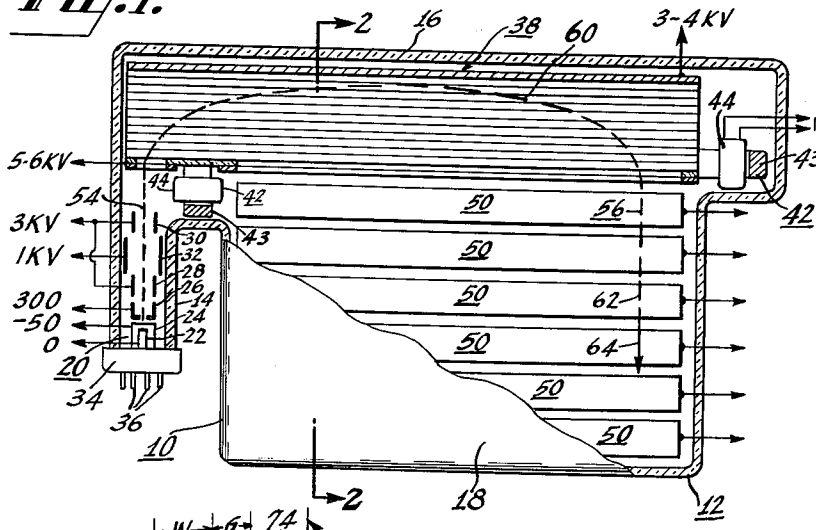
Dec. 28, 1965 TE NING CHIN 3,226,587

CATHODE RAY TUBE AND MAGNETIC DEFLECTION MEANS THEREFOR

Filed Jan. 28, 1960 3 Sheets-Sheet 1

Fig. 1.



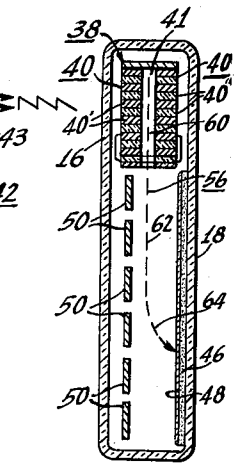




Fig. 2.

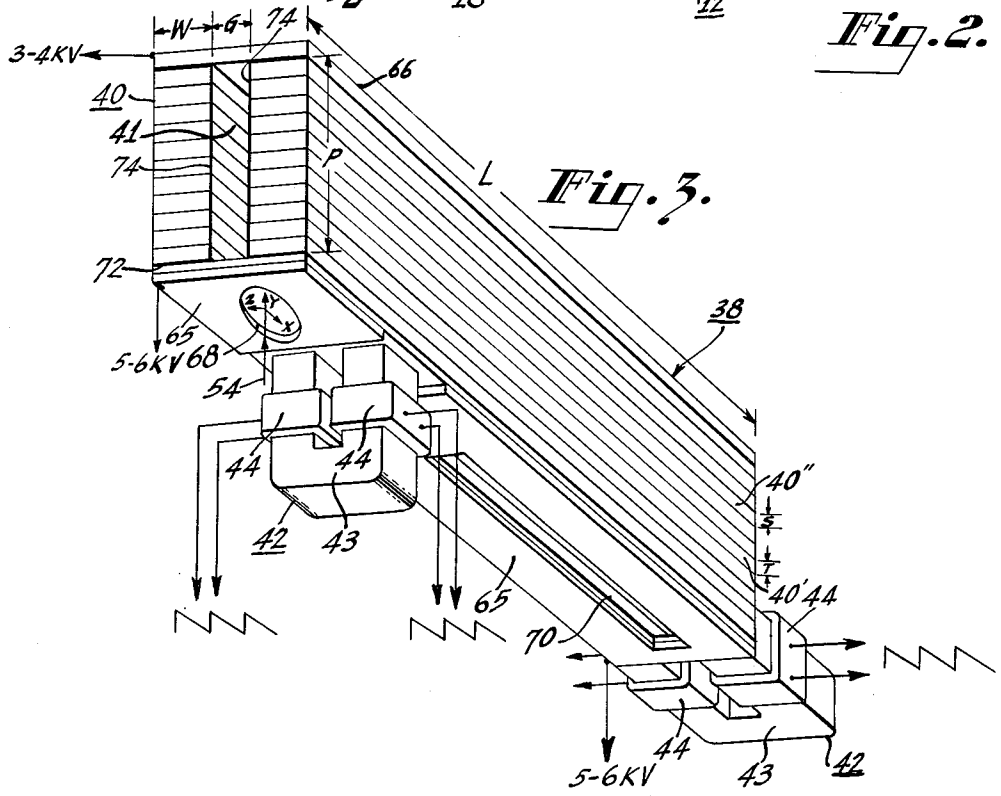



Fig. 3.

