduces the sensitivity of the system, and causes distortion as fields are produced in the spaces which modify the fields produced by the electrodes.

It is therefore an object of the present invention to provide an improved bi-axial electrostatic deflection system formed by conductive coatings on an insulating member of circular configuration so that the resulting fields are of pure sine and cosine distribution to provide a high degree of circularity.

A further object of this invention is to provide an improved electrostatic deflection system wherein electrodes are provided on a surface in an interleaved manner with a minimum spacing between adjacent electrodes for providing electrical insulation therebetween.

Another object of the invention is to provide an electrostatic deflection system for a cathode ray tube formed of coatings on an insulating surface of such a pattern that the surface is almost entirely covered to provide increased sensitivity, and with the pattern having such geometry that the distortion is at a minimum.

A feature of this invention is the provision of an electrostatic deflection system wherein conducting coatings are provided on a tubular insulating member with the coatings being symmetrically positioned and extending longitudinally of the member and being of zigzag shape with the apex portions extending angularly around the tubular member over an extent of 270°. The adjacent edges are of complementary sinusoidal configuration and have an extent of substantially 180° of the entire angular extent of 270° of each electrode, with the adjacent portions of each electrode being joined over the remaining 90° to provide a low impedance continuous electrode structure.

Another feature of this invention is the provision of a bidirectional electrostatic deflection system wherein the electrodes are formed as coatings positioned around a tubular insulating member, with insulation being provided between the electrodes by spacing the opposed edges of adjacent electrodes by a uniform angular extent. The pattern may be shifted longitudinally of the insulating member to provide greater spacing at the apex portions.

A further feature of this invention is the provision of an electrostatic deflection system wherein electrodes are deposited on a form which has a low degree of conductivity, such as conductive glass, so that the surface between adjacent electrodes is rendered inactive.

Further objects and features, and the attending advantages of the invention will be apparent from a consideration of the following description when taken in connection with the accompanying drawings; wherein,

Fig. 1 illustrates generally a cathode ray tube having the deflection system in accordance with the invention;

Fig. 2 is a development of the fundamental pattern of the electrodes for use on a circular cylinder;

Fig. 3 illustrates modifications of the pattern as required for commercial use;

Fig. 4 is a development of an electrode pattern for use on a conical form;

Fig. 5 illustrates the compensated pattern for a conical structure;

Fig. 6 is a perspective view of a conical deflection structure;

Fig. 7 is a schematic diagram illustrating the application of energizing signals to the structure; and

Figs. 8 and 9 are cross-sectional views of the structure illustrating further modified forms thereof.

In practicing the invention there is provided an electrode structure for producing electrostatic deflection fields extending in two directions at right angles to each other, such as may be utilized in a cathode ray tube for deflecting the beam thereof. The structure may be provided on a cylindrical or conical insulating member with the electrodes deposited thereon. The electrodes extend longitudinally of the beam, with each being of zigzag shape and the apex portions of adjacent electrodes being interleaved. The apex portions of each electrode extend in opposite directions and have an overall angular extent of substantially 270°. The adjacent surfaces of the electrodes are of complementary sinusoidal configuration, and are spaced substantially uniformly at the minimum spacing which will provide adequate insulation therebetween at the potential being applied thereacross. Although the electrodes extend around the beam through an angle of substantially 270°, the field produced thereby has an effective extent of only 180°, and is sinusoidal over this extent to provide uniform, non-distorted deflection fields.

The use of an insulating member having slight conducting properties, such as conductive glass, with a grounded backing plate renders the surfaces between adjacent electrodes inactive, and eliminates distortion which may be caused by the fields at these inter-electrode surfaces. Although this may not be of primary importance when the area of insulation is small compared to the plated area, such a conducting support member reduces residual distortion of the order of less than 5 percent.

In this specification and in the attached claims the word conical is used to define a longitudinal circular member which has a greater diameter at one end than at the other. The word cylindrical is used to define a member of constant diameter. The word tubular is used generically to include members which are of constant diameter (cylindrical) and also members having varying diameters (conical).

