Nov. 12, 1957 G. L. GRUNDMANN 2,813,212

ELECTROMAGNETIC CATHODE RAY BEAM DEFLECTION SYSTEM

Filed Dec. 28, 1955

2 Sheets-Sheet 1

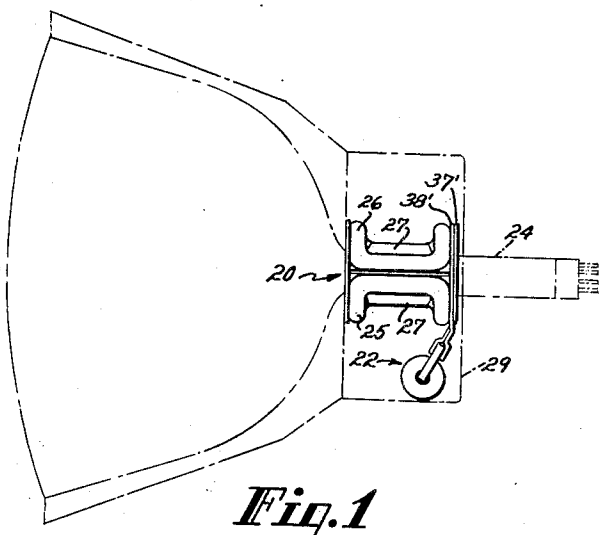


Fig. 1

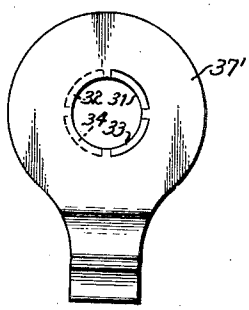


Fig. 5

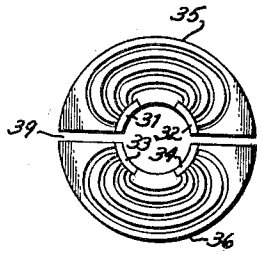


Fig. 3

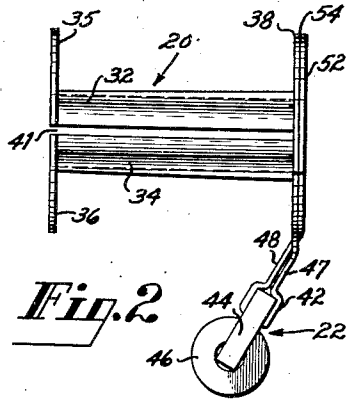


Fig. 2

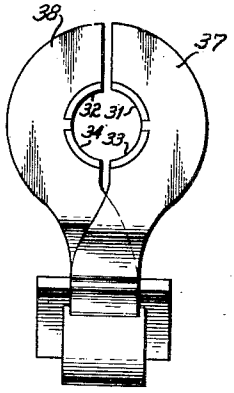


Fig. 4

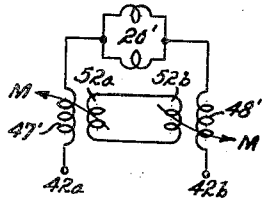


Fig. 6

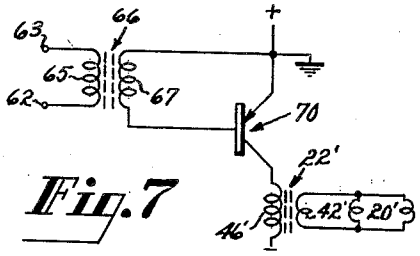


Fig. 7

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ELECTROMAGNETIC CATHODE RAY BEAM DEFLECTION SYSTEM

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2 Sheets-Sheet 2

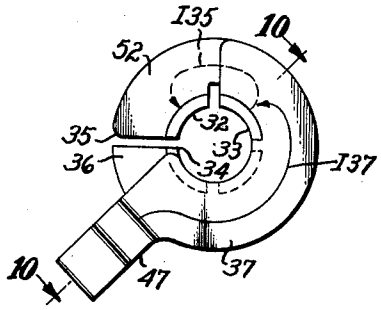


Fig. 8

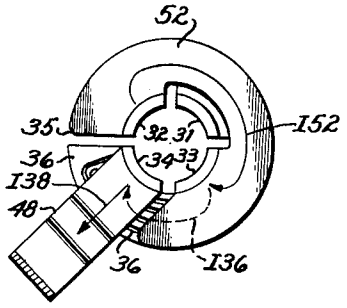


Fig. 9

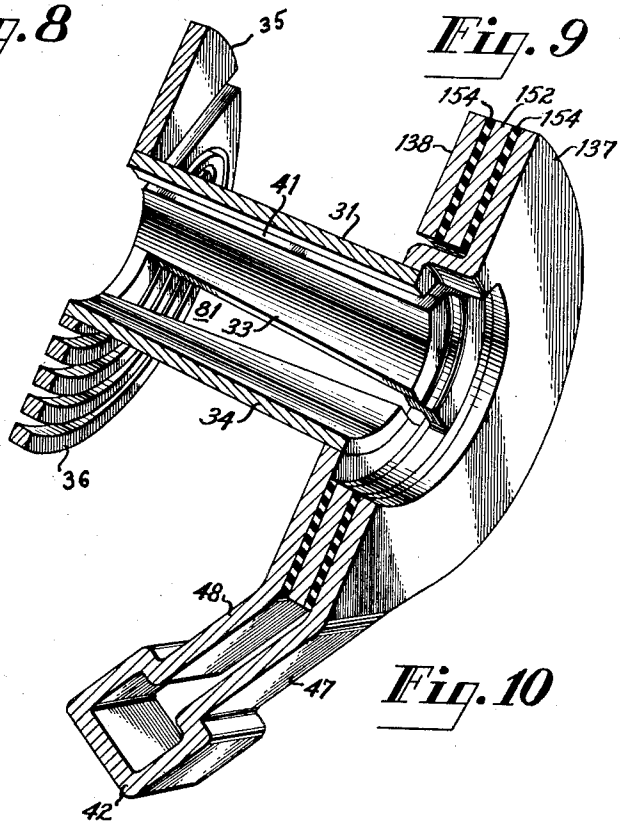


Fig. 10

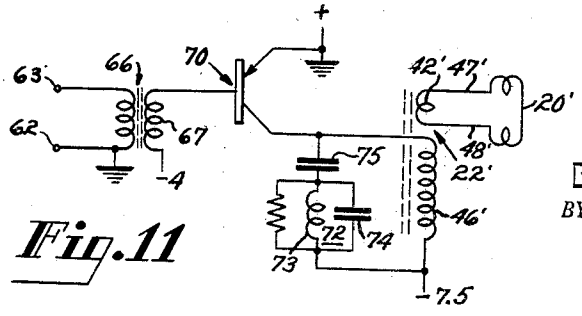


Fig. 11

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ELECTROMAGNETIC CATHODE RAY BEAM DEFLECTION SYSTEM

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Application December 28, 1955, Serial No. 555,857

11 Claims. (Cl. 313—76)

The invention relates to systems for electromagnetically deflecting the electron beam of a cathode ray tube, and it particularly pertains to the structures for developing the necessary magnetic field for the deflection of the electron beam of a television image reproducing device, or kinescope.

