Sept. 17, 1946. A. ROSE 2,407,905

TELEVISION TRANSMITTING APPARATUS AND METHOD OF OPERATION

Filed April 11, 1942 3 Sheets-Sheet 1

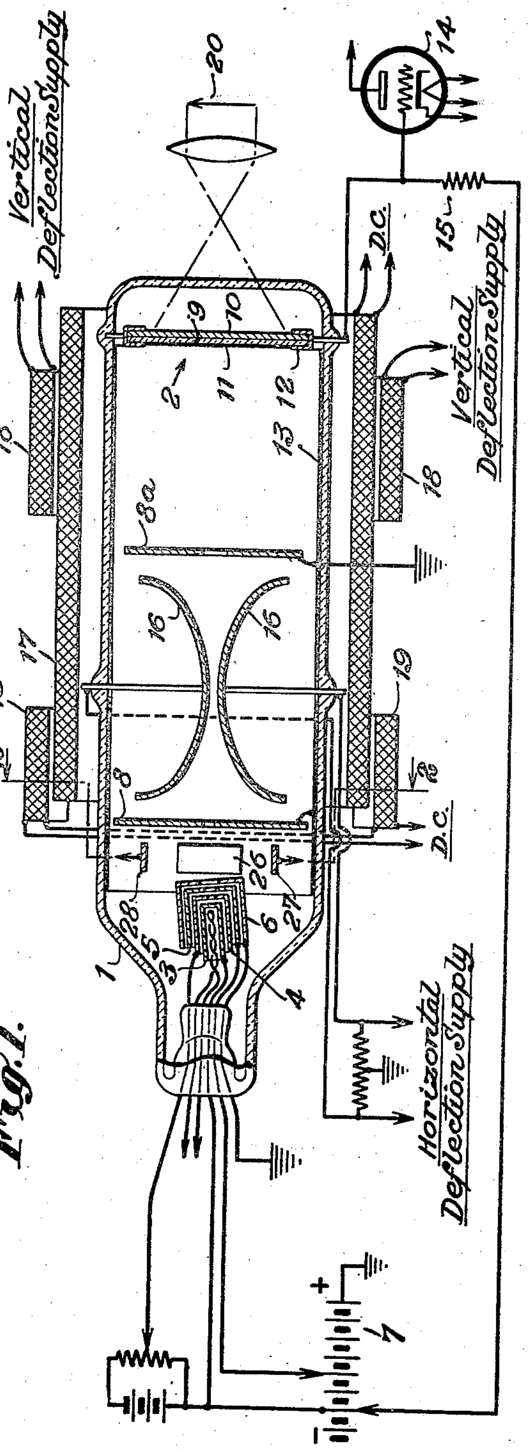

Fig. 1.

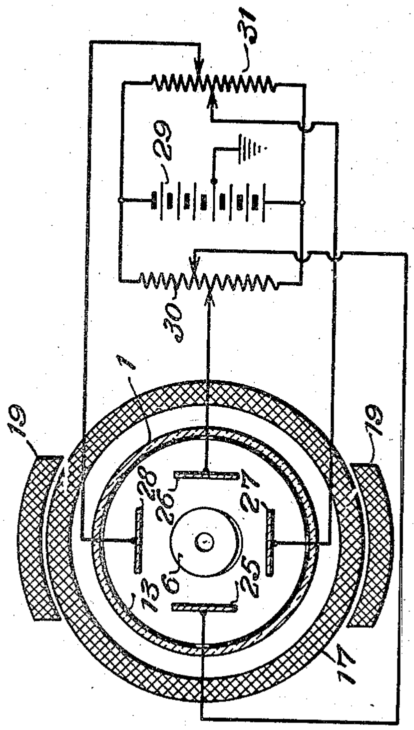

Fig. 2.