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CATHODE RAY TUBE AND MAGNETIC DEFLECTION MEANS THEREFOR

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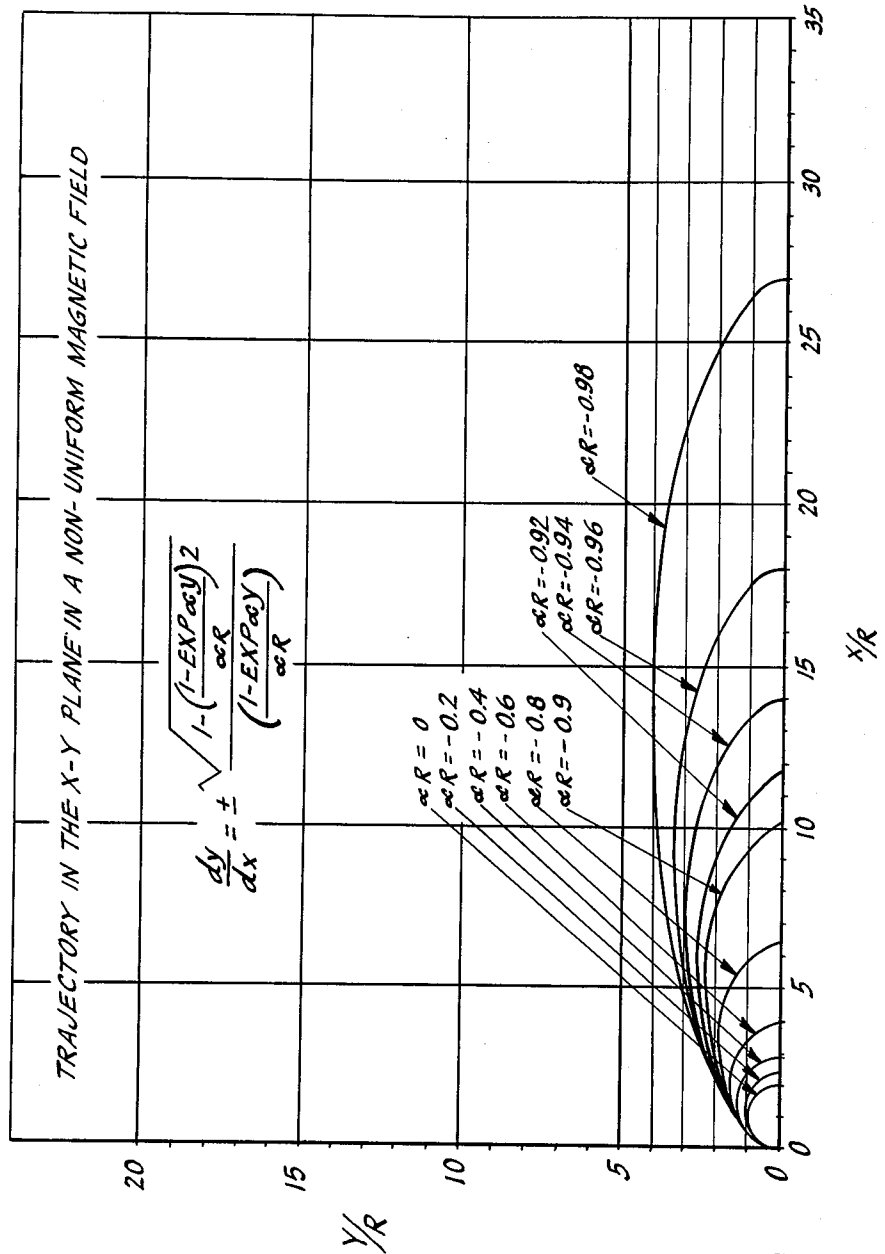



Fig. 4.