Referring now to the drawings, in Fig. 1 there is illustrated a cathode ray tube **10** embodying the electrostatic deflection electrode structure **11** in accordance with the invention. The tube includes a gun **12** which directs a beam of electrons through the electrode structure **11**. The electrode structure includes a tubular supporting member **13** which may be made of glass, ceramic or the like having conducting coatings **14** on the inside surface thereof. Connections are made to the conducting coatings through leads **15** which connect with contact pins **16** on the base **9** of the tube. Four identical symmetrically positioned electrodes are provided and only

four connections are required; one for each electrode. Accelerating potential may be proviedd for the beam by connections to one or more anodes **17** provided as coatings on the inside of the tube **10**.

Reference is now made to Fig. 2 for an explanation of the construction and operation of the electrostatic deflection structure. Fig. 2 is a development of the fundamental pattern of the electrodes as shown in Fig. 1. Four separate electrodes are provided which are designated **20**, **21**, **22** and **23**. It will be noted that electrodes **20** and **23** are cut off by the ends of the pattern and continue from one end to the other. As stated above, all of the electrodes are identical in configuration and they are symmetrically positioned, with the apex portions thereof interleaved with each other. The electrode **21** will be described in detail and the configuration of the other electrodes will be obvious as they are all identical.

The electrode **21** is made up of four sections designated A, B, C, and D. The section A is bounded by two parallel sides E and F which are joined by two sides G and H which are of sinusoidal configuration. The sides G and H are exactly alike, and the spacing therebetween in the horizontal direction on Fig. 2 is uniform at all points between the parallel sides E and F. The horizontal dimension in Fig. 2 is the circumferential dimension of the tubular structure of Fig. 1, and the vertical dimension of Fig. 2 is the longitudinal dimension of the tubular deflection structure. It will be apparent that the sides E and F have a circumferential extent which corresponds to an arcuate extent of 90°. The sinusoidal lines G and H which bound the section A have an extent in the circumferential direction corresponding to an arcuate extent of 180°. It is therefore seen that the section A (as well as the other sections) has an overall circumferential extent from 0 to 270°.

It has been proven both mathematically and in practice that the electrodes having sections made up like the section A just described operate as though they were sections having an overall extent of 180°, 90° on either side of the dotted line K, and with the distribution of the field produced thereby being that which would be provided by a section varying sinusoidally in the horizontal direction (circumferentially). The various sections A, B, C and D produce entirely similar effects and are of exactly the same configuration as each other except every other section is opposite. The sections A, B, C and D may be formed as one continuous electrode and it will be noted that the horizontal or circumferential distance of the electrode throughout the entire length thereof is the same and corresponds to an arcuate extent of 90°. This facilitates connections to the electrodes since they are of large area and the point of connection is therefore not critical. Connection can be made to the points L, M, N, and P of Fig. 2.

It is therefore seen that the pattern provided is such that no gaps or unused space is provided between the electrodes on the insulating surface in order to provide the desired pattern geometry. This has two important advantages: first, increased sensitivity because of the complete utilization of all space, and second, the elimination of objectionable fields in the spaces not covered by electrodes which modifies the field produced by the electrodes and thereby distorts the overall field. However, in order to produce a usable deflection structure it is necessary to provide insulation between the individual electrodes. The use of uniform spacing between the electrodes, even though the space is small compared to the electrode area, results in distortion which may be objectionable in certain applications. Because of the tendency for flashover adjacent the points in the pattern, it is necessary to cut back the pattern to provide insulation at these points and this affects the geometry sufficiently to affect the field produced thereby.

It has been found that to provide spaces between adjacent electrodes which are of uniform width in a horizontal or circumferential direction does not affect the circular field distribution. This modification of the pattern is illustrated in Fig. 3, which shows on an enlarged scale the top section of the electrodes **20**, **21**, **22** and **23** of Fig. 2. The modification of the pattern to provide insulation between the various electrodes will be described with respect to electrodes **21** and **23** in Fig. 3. As in Fig. 2, the lines defining the electrode **21** have been designated E, F, G and H in Fig. 3. To provide the required spacing between electrodes, the electrodes **20** and **21** have been moved horizontally to the left and right respectively to the lines G_1 and G_2 to provide spacing therebetween. Similarly the electrodes **21** and **22** along the line H have been moved horizontally to the left and right to the position shown by lines H_1 and H_2. This provides a spacing between the electrodes which has a uniform horizontal or circumferential distance.