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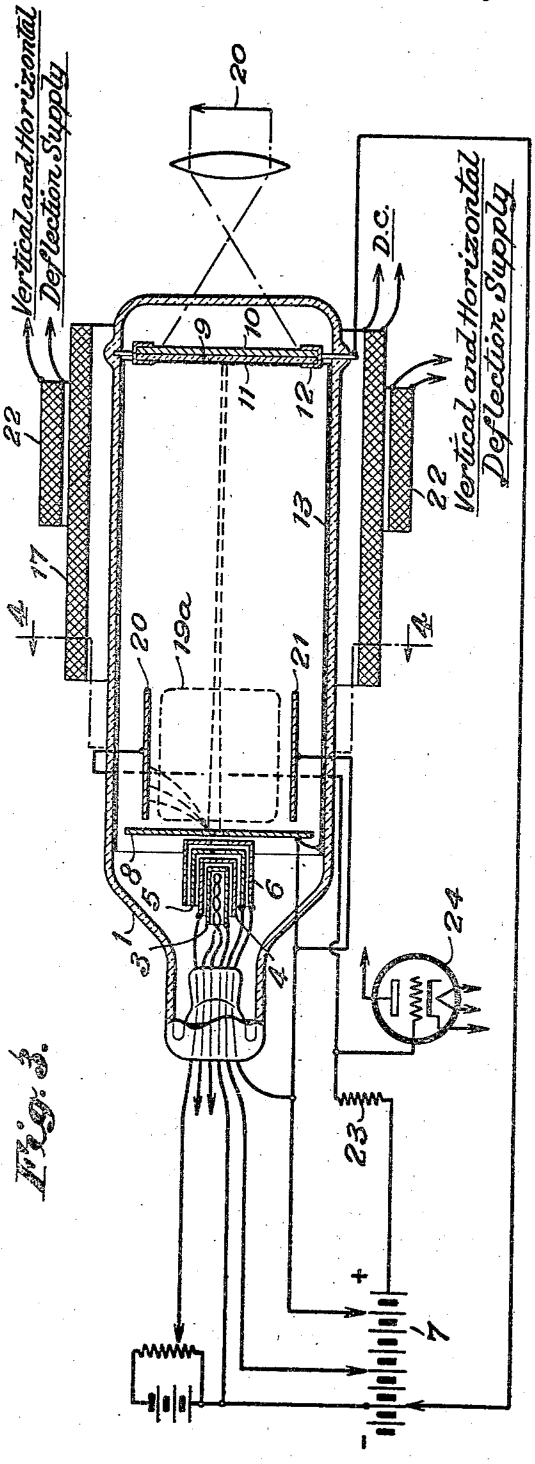

Fig. 3.

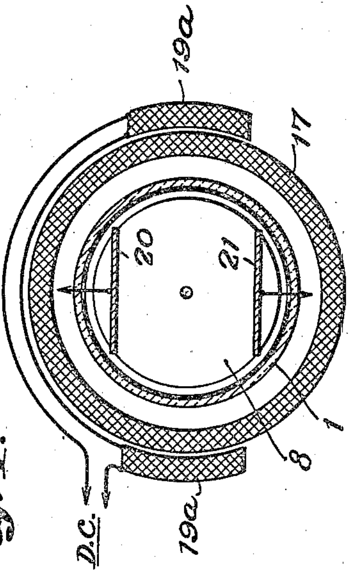

Fig. 4.

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Fig. 5.

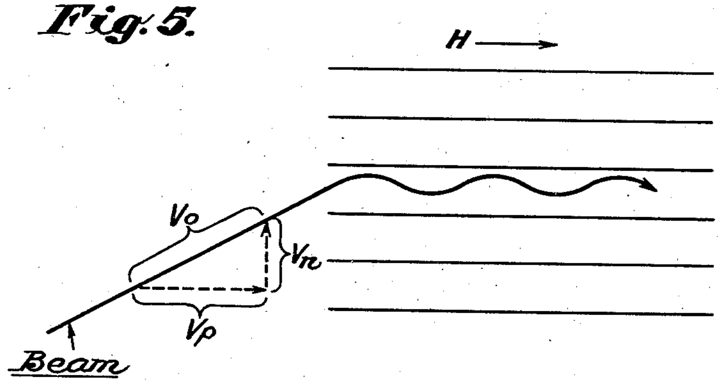


Fig. 6.