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CATHODE RAY TUBE AND MAGNETIC DEFLECTION MEANS THEREFOR

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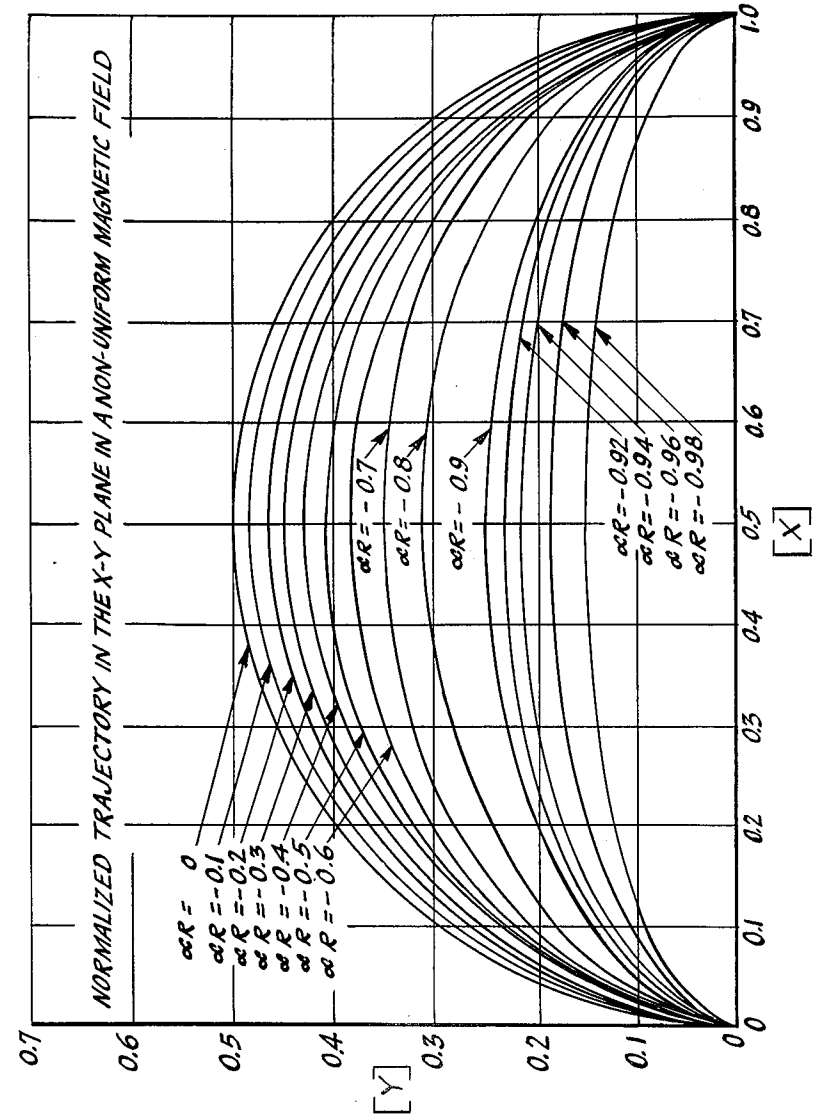



Fig. 5.

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United States Patent Office 3,226,587 Patented Dec. 28, 1965



3,226,587

# CATHODE RAY TUBE AND MAGNETIC DEFLECTION MEANS THEREFOR

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Filed Jan. 28, 1960, Ser. No. 5,200
12 Claims. (Cl. 313—75)

This invention relates to cathode ray tubes and particularly to electron beam deflection means for use in such tubes.

In panel-type cathode ray tubes, such as are designed for commercial television reception, one known raster scanning technique involves first scanning an electron beam back and forth in a given plane parallel to, spaced from, and overlying the phosphor screen of the tube and then deflecting the electron beam from that plane and into contact with the phosphor screen. This first back and forth scanning in a plane parallel to the phosphor screen may be termed monoplanar scanning.

Various arrangements for obtaining the monoplanar scanning of the electron beam have been proposed. However, many of the otherwise suitable arrangements so proposed present the problem of effectively translating electron beam deflection signals into actual electron beam deflection forces for deflecting the beam back and forth in the "monoplane." Many such scanning arrangements which involve electrostatically deflecting the beam have the inherent disadvantage of requiring electrode arrangements in the tube suitable for switching high voltages at extremely fast rates. This is particularly true for horizontal scanning in commercial television where the active scanning period for a single horizontal line is only fifty-two microseconds.

According to my invention, I provide monoplanar deflection of an electron beam by use of a novel and improved magnetic field arrangement. However, since an electron follows a circular path when it is projected through a magnetic field having a component perpendicular to the beam path, application of the magnetic deflection phenomenon according to prior art techniques requires an undesirably large volume magnetic field if used with conventional size image screens in panel-type cathode ray tubes. Moreover, prior art magnetic deflection arrangements make comparatively inefficient use of power input thereto.

Accordingly, it is an object of my invention to provide a panel-type cathode ray tube having novel and improved magnetic deflection means for monoplanar scanning of an electron beam wherein the improved deflection means is comparatively small, requires a minimum of input energy, and provides good scan sensitivity.

According to my invention, I provide a novel arrangement of improved magnetic electron deflection means for scanning an electron beam through a given plane, for example parallel to and overlying the phosphor screen of a flat, panel-type cathode ray tube. The electron beam so scanned is then deflected from the given plane and onto the phosphor screen by other suitable well-known means to thereby provide a scanned raster. The improved magnetic deflection means according to my invention comprises an electromagnet designed to provide a nonuniform magnetic field having a gradient in one direction perpendicular to the field lines, which are themselves oriented perpendicular to the phosphor screen. Deflection of the electron beam is obtained by a projection of the beam through the magnetic field at right angles thereto; scanning is obtained by varying the strength of the field according to a scanning signal wave.

In the drawings:

FIG. 1 is a partially broken away partially schematic



front elevation view of a flat, panel-type cathode ray tube embodying my invention;

FIG. 2 is a section view taken along line 2—2 of FIG. 1;

FIG. 3 is a perspective view of magnetic deflection means suitable for providing the novel magnetic deflection according to my invention; and

FIGS. 4 and 5 are graphical representations useful in explaining the mathematical concepts of my invention.