In present television practice, the electron beam in a cathode ray image reproducing device, or kinescope, is deflected in two directions at right angles with respect to each other by means of magnetic fields produced by separate windings mounted in a mechanical yoke arranged about the neck of the kinescope. Usually each of the windings is made up of two coils or sections which are shaped to conform to the curvature of a winding form. The form, which may be of tubular configuration, has an axial bore in which a portion of the cathode ray tube is located. One of the two coils or sections of a winding is placed about the form on one side of the bore and the other coil or section is placed on the opposite side. The two coils or sections of the other winding are similarly placed relative to one another in positions which are respectively 90° from the coils or sections of the first winding.

Each coil consists of two principal conductor portions. One portion is constituted by two groups of active conductors positioned on either side and parallel to the longitudinal axis of the kinescope. These conductors are effective in establishing the main flux in the path of the electron beam in the kinescope. The other portion is constituted by the two groups of end turns ordinarily formed in arcuate pattern about the neck of the cathode ray kinescope for connecting the active conductors together. While the end turns do not produce a strong field in the path of the electron beam, nevertheless, they must be placed properly to prevent the end turn field from causing distortion in the main field of the electron beam deflecting winding. Thus, extreme care must be taken in fabricating the windings of an electron beam deflection system and therefore the deflecting windings constitute a very expensive component of a television receiver.