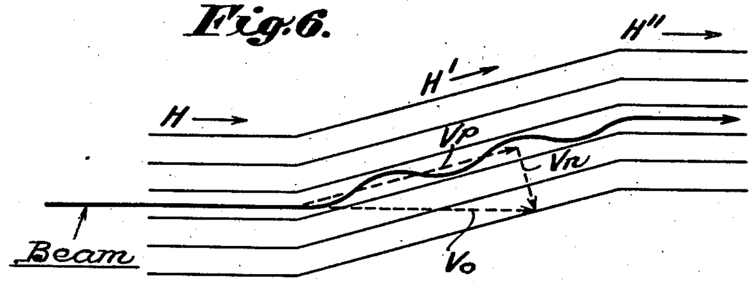
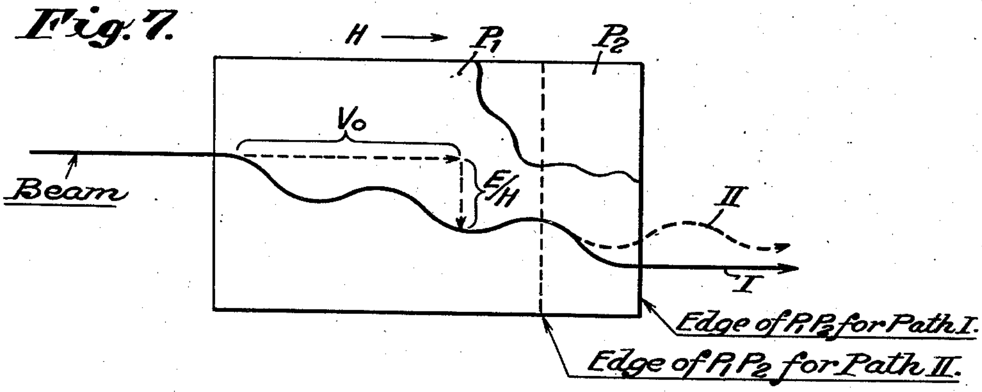


Fig. 7.



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2,407,905

UNITED STATES PATENT OFFICE

2,407,905

TELEVISION TRANSMITTING APPARATUS AND METHOD OF OPERATION

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Application April 11, 1942, Serial No. 438,562

20 Claims. (Cl. 178—7.2)

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My invention relates to television transmitting tubes, and systems, and to methods of developing television signals and is particularly directed to such tubes and systems utilizing low velocity electron scanning beams.

Tubes of the low velocity beam type, whether they be of the magnetic deflection type described by Farnsworth in his U. S. Patent 2,087,683 or of the electrostatic deflection type described in my U. S. Patent 2,213,174, utilize a longitudinal magnetic field over substantially the entire length of the electron beam path to cause the electrons to follow pre-determined path between the electron source and the scanned target and to likewise direct electrons not reaching the target along a return path to a collecting electrode. Such tubes are difficult to construct because for ideal operation the electron beam must be directed longitudinally of the magnetic field to prevent imparting to the beam a radial component of velocity which produces a helical beam motion. Furthermore, as pointed out in my joint patent with Harley A. Iams, U. S. 2,213,175, the provision of any electrostatic electrode structure within the tube capable of developing electrostatic fields into which the beam is suddenly directed likewise produces a helical motion of the beam and consequent distortion and loss of resolution in the recreated television image replica. Thus in tubes of the prior art it is often difficult to provide substantially perfect electron gun alignment, and for certain applications particularly when it is desired to multiply the electrons not reaching the target by secondary emission, it is desirable to use additional electrode structure which may introduce such helical beam motion and consequently produce a loss in image resolution.