In FIGS. 1 and 2 a flat, panel-type cathode ray tube **10** is shown comprising an envelope **12** having a neck section **14**, a deflection section **16**, and an image section **18**. An electron gum **20** disposed in the neck section **14** of the envelope comprises a cathode **22**, a control grid **24**, a screen grid **26**, and includes an electrostatic lens comprising first and second anodes **28** and **30**, and a focus ring electrode **32**. A conventional stem and base **34** including a plurality of leads **36** for connection (not shown) to different ones of the electron gun electrodes to supply operating potentials thereto are shown. However, for clarity of illustration, schematic leads are also shown to indicate one set of suitable operating potentials as follows:

| | | |
|---|---|---|
| Cathode **22** | v.. | 0 |
| Control grid **24** | v.. | −50 |
| Screen grid **26** | v.. | 300 |
| First anode **28** | kv.. | 3 |
| Second anode **30** | kv.. | 1 |
| Focusing electrode **32** | kv.. | 3 |

Disposed within the deflection section **16** of the envelope **12** is a magnetic deflection means made according to my invention for scanning an electron beam through a given plane parallel to the image screen of the tube. According to the embodiment of the invention shown in FIGS. 1 and 2, the magnetic deflection means serves as horizontal scanning means. The magnetic deflection means comprises an electromagnet **38** having a pair of rectangular plate-like pole pieces **40** each comprising alternate laminae of magnetic material **40'** and nonmagnetic material **40''** of given length, width and thickness. The laminated pole pieces **40** are suitably spaced from each other to provide a gap **41** therebetween. The pole pieces **40** are energized by a pair of magnets **42** comprising a pair of horseshoe shaped members **43** on each leg of which is wound a solenoid **44** as better shown in FIG. 3. The horseshoe members **43** are mounted adjacent the electron gun side of the laminated pole pieces **40** with a different leg of a horseshoe member adjacent a different one of the pole pieces.

Within the image section **18** of the envelope **12** I provide a phosphor screen **46** which is disposed on the internal surface of one flat face on the envelope. A metallic coating **48**, such as aluminum, is evaporated upon the exposed surface of the phosphor layer **46** according to well-known practices. Electrodes **50** of a suitable vertical deflection system are disposed in a monoplanar array opposite to and spaced from the phosphor screen **46**. The electrodes **50** may comprise a series of mutually parallel metallic rods or bars, as shown, or alternatively may be formed as conductive coatings on the internal surface of the envelope wall opposite the wall on which the phosphor screen **46** is disposed.

Any suitable known arrangement may be employed for obtaining deflection of the electron beam onto the phosphor screen **46**. One such suitable deflection means, which employs electrodes such as the electrodes **50** shown, is fully described in U.S. Patent 2,795,731, issued to W. R. Aiken on June 11, 1957. Accordingly, no further description of this or other suitable means for deflecting the electron beam onto the phosphor screen to provide vertical scanning will be included herein.

In the operation of the cathode ray tube 10, an electron beam 54 is developed by the electron gun 20 and is projected into the gap 41 between the laminated pole pieces 40 of the electromagnet 38. Suitable energizing signals are supplied to the solenoids 44 to establish a magnetic field across the gap 41 perpendicular to the opposed faces of the pole pieces 40 and to the projected path of the electron beam 54. Accordingly, the electron beam 54 follows a curved path such as, for example, the path 56.

The particular path which the electron beam takes will include a curved portion 60 which changes the direction of travel of the electrons 180° relative to their direction upon leaving the electron gun 20. Such a change, as effected by the magnetic field across the gap 41, causes the electron beam to be directed to travel between the phosphor screen 46 and the vertical deflection electrodes 50 along a straight path portion 62. At a predetermined point along the path 62, and in accordance with potentials applied to the electrodes 50, the electron beam is deflected from its heretofore monoplanar path and onto the phosphor screen 46 along the curved deflection path 64. The horizontal position, as viewed in FIG. 1, of the electron beam path 62 is determined by the strength of the magnetic field provided by energization of the solenoids 44. As is hereinafter more fully described, the greater the strength of the magnetic field, the further to the left the electron path 62 will be. Such operation will be better understood by a description of the electromagnet 38 with reference to FIG. 3.

In FIG. 3 the electromagnet is shown to include, in addition to the laminated pole pieces 40 and the energizing magnets 42 a two-piece front metallic plate 65 and a rear metallic plate 66. One piece of the two-piece front plate 65 is provided adjacent one end with an aperture 68 through which the electron beam 54 is projected from the electron gun 20. An elongated slot 70 is provided centrally along the other piece of the two-piece front plate 65 opposite the gap 41 to permit emergence of the deflected electron beam 54 from the gap 41 to the region adjacent the phosphor screen 46. The front plate 65 is made of a magnetic material and thus serves to magnetically shield the image section 18 of the cathode ray tube 10 from the magnetic field established in the deflection section 16. On the other hand the spacing between the two pieces of the two-piece plate 65 prevents magnetically shorting out the electromagnet 42 mounted at that point. In operation of the tube 10, both pieces of the front plate 65 are maintained at a suitable potential, e.g., 5 to 6 kv. as shown by the schematic lead lines.