An object of the invention is to reduce the cost of manufacture of an electromagnetic deflection system for cathode ray tubes and kinescopes.

Another object of the invention is to produce an electromagnetic electron beam deflection system for a cathode ray tube or kinescope by means providing closer manufacturing tolerances than is provided by the means for manufacturing the prior art deflection systems.

A further object of the invention is to simplify the structure of electromagnetic cathode ray beam deflection systems.

According to the invention, the electron beam in a cathode ray tube, or kinescope, is deflected from the normal trajectory by passing an electric deflection wave current through elongated field producing conductors axially disposed on either side of the envelope of the cathode ray tube to vary the magnetic field in which the beam is

arranged. An annular conductor arranged about the neck of the tube and substantially normal to the axial conductors serves to connect like ends of the axial conductors together at one end of the structure, while at the other ends of the axial conductors, segments of another annular conductor are used to apply deflection currents. Both annular conductors also are arranged to confine the magnetic field to the desired portion of the cathode ray tube and distribute the flux within the field in the manner predetermined for the desired deflection of the electron beam. The terminal conductors are connected to a heavy conductor forming a single turn about the core of a deflection wave output transformer. An annular ring insulated from but mounted in close contiguous relationship to the annular terminal conductor segments serves to reduce the inductance component in the leads so that the effective inductance component is in the deflecting structure itself. Alternatively, the terminal conductors may be in the form of two parallel annular rings separated by a thin dielectric member and individually connected to the ends of the elongated conductors. In such construction the rings cooperate to reduce the lead inductance component.

For deflection of an electron beam in two directions normal with respect to each other, two such structures may be employed and arranged in concentric relationship. The efficiency of each structure will be adversely affected due to circulating currents induced in the low impedance and conductor of the adjacent structure. According to the invention in such cases, the elongated axial conductors of the inner structure are given longitudinal slot coupling between the elongated conductors of the outer structure and the annular end conductor of each structure is slotted to provide a plurality of annular segment conductors with slots of annular segment configuration therebetween which effectively decreases the circulating current induced by the other deflection structure.

In the arrangements as thus far described the deflection currents flow in the longitudinal elongated magnetic field producing conductors of each structure in two paths effectively in parallel with respect to the deflection current source. In another embodiment of deflection structures according to the invention the annular sector terminal conductors of each structure are insulated from another conductor which is arranged to "cross-over" and interconnect one of the conductors of each pair to cause the deflection currents to traverse the pairs of elongated conductors in series relationship with respect to the current source. With this arrangement the inductance component due to the lead conductors is reduced by the cross over conductor.

The deflection structure according to the invention lends itself readily to fabrication by diecasting or stamping. The conductive material may be in a less expensive form and the tedious and expensive winding process is also eliminated. Furthermore, the conductive members of the structure according to the invention are sufficiently rugged so as to withstand distortion and, if desired, may be molded into an insulating medium rendering a structure that is light while at the same time sufficiently strong to serve as at least a partial support for the cathode ray tube or kinescope.

In order that all the advantages may be fully realized in practice, several embodiments of the invention will be described, by way of examples only, with reference to the accompanying drawing in which:

Figure 1 is an elevation view of a deflection structure according to the invention shown in relationship to a conventional electron beam deflection system;

Figure 2 is an elevation view of an embodiment of the deflection structure according to the invention;

Figures 3 and 4 are end views of the structure shown in Figure 2;

Figure 5 is an end view of a terminal plate of an alternate embodiment of the invention;

Figure 6 is an equivalent circuit diagram of an embodiment of the invention;

Figure 7 is a schematic diagram of a circuit used for generating deflection currents for application to the structure according to the invention;

Figures 8 and 9 are end views of a further embodiment of the invention;

Figure 10 is a cross-section view of another embodiment of the invention taken along a line corresponding to the line 10—10 of Figure 8; and

Figure 11 is a schematic diagram of another circuit arrangement for applying deflection currents to a deflection structure according to the invention.