To consider the field distribution resulting from the pattern of Fig. 3, it is assumed that the electrode **21** is at a positive potential and the electrode **23** is at a negative potential of the same value. The electrodes **20** and **22**, which form the second pair, are assumed to be at zero potential. The electrodes are shifted horizontally on either side of the sinusoidal dividing lines by an increment d which is illustrated in Fig. 3 as 15°. To consider the field distribution produced by the electrodes, it is necessary to consider the surface distribution in two areas, first, the section from line Q to line R of electrode **21** for example, and second, the section which includes the portion of electrode **21** to the right of line R and the overlapping portion of electrode **23** to the left of line S.

Considering the first section, the area between lines Q and R is defined by the sinuosidal line G_2 and the sinusoidal line H_1. The line G_2 may be defined by the function

$$\tfrac{1}{2}[1-\cos(a-d)] \tag{1}$$

where a is the angular position as shown by the angular scale along the bottom of Fig. 3 and d is the angular spacing (horizontal) of the line G_2 from the line G. Similarly, the line H_1 may be defined by the function

$$\tfrac{1}{2}[1-\sin(a+d)] \tag{2}$$

The vertical distance varies as the difference between the lines G_2 and H_1 and is therefore equal to (1)—(2) or

$$\tfrac{1}{2}[\sin(a+d)-\cos(a-d)] \tag{3}$$

This may be changed in form to

$$-\tfrac{1}{2}(\cos a-\sin a)(\cos d-\sin d) \tag{4}$$

and further to

$$-\frac{1}{\sqrt{2}}\sin(a-45°)(\cos d-\sin d) \tag{5}$$

As the last term $(\cos d-\sin d)$ is a constant which depends on the spacing, it is apparent that the vertical dimension varies in a sinusoidal manner, with the maximum point being shifted by 45° from the axes as indicated by the line K.

The total effective vertical extent of the section between the lines R and S may be obtained by taking the portion of electrode **21** and subtracting the portion of electrode **23**, since this latter electrode is negative.

The portion of electrode **21** is defined by

$$1-\tfrac{1}{2}[\sin(a+d)-\cos(a-d)] \tag{6}$$

and the portion of electrode **23** is defined by

$$\tfrac{1}{2}[1-\cos(a+d)] \tag{7}$$

Subtracting (7) from (6) the following expression is obtained:

$$\tfrac{1}{2}[\sin(a+d)-\cos(a-d)] \tag{8}$$

This is the same expression obtained for the first section (3) and may be expressed

$$-\frac{1}{\sqrt{2}}\sin(a-45°)(\cos d-\sin d) \tag{9}$$

Accordingly it is apparent that the same sinusoidal distribution is continued from the first to the same sections, and will be continued throughout the entire pattern.

As stated above, the quantity (cos d—sin d) is a constant depending on the spacing. This is in effect a sensitivity factor, with the sensitivity going down as the spacing increases. Various spacings and the resulting sensitivity factors are shown in the following table.

d	(cos d—sin d)
0°	1
9°	.83
12°	.77
15°	.70
18°	.64

The spacing required depends, of course, on the voltage applied to the electrodes. It is believed that spacings in the range from 12° to 15° will generally be practical, and the sensitivity factor provided by this spacing will be adequate.

Because the points of the pattern are substantially horizontal lines, the horizontal shift described above provides very little spacing between adjacent electrodes at the points. That is, the point defined by lines G_2 and F of electrode **21** is very close to the line G_1 which defines the electrode **20**. That is, at the points, the vertical spacing between lines G_1 and G_2 becomes very small. This is particularly objectionable since as stated above, the tendency of arc over is greatest at the points. In order to provide adequate spacing at the points, greater clearance is provided by removing a portion T of electrode **20** to thereby move the line G_1 farther away from the line G_2 at this point. The conducting portions so removed may be replaced by adding a corresponding portion U which is displaced vertically on the electrode **20**. This material is placed in the gap between electrodes **20** and **23** at the intermediate point thereon at which the curves defining the electrodes have the greatest vertical component and thereby have the greatest vertical spacing. Therefore adequate insulation is still provided between the adjacent electrodes. The amount of material replaced is such that the vertical length of the electrode remains the same, and the active metal is exactly the same so that the field distribution is not substantially affected thereby.