The front plate magnetic shield 65 is mounted on one face of the laminated pole pieces 40 and is electrically insulated therefrom by an intermediate insulator plate 72. The insulator plate 72 may be of any suitable material, such as mica or Lucite. It contains an aperture 68 and slot 70 aligned with the corresponding openings in the front plate 64.

The electromagnet 38 also includes an electrically conductive, nonmagnetic member 74 disposed over the opposed surfaces of the laminated pole pieces 40. The conductive member 74 is extended into contact with the back plate 66 so that together therewith it forms a conductive surface suitable for providing an electrostatic field free space in the gap 41. This permits a suitable electric potential, e.g., 3 to 4 kv. as shown by the schematic lead-in to the back plate 66, to be applied thereto so that the electron beam 54 is not subjected to changing electric fields while it undergoes deflection in the gap 41. The conductive member 74 may, e.g., comprise a mesh structure or a thin conductive coating on the pole pieces 40.

For simplicity of reference in subsequent description of the magnetic field, "X," "Y," and "Z" axes have been indicated in FIG. 3. The "X" axis extends parallel to the slot 70 in the front plate 65; the "Y" axis extends perpendicular to the front plate 65; and the "Z" axis is perpendicular to both the "X" and "Y" axes. Thus, the "Z" axis extends perpendicularly across the gap 41 parallel to the lines of force of the magnetic field.



The location of the energizing magnets 42 is such that the magnetic field created in the gap 41 will be strongest adjacent the phosphor screen 46 and decrease in the direction along the "Y" axis away from the screen or parallel to the width of pole pieces 40. Accordingly, the energizing magnets 42 are placed in contact with or adjacent the pole pieces adjacent the corners thereof nearest the phosphor screen. The magnets 42 may be in contact with the ends or the screen side of the pole pieces 40, or may be arranged with one magnet contacting an end of the pole pieces and one on the screen side as shown in FIG. 3. The arrangement of FIG. 3 wherein the magnet 42 adjacent the gun is in contact with the side of the pole pieces 40 results in avoidance of excessive envelope length.

Since the pole pieces 40 comprise alternate laminae of magnetic and nonmagnetic material, and since the energizing magnets 42 are disposed in contact therewith adjacent the front plate 65, a nonuniform magnetic field is established across the gap 41 which decreases in magnitude along the "Y" direction as indicated by the arrow in FIG. 3. For all practical purposes, the strength of the magnetic field is substantially uniform along the "X" direction or parallel to the length of pole pieces 40. It is the concept of utilizing such a non-uniform magnetic field which forms an important feature of my invention.

As has been previously stated, were a uniform magnetic field to be established for deflecting the electron beam 54, the beam would follow an exact circular path. Accordingly, in order to scan the beam to the extreme right edge of the phosphor screen, as viewed in FIG. 1, it would be necessary that the "Y" dimension of the pole pieces 40 be at least half their "X" dimension since the electron beam would traverse a complete semicircle in the gap 41. However, by providing a nonuniform magnetic field, which decreases in magnitude along the "Y" axis in a direction away from the front plate 65, a flattened, though curved, electron path 60 is effected. Such a path results because the electrons enter the gap 41 in a relatively strong magnetic field and follow a curved path of small radius, but after moving farther into the gap and thus into a weaker magnetic field, consequently follow a curved path of larger radius. The curvature of the electron beam path is thus first relatively sharp and then less curved until it returns to the stronger field region of the gap 41. Accordingly, the "Y" dimension requirement of the pole pieces 40 is appreciably lessened. Furthermore, as will be hereinafter explained, total energy input to the solenoids 44 is consequently appreciably reduced and/or scan sensitivity appreciably increased.

The flattened curved electron beam path 60 described above and produced according to my invention can be verified mathematically as follows.

The equations of monoplanar motion of an electron in a magnetic field perpendicular to the monoplane can be written as

$$\frac{m}{e}\frac{d^2x}{dt^2}=B_y\left(\frac{dz}{dt}\right)-B_z\left(\frac{dy}{dt}\right) \tag{1}$$

$$\frac{m}{e}\frac{d^2y}{dt^2}=B_z\left(\frac{dx}{dt}\right)-B_x\left(\frac{dz}{dt}\right) \tag{2}$$

where $t$ is the time variable, $m$ and $e$ are, respectively, the mass and charge of the electron, and $B_x$, $B_y$, and $B_z$ are the components of the magnetic field along the respective axes.