Figure 1 illustrates the setting of the invention. The beam deflecting structure 20 according to the invention is energized through the intermediary of an output deflection wave transformer 22 in order, for example, to deflect an electron beam within the envelope of a cathode ray tube or kinescope, the outline of which is indicated by the chain line 24 in the horizontal direction. As shown in this figure the electron beam is deflected in a direction normal to the above described deflection by means of a beam deflecting winding comprising two sections 25, 26 which may be entirely conventional in all respects. Ferromagnetic core pieces 27 are arranged about the beam deflecting structure 20 and the coil sections 25, 26. In the figure only the off core pieces are shown, the near core pieces being removed to show the construction. Usually a metal band (not shown) is arranged about the core pieces 27 to hold the entire structure firmly in place. In practice this metal band is held by conventional structural means in fixed relationship to the chassis of a television receiver or to a metal shield which is arranged about the cone of the kinescope and the deflection system components, which shield is indicated by the double chain line 29. If desired this practice may be adhered to with the structure of the invention. It should be understood at the outset that the arrangement shown in Figure 1 includes conventional deflection system winding sections 25, 26 only in order to show the relative structural relationship between the arrangement according to the invention and the prior art and that deflection of an electron beam in two directions may be readily accomplished by two structures according to the invention arranged in coaxial relationship.

An elevation view and two end views of an embodiment of beam deflecting structure according to the invention is shown in Figures 2 to 4. For clarity the transformer 22 is omitted from Figure 3 and members 52 and 54 are omitted from Figure 4. The desired magnetic field is developed between pairs of elongated magnetic field producing conductors or bars 31, 32 and 33, 34 of equal length arranged in the surface of a figure at revolution about the axis of the kinescope. These bars may have flat surfaces on all sides, or may have irregular cross-sections, or may be constituted by segments of a tubular structure. The latter configuration is preferred because more uniform magnetic field distribution is afforded thereby. Each pair of bars 31—32, 33—34, are electrically connected together at one end by annular segments 35, 36 respectively of an annular current return plate. By means of annular segments 37, 38 of an annular lead plate, deflection currents are applied at the other ends of the bars 31, 33 and 32, 34. Alternatively, the end plates 35, 36 may be segments of a frustum of a cone more closely adhering to the shape of the kinescope instead of flat as shown. Conductive leads connected to the lead plates 37 and 38 are connected to a secondary winding 42 arranged on a core 44 of ferromagnetic material of the deflection wave output transformer 22 having a primary winding 46. As shown the leads 47, 48

are integral parts both of the lead plate segments 37, 38 and of the single turn of the secondary winding 42, although separate parts may be used if adequate current carrying joints are provided. The arrangement shown lends itself to simple and inexpensive construction eliminating the difficulty of making joints of high current carrying capacity and low resistance. The lead plate segments 37 and 38 are arranged in a single plane with the leads 47 and 48 spaced apart from each other, the only connections between the lead plate segments 37, 38 being through the bars and return plate segments 31 to 36. In the structure shown in Figures 2 to 4 the deflection current is divided into two parallel paths, one path constituted by the upper bars 31, 32 and return segment 35 and the other being constituted by the lower bars 33, 34 and return segment 36.

Alternatively, where beam deflection is required in one direction only as in a few types of potential indicating instruments, the bars 31 and 33, the return segments 35 and 36, and the bars 32 and 34 may be integrally joined to form a simpler arrangement.

Circulating currents induced in this low impedance structure by the structure for deflecting the electron beam in another direction will reduce the efficiency of the structure for deflecting the beam in the other direction. The effect is mutual between the two structures. According to the invention, the segments of both structures are separated in effect into a plurality of annular conductor segments 35′ and 36′ separated by slots of annular segment configuration, as shown for one structure, in order to eliminate or reduce these losses. Further according to the invention, efficient coupling between the bars of another associated deflection structure, is provided by a single further diametrical slot 41 dividing each of the axial conductors into two pairs of bars as shown.