The amount of material removed and shifted is exaggerated in Fig. 3 for purpose of illustration. This shifting will take place throughout the entire pattern as is illustrated in Fig. 4. This figure shows the same pattern as in Fig. 2, with insulation provided by horizontal shifting and by vertical compensation at the points, as shown in Fig. 3.

As described in Patent 2,617,077, greater deflection sensitivity can be obtained by providing the deflection structure on a conical support so that the electrodes assume an angle generally similar to the angle of the deflection of the beam. Deflection patterns for use on conical supports are illustrated in Fig. 5. The pattern of Fig. 5 is exactly the same as the patterns in Figs. 2 to 4 except that the dimension which is generally horizontal is smaller at the bottom than at the top, so that the pattern will fit a conical surface. Accordingly, the circumferential dimension of each electrode **30**, **31**, **32** and **33** varies linearly, and the arcuate extent thereof still remains constant. As in the case for a cylinder support, the overall arcuate extent of each electrode is 270° less the shift at each end thereof which provides the insulation. The pattern in Fig. 5 is made up of portions of the same general configuration as in Figs. 2 to 4 except for the change in the circumferential dimension so that the pattern will fit a cone.

In order to provide spacing between the electrodes **30**, **31**, **32** and **33** of Fig. 5 the individual electrodes are shifted in a circumferential dimension so that the spacing therebetween is constant in the circumferential direction. Fig. 5 shows in dotted lines the pattern with uniform circumferential spacing between the electrodes. However, as stated before, this does not provide sufficient insulation at the points, and in order to obtain this, material is shifted in the axial direction of the pattern to provide more spacing at the points and to reduce the spacing in the intermediate sections of the electrodes. The solid lines of Fig. 5 show the final pattern including shifts which are required to provide the necessary insulation. This follows the teachings set forth with respect to Fig. 3.

In Fig. 6 there is illustrated structurally a conical deflection unit in which a pattern as shown in Fig. 5 is used. The conical structure of Fig. 6 is shown to have only slight taper but it has been proven that relatively large tapers can be used when wider deflection angles are required, and this will result in increased sensitivity of the unit.

In Fig. 7 there is illustrated schematically a manner of operation of the deflection system to provide deflection in two directions at different frequencies. The tubular support member **40** has electrodes **41**, **42**, **43** and **44** on the inside thereof. These electrodes may be of the configurations previously described and are shown only schematically in Fig. 7. The high frequency (horizontal) deflection voltage is applied to terminals **45** and **46**, with the voltage on terminal **45** being applied through condensers **47** and **48** to electrodes **43** and **42** respectively, and the voltage on terminal **46** being applied through condensers **49** and **50** to electrodes **41** and **44** respectively. It is therefore seen that the entire electrode surfaces are utilized for providing horizontal deflection. The low frequency (vertical) deflection voltage may be applied to terminals **51** and **52**, with the voltage on terminal **51** being applied through resistors **53** and **54** to electrodes **43** and **41** respectively, and the voltage on terminal **52** being applied through resistors **55** and **56** to the electrodes **44** and **42** respectively. Accordingly, all of the electrode surface is also used for vertical deflection.

If the different frequencies used are widely separated, the resistor condenser network described will operate entirely satisfactorily to provide isolation therebetween. It is noted that the inputs are shown on opposite sides of a ground connection and this is to represent schematically that the voltages applied for both horizontal and vertical deflection must be balanced with respect to ground. Fig. 7 also illustrates the ease of shielding the deflection structure by providing a coating **60** on the outside of the tubular insulating member **40**. This coating may be grounded and will effectively shield the entire system.

As stated above, the space between the electrodes may cause undesirable fields which distort the overall deflecting field. This may be eliminated by controlling the potentials between the electrodes themselves by the use of a support member which is slightly conducting. For example, glass has been produced which, although having a very high resistance, is still somewhat conducting. This has been generally referred to as conducting glass. By using such a support member, and a grounded backing plate the surface between the various electrodes is held at ground potential so that no field is produced at these points. This is illustrated in Fig. 8 wherein the glass **35** is slightly conducting. A conducting plate **36** grounds one surface of the glass, and electrodes **37** and **38** are provided on the other side. The surfaces of the glass between the electrodes are therefore held at ground potential. If it were not for the conducting glass and ground plate, the surfaces might take potentials related to the potentials on the adjacent electrodes.