In present considerations the magnetic field is independent of $x$, but the $z$-component of the magnetic field decreases exponentially as a function of $y$, namely,

$$B_x=0 \tag{3}$$

$$B_z=-B_0e^{\alpha y} \tag{4}$$

where $B_o \geq 0$ and $\alpha \leq 0$. In Equation 4 $B_o$ is the magnitude of the magnetic field at $y=0$ and $\alpha$ is a constant which represents the rate of exponential change of $B_z$ along the "Y" axis. The constant $\alpha$ is a factor determined by the design construction of the electromagnet **38**. Also, in the present consideration, because of the fact that flux lines in traveling through the pole pieces **40** in the "Y" direction fringe out into the gap **41**, a "Y" component of magnetic field will necessarily exist as

$$B_y = -\alpha B_o z e^{\alpha y} \tag{5}$$

However, since the electron beam **54** travels substantially monoplanar in the X–Y plane, $B_y$ will for all practical considerations be zero since $Z \rightarrow 0$ for the region close to the X–Y plane.

If the electron is injected at the origin with the velocity corresponding to a potential V in the direction of $y$-axis, namely,

$$\frac{dy}{dt} = \sqrt{\frac{2eV}{m}} \tag{6}$$

it is apparent that the electron path will be confined to the X–Y plane. After the substitution of Equation 4 into Equation 1 and integrating with respect to $t$, Equation 1 becomes

$$\frac{dx}{dt} = \frac{\omega}{\alpha}(e^{\alpha y} - 1) \tag{7}$$

where

$$\omega = 2\pi f_L = \frac{eB_o}{m} \tag{8}$$

Here $f_L$ is known as the Larmor frequency.

With the aid of Equation 7, Equation 2 can be integrated to yield:

$$\frac{dy}{dt} = \pm\sqrt{\frac{2eV}{m} - \left[\frac{\omega}{\alpha}(1-e^{\alpha y})\right]^2} \tag{9}$$

after the use of the intial conditions of Equation 6. Eliminating the time variable $t$ from Equations 7 and 9, we obtain the equation describing the electron path in the $x$–$y$ plane:

$$\frac{dy}{dx} = \mp\frac{\sqrt{1-\left(\frac{1-e^{\alpha y}}{\alpha R}\right)^2}}{\frac{1-e^{\alpha y}}{\alpha R}} \tag{10}$$

where

$$R = \frac{1}{\omega}\frac{2eV}{m} \tag{11}$$

and represents the radius of trajectory of an electron beam when $\alpha=0$, i.e., when $B_z$ is uniform along the "Y" axis.

Equation 10 indicates that the path will be normal to the "X" axis wherever it crosses the "X" axis. Since the slope of the curve is a function of $y$ alone, the magnitude of the slope for the same $y$ must be equal, but the sign may be different. If the curve is continuous, the trajectory is symmetrical to a line parallel to the "Y" axis.

The integration of Equation 10 yields an extremely complex equation and is therefore not set forth here. However, the various values of $\alpha R$ for the integrated form of Equation 10 are plotted in FIG. 4.

For the condition of $\alpha=0$, Equation 10 becomes

$$\frac{dy}{dx} = \frac{\mp\sqrt{R^2-y^2}}{y}$$

which exactly describes a circular path. This condition is indicated by the corresponding curve in FIG. 4. When $\alpha R$ decreases from zero, $x_m$ increases much faster than $y_m$ does, $x_m$ and $y_m$ indicating maximum values of $x$ and $y$ for a given value of $\alpha R$, i.e., for a given beam path. As a result, the configuration of the beam path becomes much more slender or flatter. In FIG. 5 the curves of FIG. 4 are normalized according to their maximum values of $(x/R)$. This permits a comparison of shape of possible beam paths as determined by the design of the electromagnet **38**.



When $\alpha R$ approaches $-1$, the normalized path collapses to the "X" axis. This indicates that the electrons do not return to the "X" axis if $\alpha R$ is less than $-1$.

One magnetic deflecting device constructed according to my invention is for producing the desired magnetic field and shown in FIG. 3 comprises pole pieces of alternate silicon-iron and Lucite laminae. Other magnetic and nonmagnetic laminae can be used, such as a vacuum gap between the magnetic laminae to serve as the nonmagnetic laminae.

The arrangement of alternate magnetic and nonmagnetic laminae apparently takes the form of an iterative structure. It is known that the magnetic circuit is in perfect analogy with the electric circuit. Therefore, the equivalent circuit can be considered either H or T type. Then the propagation constant $\alpha$ of the structure can be written as

$$\alpha = \left[\frac{z_1}{z_2}\right]^{1/2}$$

per unit section, where $z_1$ is the series impedance in a section and $z_2$ is the shunt impedance in a section.

The following symbols will be used to define the geometry of the pole pieces and air gap:

$T$=Thickness of a magnetic lamina
$W$=Width of a magnetic lamina
$L$=Length of a magnetic lamina
$S$=Spacing between the magnetic lamina (thickness of a nonmagnetic lamina)
$G$=Gap spacing between the pole pieces.

If the permeability of the magnetic strips is much greater than that of air, we have

$$z_1 = \frac{2S}{WL}$$

$$z_2 = \frac{G}{TL}$$

and then

$$\alpha = \left[\frac{2ST}{GW}\right]^{1/2}$$

per unit section or

$$\alpha = \left[\frac{2ST}{GW(S+T)^2}\right]^{1/2}$$

per unit length.