The inductance of such a structure itself is very low. A structure designed for use with conventional kinescopes for deflection at frequencies of 60 C. P. S. and 15 kc. will have an inductance of the order of 0.03 to 0.15 microhenry. The inductance of the lead plate segments 37, 38 and the leads 47, 48 therefore may form a large part of the total inductance presented to the source of deflection current. This inductance may be reduced by arranging a neutralizing ring 52 close to but electrically separated from the lead plate segments 37, 38 by a layer of insulating material 54. In the interest of clarity the ring 52 and the insulating material 54 are omitted from the end view of Figure 4 since they are of simple annular configuration. In the interest of simplicity, no means for mechanically fixing the ring 52 or the material 54 to the lead plates 37 and 38 are shown nor are there shown any means for rigidly holding the other members in fixed relationship to each other, since such means will be provided by those skilled in the art.

The neutralizing ring 52 may be at chassis potential and therefore may be constituted by the end plate itself of the tube shielding and mounting shell which is indicated by the chain line 29 in Figure 1. Those skilled in the art will provide a structure of strength necessary to support the neck end of the kinescope. Where mounting strength is not required, the neutralizing ring 52 can be made of a thin sheet of foil of sufficient thickness to carry the eddy currents. This foil can be fastened to the lead plates 37, 38 by a cement having insulating properties constituting the insulating material 54.

Figure 5 shows an alternate construction of lead plate wherein at least one of the lead plates 37′ and 38′ (the latter being hidden behind the former) is a complete annular ring instead of a segment. The lead plates are offset to lie in the same plane for connection to the field producing bars which must be of equal length to avoid distorting the field. It is only necessary to offset or indent the lead plates to lie in a single plane near the parts of contact with the field producing bars. Large areas may lie in different planes if desired. Portions of

the lead conductors that may interfere with such bending or offsetting may be removed without affecting the performance. The plates are insulated from each other, either or both by bending and spacing in air or by a thin layer of dielectric material capable of withstanding the electromotive potential stress. The conductor bars 31 and 33 are connected to the lead plate 37' while the other conductor bars are connected to the lead plate 38' as indicated by the dashed lines representing the hidden ends of the latter conductors. This is the form of construction illustrated in Figure 1. It has been found that in most cases the inductance will be sufficiently reduced if the lower lead plate 38' is only approximately half of the area of the other. This smaller portion is easier to pass through the transformer core 44 during manufacture, less material is consumed, and so on.

Figure 6 is an equivalent diagram illustrating the mode of operation of the reducing plate 52. The inductance components of the leads 47, 48 are represented by the inductors 47' and 48' respectively. The inductance of that part of the structure according to the invention which provides the magnetic deflection field is represented by the network 20'. The transformer secondary winding is connected to the terminals 42*a* and 42*b*. The reducing plate 52 is represented by a pair of intercoupled inductors 52*a* and 52*b* coupled to the lead inductors 47', 48'. The total inductance presented to the source 442' is $L_{20}+L_{47'}+L_{48'}-2M$. Therefore, the mutual coupling M is made as large as possible in order to reduce the total inductance as much as possible.

Figure 7 is a schematic diagram of a circuit for driving the electron beam deflecting structure according to the invention. A deflection pulse wave is applied to deflection voltage input terminals 62, 63 connected to transformer 66. A secondary winding 67 of the transformer is coupled to the input circuit of a controlled electron flow path device, shown as a transistor 70 connected in a base input circuit arrangement. The circuit is self damping. The driving pulse applied between the base and emitter electrodes is positive going and of width sufficient to maintain the base electrode sufficiently positive to block the transistor 70 during periods of high collector electrode voltage brought about by kick-back from the output transformer 22 and the electron deflecting structure 20. The low impedance afforded by the electron beam deflecting structure according to the invention makes it ideal for drive by transistor circuits because of the low output impedance of the transistor. In the circuit shown in Figure 7 the transformer primary to secondary turns ratio is of the order of 30:1 while the peak ampere turns capacity of the transformer is of the order of 380. The average current flowing in the secondary winding of the transformer and in the electron beam deflecting structure is of course much lower than this figure. The structure may be driven if desired by a vacuum tube circuit where the output transformer is designed to match the impedance of the deflecting structure 20 to the vacuum tube, although conventional vacuum tubes have output impedance that renders the matching of the low impedance of the deflecting structure shown less easy. In one tested embodiment a transformer having a ratio of 1150:1 was used to match the output impedance of an electron discharge tube to a beam deflecting structure according to the invention, with entirely satisfactory results.