It is an object of my invention to provide a tube and system developing a low velocity electron beam wherein difficulties arising from inaccuracies of electrode alignment with a longitudinal magnetic field are minimized or substantially eliminated. It is another object to provide a tube of the type described and a method of developing signals with a low velocity electron beam wherein undesired helical motion of the beam may be neutralized. It is a further object to provide a method of neutralizing the distortion producing interaction of a magnetic field with an electron beam directed transversely within such a field. It is a still further object to provide a tube of the low velocity type utilizing secondary electron multiplication wherein inherently produced distortions may be neutralized. These and other objects, features and advantages of my invention will become apparent when considered in view of the following description and the accompanying drawings wherein:

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Figure 1 is a sectionalized longitudinal view of a transmitting tube and system incorporating my invention;

Figure 2 is a cross-section of the tube shown in Figure 1 taken along the line 2—2;

Figure 3 is a view similar to Figure 1 showing a modification of the tube of Figure 1 particularly suitable for secondary electron multiplication;

Figure 4 is a cross-section of the tube shown in Figure 2 taken along the lines 4—4, and

Figures 5, 6, and 7 are schematic representations of electron beam paths when subjected to magnetic fields of different form.

Considered broadly, the apparatus of my invention comprises an evacuated envelope having a target preferably of the mosaic type at one end and an electron gun surrounded by an electron collecting electrode or electrodes at the opposite end of the tube. The target, if of the mosaic type, is provided on its front surface with an extremely large number of mutually insulated photo-electrically sensitized particles, and it is so positioned that it may be scanned by an electron beam from the gun and that it may have focused thereon an optical image of the object of which a picture is to be transmitted. In operation the potential between the electron gun and target is so adjusted that the electron beam is projected at relatively low velocity and directed upon the target at extremely low or substantially zero velocity, that is, with a velocity approaching zero at the point of impact therewith. In operation, elemental areas of the mosaic electrode acquire electrostatic potentials of a value dependent upon the intensity of the incident light, thus, particles of the mosaic which are more highly illuminated acquire the more positive electrostatic charges with respect to the lower illuminated particles, and these positive charges which represent an electrostatic image of a picture to be transmitted are neutralized by the low velocity electron scanning beam. Intermediate and preferably extending wholly between the electron gun and target electrode I provide a uniform axial magnetic field and means within or partially surrounding the axial field to deflect the beam over the target without producing undesirable deflection or distortion effects.

Referring specifically to Figure 1, which shows one modification of my tube and electrode structure, the evacuated envelope 1 encloses at one end a target or mosaic electrode 2 and at the opposite end an electron gun assembly adapted to project electrons toward the mosaic electrode.

The electron gun assembly is of the conventional type and comprises a thermionic cathode 3 from which electrons may be drawn, an apertured cold electrode, such as a control electrode 4 connected to the usual biasing battery and a first anode 5 maintained positive with respect to the cathode 3. The electron stream leaving the first anode 5 is accelerated at relatively low velocity and further accelerated and directed upon the front surface of the target or mosaic electrode by a second anode 6 which is preferably an apertured tubular member partially surrounding the first anode 5. The first anode 5 and the second anode 6 are maintained at the desired positive potentials with respect to the cathode by a battery 7. The anodes 5 and 6 are not for the purpose of focusing the electron beam, in fact, any electrostatic focusing of the beam is detrimental in the presence of the magnetic field described later which maintains the beam in a focused condition because such electrostatic focusing imparts transverse velocity to the electrons, thereby introducing defocusing effects. To avoid this difficulty the anodes 5 and 6 may be operated at the same potential or only one of these anodes may be incorporated in the structure. Closely adjacent the electron gun and between the anode 6 and the target I provided a centrally apertured electron collecting electrode 8 to which the electrons of the beam not reaching the target are directed through the slotted shield *8a*.

The mosaic electrode 2 which faces the electron gun in accordance with one teaching of my invention comprises a substantially transparent sheet of insulation such as the mica sheet 9 having on its front surface the photosensitive mosaic particles 11 and on its rear surface a translucent or semi-transparent electrically conducting signal plate or film 10. The mica sheet is supported by the metal frame 12 electrically connected to the signal plate through which an image of an object 20 is formed for purposes of transmission. The manufacture of such electrodes is well-known in the art. The conducting film 10 in the structure of Figure 1 is connected to the input electrode of a translating device 14 and to the battery 7 through the impedance 15 so that the potential of the conducting film 10 may be maintained substantially at cathode potential. If, however, signals of an opposite polarity are desired, the translating device 14 and output impedance 15 may be similarly connected in the circuit of the collecting electrode 8 to ground.