Another method of reducing the effect of fields between the various electrodes is illustrated in Fig. 9. In this figure the support is indicated at **62** and two adjacent electrodes at **63** and **64**. It is noted that in between the electrodes **63** and **64** there is a recess **65** in the support **62**. This operates to lengthen the path between the electrodes **63** and **64** and also to remove the field produced in the recess **64** from the active center of the deflection.

Such a structure could be provided by coating the entire inner surface of the support with a conducting material and cutting recesses through the coating to separate the same into four electrodes. This permits manufacture of the electrodes by relatively inexpensive painting or spraying processes rather than by expensive photoengraving processes or the like. The pattern could be exactly the same as illustrated in Figs. 2 to 5 inclusive so that the operating characteristics of the structure would be exactly the same.

It is to be noted that the patterns illustrated are relatively coarse. That is, relatively few sections of reversed direction, such as sections A and B of Fig. 2, are provided to make up the entire pattern. Although the coarseness of the pattern affects the field closely adjacent the surface of the electrodes, this difficulty is self-correcting when rectangular deflection is provided in the circular structure, as the beam is closest to the circular structure only at the corners of the pattern, and at such times the potential between adjacent plates for horizontal and vertical deflection is well below the maximum potential difference and therefore the effect of the field at the electrode structure is less objectionable.

Although glass has been mentioned as a material for the support member, it is to be pointed out that other insulating or highly resistive materials can be used. The electrodes can be provided on the support by various depositing methods such as printing or plating, and the pattern formed either when the conducting material is applied, or by etching, cutting, etc., the spaces from a continuous coating. It is obvious that various known materials and techniques may be used.

It is therefore seen that there has been provided an electrostatic deflection structure which may be used in a circular form to provide accurate and sensitive deflection in two directions at right angles to each other as is required for television and oscilloscope use. This structure is also applicable for use with circular deflection as used in radar and other applications. As previously stated, the pattern geometry which provides electrodes on the entire surface is highly advantageous, and the minimum spacing between the electrodes which is necessary for insulating the same has been arranged so that the distortion produced thereby is inconsequential and the system is highly circular.

Although certain embodiments of the invention have been described which are illustrative thereof, it is obvious that various changes and modifications can be made therein within the intended scope of the invention as defined in the appended claims.

We claim:

1. An electrode structure for providing electrostatic deflection of a cathode ray beam including, a tubular support member having an opening therein through which the beam passes, four conducting electrodes symmetrically positioned with respect to each other on the surface of said opening in said member, each of said electrodes extending longitudinally of said tubular member and being of zigzag shape with apex portions extending in opposite direction around said tubular member and having an overall angular physical extent thereabout of substantially 270°, said electrodes being interleaved to provide a substantially continuous conducting coating on said surface, said electrodes having adjacent edges of complementary sinusoidal configuration so that the electrical field produced by applying a potential to alternate electrodes has an effective angular extent of substantially 180° and a substantially sinusoidal distribution through this extent.

2. An electrode structure for providing electrostatic deflection of a cathode ray beam including, a support member having an opening therein through which the beam passes, and four conducting electrodes symmetrically positioned with respect to each other on the surface of said opening in said member, each of said electrodes extending longitudinally of the beam path and being of zigzag shape with apex portions extending in opposite directions around said opening and having an overall angular physical extent thereabout of substantially 270°, said electrodes being of such configuration that the electrical field produced by applying a potential to alternate electrodes has an effective angular extent of substantially 180° and a substantially sinusoidal distribution through this extent, said electrodes being interleaved and spaced from each other by a substantially uniform amount, with the opposed edges of adjacent electrodes being of substantially sinusoidal configuration.

3. An electrode structure for providing electrostatic deflection of a cathode ray beam including, a support member having an opening therein through which the beam passes, and four conducting electrodes symmetrically positioned with respect to each other on the inner surface of said opening in said member, each of said electrodes extending longitudinally of the beam path and being of zigzag shape with the apices thereof extending angularly around said opening and having an overall angular extent of substantially 270°, said electrodes being of such configuration that the electrical field produced by applying a potential to alternate electrodes has a substantially sinusoidal distribution through an angular extent of substantially 180°, the opposed edges of adjacent electrodes being of complementary substantially sinusoidal configuration and being spaced from each other by a substantially uniform angular extent to provide insulation therebetween, and the portions of said conducting electrodes adjacent the apices of adjacent electrodes being spaced greater than said angular extent to provide additional insulation at said apices.