The structure according to the invention as thus far described is arranged to provide parallel current paths. Figures 8 and 9 show end views of an electron beam deflecting structure according to the invention having lead plates arranged to provide flow of deflecting currents through the bars in series with respect to the secondary winding 42. Deflection current induced in the secondary winding 42 flows through the lead 47'' to a lead plate 37'' which is a segment of substantially ¾

of an annulus. This lead plate 37'' is connected only to one beam deflecting conductor bar 33 at the near end. The far end of the conductor 33 is connected to the far end of the complementary conductor 32 by the end plate segment 35 (only a small corner of which is shown in Figures 8 and 9 since it is nearly hidden by the cross-over plate 52''). The near end of the beam deflecting conductor 36 is connected by means of an annular segment inductance reducing and "cross-over" plate 52'' to the further beam deflecting conductor 33. The "cross-over" plate 52'' is also approximately ¾ of an annulus as can be seen in Figure 9 where half of the winding 42, the lead 47'' and the lead plate 37'' have been removed to expose the lead plate 38'' and lead 48''. The deflection current now flows down the beam deflecting conductor 33 to the end plate 36 and back through the complementary conductor 34 to the other lead plate 38'' and therethrough the lead 48'' and to the winding 42. The lead plate 38'' as shown is little more than an extension of the lead 48'', although it may be enlarged if necessary to reduce the inductance component. It should be noted that the instantaneous flow of deflection current in the lead plate 37'', as indicated by the arrow 137, opposes the flow in the cross-over plate 52'', as indicated by the arrow 152, and the flow in the lead plate 38'', as indicated by the arrow 138. The dashed-line arrows 135 and 136 indicate the corresponding instantaneous flow in the end plate segments 35 and 36 respectively.

Figure 10 is an isometric cross-section view of an embodiment of the invention similar to that shown in Figure 8 except for full annular lead and cross-over plates. The cross-section is taken along a line corresponding to the line 10—10 of Figure 8 whereby details of construction of the previous embodiments are also illustrated in Figure 10. For example, the offsetting or indenting of the lead plates is clearly indicated.

The lead plates 137 and 138 are constructed much the same way as the lead plate shown in Figure 5 except that only one conductor bar 31 is connected to one annular lead plate 137 and but one other conductor bar 34 is connected to the other annular lead plate 138. The remaining conductor bars 32 and 33 are connected to an annular inductance reducing and cross-over connecting plate 152 which is arranged between and insulated from the lead plates 37'' and 138 by means of two insulating members 154. The cross-over plate 52'' and one lead plate 137 must be suitably notched and indented so that the points of connection to the conductor bars 32 and 33 lie in the same plane. With this arrangement current flowing in one lead 47 flows through one lead plate 37'', the conductor 32, the end plate segment 35 and back through the conductor 32, through the cross-over plate 54'', the conductor 33, the return plate 36, back through the conductor 34, and then through the other lead plate 38'', to the other lead 48. Thus, the deflection current traverses the several bars in series.

The equivalent diagram of the arrangements shown in Figures 8 to 10 is substantially the same as that shown in Figure 6. The main difference is that the cross-over plate 52'' provides the coupling but otherwise the arrangement is the same. The structure shown in Figures 8 to 10 may be driven by an arrangement such as that shown in Figure 7. The impedance ratio is increased by a factor of 4 in such an arrangement, making it easier to drive with a vacuum tube if desired. The turns ratio of the transformer is still of the order of 275:1, however.

Figure 11 is an alternate circuit arrangement for exciting the electron beam deflecting structure according to the invention. Greater power output for the maximum dissipation is obtained by a parallel circuit 72, tuned to resonance at the third harmonic of the deflection frequency by proper value of the inductor 73 and the capacitor 74, and connected in series with a shunting capacitor 75 tuning the output circuit to resonance at the deflective

frequency. Effective results will be obtained by connecting the parallel circuit 72 in series with the collector electrode and the primary winding of the output transformer 22. A shown the parallel circuit is interposed directly in the shunt connection. Those skilled in the art can readily determine the circuit constants for the transposed circuit. With the arrangement shown a reduction of our 15% was obtained, resulting in our 15% greater deflection from the same transistor. In this circuit arrangement, which operates on a "narrow pulse basis," the transistor serves as a damping device as well as a current switch resulting in a very simple but highly efficient deflection system.