For one actual construction in which

$T$=0.0195 inch
$S$=0.0416 inch
$W$=¾ inch
$G$=5/16 inch

then

$\alpha$=1.36 per inch.

In this construction each pole piece was about 2¾" x 15" and was made up of 45 silicon-iron laminae.

Improved efficiency and scan sensitivity have been verified by actual operation of the above-described construction. Such improved qualities can also be shown mathematically. Assume parameters of

$$x_m = 13 \text{ inches} \tag{12}$$

$$y_m = 2.75 \text{ inches} \tag{13}$$

$$\frac{y_m}{x_m} = \frac{2.75}{13} = 0.21 \tag{14}$$

According to FIG. 5, such a path gives

$$\alpha R = -0.94 \tag{15}$$

and from FIG. 4 for this path

$$Y_{max}/R=2.99 \quad (16)$$

Then from Equations 12, 14, and 15

$$R=0.92 \text{ inch} \quad (17)$$

$$\alpha=-1.02 \text{ per inch} \quad (18)$$

From Equations 8 and 11 the relation between the beam voltage V and the magnetic field $B_o$ can be written as

$$B_o=1.44\sqrt{V} \quad (19)$$

Where $B_o$ is in gauss and V is in volts. If a beam voltage of 6,000 volts is chosen, then Equation 19 yields a $B_o$ of approximately 112 gauss. This represents the magnetic field necessary to produce a 13 inch deflection in the given structure.

As the magnetic field is increased during the scanning, for example, to $B_o=160$ gauss, Equations 8 and 11 yield

$$R=0.64 \text{ inch} \quad (20)$$

and from Equations 18 and 20

$$\alpha R=-0.65 \quad (21)$$

From FIG. 4, it is found that for a curve $\alpha R=-0.65$

$$\frac{x_{max}}{R}=4.5 \quad (22)$$

Then from Equations 20 and 22

$$x_{max}=2.88 \text{ inches} \quad (23)$$

The active scanning distance is then

$$13-2.88=10.12 \text{ inches}$$

In order to supply the gap field between these pole pieces, the deflection magnet has to supply at least the total flux in the air gap. If the fringe field is neglected, the total flux can be computed from

$$\phi=LB_o\int_o^P e^{\alpha y}dy=\frac{LB_o}{\alpha}(e^{\alpha P}-1) \quad (24)$$

where

$L$=length of the pole piece
$P$=width of the pole piece.

For the arrangement under discussion,

$L$=15 inches
$P$=2.75 inches
$\alpha=-1.02$ per inch

then

$\phi_2=14200$ lines for $B_o=160$ gauss

and

$\phi_1=6960$ lines for $B_o=112$ gauss.

This indicates that the electromagnet has to supply a swing of total magnetic flux

$$\Delta\phi=\phi_2-\phi_1=7240 \text{ lines}$$

If, instead of a nonuniform magnetic field according to my invention, the magnetic field were uniform, the path would be a semicircle. The relation in that case is known to be

$$B=3.37\frac{\sqrt{V}}{r} \quad (25)$$

where the magnetic field B is in gauss, the beam voltage V is in volts, and the radius $r$ is in cm.

To compare this with the deflection by a nonuniform field according to my invention, the same amount of deflection distance, 10.12 inches, is considered in both situations. For the case of 13 inch deflection in a uniform field, one obtains from Equation 25

$$B=15.8 \text{ gauss}$$



Since the beam path is now semicircular and the width of the pole piece must be at least half the maximum scan distance the total flux

$\phi_1=(15.8)(15)(6.5)(2.54)^2=9930$ lines.

For the case of 2.88 inches, Equation 25 yields

$B=71$ gauss

and the total flux becomes

$\phi_2=44700$ lines.

Therefore, to drive a uniform magnetic field, the electromagnet would have to supply a swing of 44700—9930 or 34770 lines. This shows that the deflection sensitivity is much better in the case of a nonuniform field according to my invention. For the case in question, scan sensitivity is increased by a factor equal to 34770/7240 or 4.8.

The decrease of total flux requirements which results in this improvement of scan sensitivity can be explained as follows. Since in a nonuniform magnetic field according to my invention, the curved deflection path of the electron is flattened from that of a semicircular path, narrower pole pieces may be used. Thus, for a magnetic field of given density the total flux is less simply by virtue of smaller area pole pieces. In addition to this reduced flux, use of a nonuniform magnetic field according to my invention provides maximum field strength only where it is most effectively used. Accordingly, the established field is made maximum only at one side of the pole piece and decreases along the "Y" axis toward the other side. This arrangement results in a lower average field strength being provided over the required area of the pole pieces. Thus, flux requirements are lessened due to the decreased requirements of both pole piece area and average flux density.