The electron beam developed by the electron gun may be deflected either electrostatically or electromagnetically but as shown in Figure 1 is deflected in one direction over the mosaic electrode by a pair of deflection plates 16—16, preferably formed as described in my above-mentioned joint patent. the plates being connected to a source of deflection potential and to ground through a center-tapped resistor of from 1 to 10 megohms. The electrostatic field produced between the plates 16 in combination with a coaxial or longitudinal magnetic field deflects the electron beam over the mosaic electrode 2 in a direction perpendicular to the plane of the drawing of Figure 1. The coaxial magnetic field is preferably generated by a magnetic coil 17 which is of slightly larger diameter than the envelope 1 and preferably extends over and beyond the mosaic electrode 2 and terminating to the front of electrode 2. Deflection of the electron beam in a direction normal to that proposed by the plates 16 may be accomplished by a pair of deflection coils 18—18, this latter deflection preferably being the frame or vertical deflection since in standard television systems the frame deflection is at lower frequency and the horizontal line deflection produced by the plates 16 should preferably be at the higher of the two frequencies. Electrons from the electron gun are thus scanned in two mutually perpendicular directions and are accelerated by the anodes and the accelerating electrode or wall coating 13. However, since the signal plate or film 10 is operated at or near cathode potential, the electrons of the beam are decelerated and approach the mosaic with substantially zero velocity. It will be understood that my invention is not limited to this particular type of low velocity electron beam scanning tube but that other types such as those utilizing full magnetic deflection of the electron beam as shown in Figure 2 may be utilized.

If the electron beam developed by the cathode 3 is not directed along the longitudinal axis of the magnetic field developed by the coil 17, the radial velocity of the beam is converted into a velocity of helical motion so that the beam follows a helical path whose diameter is proportional to the component of beam velocity normal to the magnetic field and inversely proportional to the magnetic field strength. The presence of such helical beam motion makes further control and focus of the beam difficult and reduces the capable resolution of the tube. Referring to Figure 5, the electron beam is shown entering a magnetic field H with a longitudinal velocity component V_D and a velocity component V_n normal to the field H. Under such conditions the electron beam follows a new path but describes a path which is helical as shown. The radius of this helix is

$$\frac{mV_n}{eH}\text{ cms.} \qquad (1)$$

where

$e/m=1.78\times10^7$ e.m.u./gram,

V_n=velocity in cms./sec. of beam normal to magnetic field,

H=magnetic field in gausses.

In accordance with my invention, I neutralize the undesired radial or normal component of velocity which causes a helical motion of the electron beam by developing a magnetic field acting upon the beam to produce a second radial or normal component of velocity in a direction opposite to and in an amount equal to this original radial or normal component of beam velocity. Referring again to Figure 1, I have shown the electron gun comprising the electrodes 3—6 as misaligned with the longitudinal axis of the tube and consequently misaligned with the longitudinal magnetic field developed by the coil 17. The showing in Figure 1 is slightly exaggerated merely for the purpose of explanation. it being understood that all of the electrodes of the gun or only one or more of these electrodes may be misaligned, thereby causing a similar action. Thus as the electrons are emitted and directed into the longitudinal magnetic field developed by the coil 17, the beam acquires a path as shown in Figure 5. In accordance with my invention, however, I develop a magnetic field transverse to the longitudinal magnetic field such as by oppositely disposed coils 19, the position of these coils being determined by the direction of misalignment of the electron gun. For example, as shown in Figure 1, for a misalignment wherein the electron gun electrodes direct the beam in the plane of the tube and longitudinal magnetic field axis but tilted upwardly, the position of the coils 19 may be as shown, although for misalignment wherein the axis of these electrodes is out of the axial plane, that is, the plane of the drawing, the coils 19 would be shifted circumferentially to compensate for the helical motion produced by such misalignment. In the tube of Figure 1 utilizing electrostatic deflection in one coordinate it is desirable to immerse the deflection plates wholly within the longitudinal magnetic field developed by the coil 17, and conversely it is desirable to provide the coils 19 at a position where the longitudinal field is relatively weak. Consequently, the coils 19 have been shown as overlapping the coil 17 so that they are effective over weaker fringing portions of the longitudinal field.