It should be clearly understood, however, that the electron beam deflecting structure according to the invention is by no means limited as to the form of exciting circuit arrangement. The circuits shown and described are given as examples of successfully operated circuits.

Two electron beam deflecting structures according to the invention may be superimposed and arranged to deflect the electron beam in two directions normal with respect to each other just as the conventional horizontal and vertical deflection coils of a television receiver are so arranged. The two structures, one of which is essentially arranged within the other, may be molded into insulating material to form a unitary structure of considerable strength.

The magnetic field producing conductor bars 31 to 34 may be arranged to provide either uniform or nonuniform distribution of the magnetic flux. With bars of uniform cross-section the spaces or slots 41 between the bars 32 and 34 as shown in Figure 2 are rectangular and of uniform width, tending to establish a uniform flux distribution. The alternate spaces 81, termed windows, between the bars 33 and 34 may be, for example, tapered as can be determined from examining Figures 2 to 4 and which is better shown in Figure 10. With this arrangement the magnetic flux is concentrated near the electron gun end of the kinescope at which point maximum beam deflection is desired so that much more of the flux is concentrated in the conical space increasing the deflection sensitivity of the kinescope. This also introduces a barrel-shaped magnetic field at the gun end which will offset the normal tendency to establish a pin cushion-shaped magnetic field at the other end. With proper design of the conductor bars, excellent linear deflection can be obtained.

Small quantities of the structure according to the invention may be made by cutting parts from sheet and tubular stock and soldering them together. For production in quantity the structure may be diecast if desired. Alternatively, the structure may be stamped from sheet metal such as copper, silver, aluminum and so on; the choice depending on relative cost and/or the degree of conductivity required. The structure can be held by a form of Bakelite, polystyrene and the like, providing the necessary rigidity of structure, insulation and form for holding the core pieces. If desired the structure can even be molded right into the insulating material.

The invention claimed is:

1. A structure for deflecting an electron beam produced within a cathode ray tube, including a plurality of pairs of elongated conductors, the conductors of each pair being arranged longitudinally on either side of the longitudinal axis of the cathode ray tube in position for operation, a sectored annular conductor, each sector of said conductor interconnecting like ends of each of said pair of elongated conductors, two lead conductors of configuration lying within the confines of an annular geometrical figure of rotation about the longitudinal axis of the cathode ray tube in position for operation and connected to the other ends of said elongated conductors, and means to apply deflection currents between said lead conductors.

2. A structure for deflecting an electron beam produced within a cathode ray tube, including two pairs of elongated conductors, the conductors of each pair being arranged longitudinally on either side of the longitudinal axis of the cathode ray tube in position for operation, annular sector conductors of configuration lying within the confines of an annular geometric figure of rotation about the longitudinal axis of the cathode ray tube in position for operation and interconnecting like ends of each of said pair of elongated conductors, two lead conductors of configuration lying within the confines of an annular geometrical figure of rotation about the longitudinal axis of the cathode ray tube in position for operation and connected to the other ends of said elongated conductors, an annular conductor contiguous to and insulated from both of said lead conductors, and means to apply deflection currents between said lead conductors.

3. A structure for deflecting an electron beam produced within a cathode ray tube, including a bisected annular conductor of configuration of a geometrical figure of rotation about the longitudinal axis of said cathode ray tube in position for operation, a pair of lead conductors of configuration lying within an annular geometrical figure substantially parallel and spaced from said bisected annular conductor along said longitudinal axis, two pairs of elongated conductors arranged uniformly about said cathode ray tube and connected between the sectors of the annular conductors, at least the alternate conductors being wider at one end than at the other, and means to apply deflection currents to said lead conductors.

4. A structure for deflecting an electron beam produced within a cathode ray tube, including two pairs of elongated conductors, the conductors of each pair being arranged longitudinally on either side of the longitudinal axis of the cathode ray tube in position for operation, a pair of annular sector conductors individually interconnecting like ends of each of the elongated conductors of said pairs, a pair of annular sector lead conductors individually interconnecting the other ends of one elongated conductor of each of said pairs of conductors, and means to apply deflection currents between said lead conductors.