4. An electrode structure for providing electrostatic deflection of a cathode ray beam including, a tubular support member of frusto-conical configuration having an opening adapted to receive the cathode ray beam therethrough, four conducting electrodes symmetrically positioned with respect to each other on the surface of said opening in said member, each of said electrodes extending longitudinally of said tubular member and being of zigzag shape with apex portions extending in opposite direction around said tubular member and having an overall angular physical extent thereabout of substantially 270°, each of said electrodes having a continuous angular circumferential extent of substantially 90° with the edges of adjacent electrodes being of complementary sinusoidal configuration through an angular extent of substantially 180° said electrodes being interleaved to provide a substantially continuous conducting coating on said surface and being of such configuration that the electrical field produced by applying a potential to alternate electrodes has an effective angular extent of substantially 180° and a sinusoidal distribution through this extent.

5. An electrode structure for providing electrostatic deflection of a cathode ray beam including, a tubular support member having a circular opening therein through which the beam passes, four conducting electrodes symmetrically positioned with respect to each other on the inner surface of said opening in said tubular member, each of said electrodes extending longitudinally of said tubular member and being of zigzag shape with the apices thereof extending around said member and having an overall angular extent of substantially 270°, each of said electrodes having an angular extent of substantially 90° at all points throughout the entire length thereof, with adjacent electrodes having opposed edges of complementary substantially sinusoidal configuration which have an angular extent of substantially 180°, whereby the electrical field produced by applying a potential to alternate electrodes has a substantially sinusoidal distribution through an angular extent of substantially 180°.

6. An electrode structure for providing electrostatic deflection of a cathode ray beam including, a tubular support member having an opening therein through which the beam passes, said support member being made of a

material having high electrical impedance, four highly conducting electrodes symmetrically positioned with respect to each other on the inside surface of said tubular support member, each of said electrodes being a continuous conductor extending longitudinally of said tubular member having substantial width and being of zigzag configuration, said electrodes having apex portions extending around said tubular member in opposite directions and being interleaved with the apex portions of the adjacent electrodes, each of said electrodes having an overall angular extent of substantially 270° and being of such configuration that the field produced by alternate electrodes has a substantially sinusoidal distribution throughout an angular extent of substantially 180°, said electrodes being spaced from each other to provide a high impedance conducting path therebetween through said support member, and a conducting coating on the outside of said tubular member adapted to be connected to a reference potential and forming a shield about said electrodes.

7. An electrode structure for providing electrostatic deflection of a cathode ray beam including, a tubular support member having an opening therein through which the beam passes, said support member being made of conducting glass having high electrical impedance, four highly conducting electrodes symmetrically positioned with respect to each other on the surface of said opening in said support member, each of said electrodes being a continuous conductor of substantially 90° circumferential width and of zigzag configuration with edges comprising sinusoidal portions having an extent of substantially 180°, each of said electrodes extending longitudinally of said tubular member and having apex portions extending around said tubular member in opposite directions and interleaved with the apex portions of the adjacent electrodes, each of said electrodes having an overall angular extent of substantially 270° and being of such configuration that the field produced by alternate electrodes has a substantially sinusoidal distribution throughout an angular extent of substantially 180°, said electrodes being uniformly spaced from each other to provide a high impedance path therebetween through said support member.

8. An electrode structure for providing electrostatic deflection of a cathode ray beam including, a tubular support member having an opening therein through which the beam passes, conductor means on the surface of said opening, said conductor means having gaps therein which divide the same into four substantially identical symmetrically positioned electrodes, each of said electrodes extending longitudinally of said support member and being of zigzag shape with apex portions extending in opposite directions around said tubular member, said apex portions of each electrode having an overall angular extent of substantially 270°, said electrodes having such configuration that the electrical fields produced by applying a potential to alternate electrodes has a substantially sinusoidal distribution through an angular extent of 180°, said support member having recesses therein at the gaps in said conductor means, said recesses being effective to reduce the field produced at the gaps between said electrodes so that such field has substantially no effect on the field produced by said electrodes.

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