I claim:

1. Apparatus for scanning an electron beam through a given plane comprising a pair of oppositely disposed spaced rectangular plate-like magnet pole pieces of substantial length and width, said pole pieces comprising portions of varying reluctance adapted to establish in the space therebetween a magnetic field of substantially uniform strength in directions parallel to said length and having a gradient according to a predetermined decay ratio over a substantial portion of its length in a direction parallel to said width, and means for projecting an electron beam into said space, said pole pieces being further adapted to be variably energized to thereby vary the strength of said field to scan said electron beam.

2. An electron beam device of the type wherein the electron beam thereof is scanned through a given plane, said device including means for directing said beam in a given initial direction along a first axis in said plane; means comprising a pair of pole pieces of varying reluctance for establishing a magnetic field perpendicular to said plane, said field being substantially uniform for a substantial distance in directions parallel to a second axis in said plane perpendicular to said first axis and being nonuniform with a decreasing gradient throughout a substantial portion of its length in said given direction parallel to said first axis; and means for varying the strength of said field to scan said beam through said plane.

3. A cathode ray tube comprising a phosphor screen, a pair of mutually spaced and parallel plate-like electromagnet pole pieces comprising portions of varying reluctance disposed alongside said phosphor screen for establishing a magnetic field having substantially uniform strength for a substantial distance in directions parallel to the adjacent edge of said screen and a gradient throughout a substantial portion of its length along a direction perpendicular to said edge, an electron gun disposed to project an electron beam into the gap between said pole pieces and generally away from said phosphor screen, and means generally coextensive with and spaced from said phosphor screen for deflecting said electron beam

from the parallel midplane between said pole pieces toward and onto said phosphor screens.

4. A cathode ray tube comprising an envelope, a phosphor screen disposed on an inside face of said envelope, a pair of plate-like electromagnet pole pieces comprising portions of varying reluctance disposed in spaced parallel disposition generally parallel to said phosphor screen along an edge thereof and extending therefrom away from said phosphor screen, an electron gun positioned to project an electron beam into the gap between said pole pieces parallel thereto, said pole pieces being adapted to provide a magnetic field therebetween having a uniform strength for a substantial distance in directions parallel to said adjacent edge of said phosphor screen and having a decreasing strength over a substantial portion thereof in the direction perpendicular to said adjacent edge and parallel to and away from said screen.

5. A magnetic field structure comprising pole pieces each having a plurality of alternate laminae of magnetic and nonmagnetic material, said pole pieces being arranged substantially parallel and mutually spaced from each other to provide a gap therebetween and a first and second metallic plate, each parallel to said laminae, closing said gap, one of said metallic plates having a slot therein in registry with said gap.

6. The magnetic field structure in accordance with claim 5 and including an insulator plate between said slotted metallic plate and said pole pieces, said insulator plate also having a slot therein in registry with the slot in said one metallic plate.

7. A magnetic field structure comprising a pair of plate-like pole pieces each having a plurality of alternate laminae of magnetic and nonmagnetic material, said pole pieces being arranged substantially parallel to each other and having a planar gap therebetween, said laminae being perpendicular to said gap, and magnetic field producing means bridging said gap for energizing said pole pieces at a position near an edge of said pole pieces.

8. A magnetic field structure comprising pole pieces each having a plurality of alternate laminae of magnetic and nonmagnetic material, said pole pieces being arranged substantially parallel and having a gap therebetween with the edges of the laminae of one pole piece facing the edges of the laminae of the other pole piece across said gap, and magnetic field producing structure arranged to magnetize said pole pieces, said field producing structure being adjacent magnetic laminae along an edge of said pole pieces.

9. A magnetic field structure comprising pole pieces each having a plurality of alternate laminae of magnetic and nonmagnetic material, said pole pieces being arranged substantially parallel and having a gap therebetween, and an electrically conductive means adjacent said pole pieces within said gap.

10. The magnetic field structure as described in claim 9 in which said electrically conductive means also extends across said gap.

11. A cathode ray tube comprising an envelope, a phosphor screen on a substantially planar inner surface of said envelope, a magnetic field producing structure disposed along one side of said phosphor screen for scanning an electron beam through a plane spaced from and parallel to said phosphor screen, said structure comprising a pair of plate-like pole pieces each having a plurality of alternate laminae of magnetic and nonmagnetic material, said pole pieces being disposed substantially parallel to each other and having a gap therebetween, and magnetic field producing means bridging said gap for energizing said pole pieces at a position near an edge of said pole pieces adjacent said phosphor screen; means for generating and projecting an electron beam into said gap in said plane parallel with said phosphor screen; and other electron beam deflection means for deflecting said beam out of said plane and onto said phosphor screen.

12. A cathode ray tube comprising a substantially rectangular planar phosphor screen, a pair of electromagnet pole pieces defining a gap therebetween adjacent to said phosphor screen for providing in said gap a magnetic field of substantially uniform strength along a first direction parallel to the adjacent edge of said phosphor screen and of non-uniform strength along a second direction perpendicular to said adjacent edge, said pole pieces comprising alternate laminae of magnetic and nonmagnetic material with said laminae being perpendicular to said second direction, and an electron gun for projecting an electron beam into said gap.

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