5. A structure for deflecting an electron beam produced within a cathode ray tube, including two pairs of elongated conductors, the conductors of each pair being arranged longitudinally on either side of the longitudinal axis of the cathode ray tube in position for operation, a pair of annular sector conductors individually interconnecting like ends of each of the elongated conductors of said pairs, a pair of coplanar annular sector lead conductors individually interconnecting the other ends of one elongated conductor of each of said pairs of conductors, an annular conductor contiguous to and insulated from said coplanar lead conductors, and means to apply deflection currents between said lead conductors.

6. A structure for deflecting an electron beam produced within a cathode ray tube, including two pairs of elongated conductors the conductors of each pair being arranged longitudinally on either side of the longitudinal axis of the cathode ray tube in position for operation, a pair of annular sector conductors individually interconnecting like ends of each of the elongated conductors of said pairs, annular lead conductors lying in separate parallel planes and individually interconnecting the other ends of one elongated conductor of each of said pairs of conductors, and means to apply deflection currents between said annular lead conductors.

7. A structure for deflecting an electron beam produced within a cathode ray tube, including two pairs of elongated conductors the conductors of each pair being arranged longitudinally on either side of the longitudinal axis of the cathode ray tube in position for operation, a pair of annular sector conductors individually interconnecting like ends of each of the elongated conductors of said pairs, annular segment lead conductors lying in a given plane and individually connected to the other ends of one elongated conductor of each of said pairs of conductors, an annular conductor having one portion in-

terposed between and lying in the same given plane with said annular lead conductors and interconnecting the other ends of the other conductors of said pairs, and means to apply deflection currents between each of said annular lead conductors and said annular conductor in common.

8. A structure for deflecting an electron beam produced within a cathode ray tube, including a pair of elongated conductors arranged longitudinally on either side of the longitudinally axis of the cathode ray tube in position for operation, an end conductor lying in an annular geometric figure of revolution about the longitudinal axis of said elongated conductors and interconnecting like ends of said pair of elongated conductors, said end conductor having annular segment slots arranged therein, a pair of lead conductors lying in an annular geometric figure of revolution about said longitudinal axis and individually connected to the other ends of said conductors, and means to apply deflection currents between said pair of lead conductors.

9. A structure for deflecting an electron beam produced within a cathode ray tube, including a plurality of pairs of elongated conductors, the conductors of each pair being arranged longitudinally on either side of the longitudinal axis of the cathode ray tube in position for operation, a sectored annular conductor, each sector of said conductor interconnecting like ends of each of said pair of elongated conductors and having annular slot portions therein, two lead conductors of configuration lying within the confines of an annular geometrical figure of rotation about the longitudinal axis of the cathode ray tube in position for operation and connected to the other ends of said elongated conductors, and means to apply deflection currents between said lead conductors.

10. A structure for deflecting an electron beam produced within a cathode ray tube, including two pairs of elongated magnetic field producing conductors, the conductors of each pair being arranged longitudinally on either side of the longitudinal axis of the cathode ray tube in position for operation, a pair of annular sector conductors individually interconnecting like ends of each of the elongated conductors of said pairs, said sector conductors each comprising a plurality of separate conductors having ends interconnected with the ends of each pair of field producing conductors and spaced apart to leave apertures of annular segment configuration in the annular confines of said sector conductors, a pair of coplanar annular sector lead conductors individually interconnecting the other ends of one elongated conductor of each of said pairs of conductors, and means to apply deflection currents between said lead conductors.

11. A structure for deflecting an electron beam produced within a cathode ray tube, including two pairs of elongated conductors, the conductors of each pair being arranged longitudinally on either side of the longitudinal axis of the cathode ray tube in position for operation, a pair of annular sector conductors individually interconnecting like ends of each of the elongated conductors of said pairs, a pair of annular sector lead conductors having coplanar portions individually connected to the other ends of one elongated conductor of each of said pairs of conductors, an annular conductor contiguous to and insulated from said lead conductors and having portions coplanar with the coplanar portions of said lead conductors interconnecting the other ends of the other of said conductors, and means to apply deflection currents between said lead conductors.

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