The action of such a compensating transverse magnetic field may be understood by reference to Figure 6 wherein the initial magnetic field H is bent or sharply kinked as shown at H' and again directed axially as shown at H'' and wherein the electron beam is normally parallel with the initial portion of the field H. If an electron beam in such a uniform magnetic field H encounters a sharp change of angle of the magnetic field, its motion will be a helical motion along the new direction of magnetic field with a helical radius proportional to the component of velocity of the electron beam which is normal to the new direction of field. Such a sharp change of direction of a magnetic field is, however, physically impossible. It does, nevertheless, serve to define the upper limit of transverse velocity which a beam may acquire due to a change in direction of magnetic field. When a magnetic field changes direction, it does so over a finite region of curved magnetic lines. Any actual change of direction is therefore characterized by a radius of curvature of the magnetic field lines and a strength of magnetic field in the curved portion. As a result of passing into a cured section of magnetic field the beam acquires a helical motion whose radius is approximately

$$12\,\frac{V}{H^2 r}\text{ cms.} \qquad (2)$$

where

V=initial beam velocity in volts,
H=magnetic field of the curved section in gausses,
r=radius of curvature of the magnetic field lines in cms.

If the beam performs an integral number of helical revolutions in the inclined section H', it will emerge at the second break with all of its velocity directed along the axis, that is, with no helical motion. Now, if the beam in the inclined section of field is considered to be the given beam with helical motion, it is evident that the distortion of magnetic field at the second break introduces a helical component which together with the given helical component adds algebraically to give a helical component of zero amplitude. The condition of an integral number of revolutions or orders of focus means that the helical components must be added in the proper phase. Thus, a helical component may be considered to be a vector which rotates about the average beam path with an angular velocity determined by the magnetic field. If this vector is to be added to another vector to give zero amplitude, the phase must be so chosen that the two vectors are of equal amplitude and are oppositely directed along the same line.

As indicated above, magnetic deflection means may be utilized in place of the deflection plates 16, Figure 1, for deflecting the beam in the vertical coordinate across the surface of the target 2, although magnetic means for both vertical and horizontal deflection cause the electrons not reaching the target to retrace the original scanning paths in a direction toward the apertured electrode 8. Unless some means is provided to prevent these electrons from passing through the aperture, the electrons may approach the cathode and then return to the target, thereby causing distortional effects. Since the target collects electrons from the beam only over the illuminated areas in proportion to illumination intensity, electrons not reaching the target are therefore representative of the picture image intensity. Consequently such an arrangement utilizing full magnetic deflection is of particular advantage where secondary electron intensification of the returning electrons is desired to provide a higher signal output. To prevent the returning electrons from being directed through the aperture in the electrode 8, I provide a pair of electrodes 20 and 21 as shown in Figures 3 and 4 on opposite sides of the electron beam path which develop lines of force transverse to the londitudinal magnetic field and lift the electron beam slightly from its normal longitudinal axis. Following such lifting action, the electron beam is deflected over the surface of the target by the combined vertical and horizontal deflection coils 22 so that the beam not reaching the target returns over substantially the same path as the electrons approaching the target. As the returning electrons enter the electrostatic field developed between the plates 20—21, these returning electrons are additionally lifted so as to be incident upon the electrode 8 over its nonapertured area. Somewhat similar beam lifting structures and their mode of operation are disclosed by Iams in his U. S. Patent 2,213,177. Furthermore, the electrons not reaching the target are accelerated to a velocity corresponding to the potential applied to the electrode 8 and when incident thereon liberate secondary electrons which are collected by the plate 20. To provide this mode of operation the plate 20 is maintained slightly positive with respect to electrode 8 and may be connected to the most positive point on the battery 7 through an output impedance 23. Since the electrons returning from the target and incident on the electrode 8 are representative of the elemental electrostatic charges on the target over successive periods of time determined by the rate of scanning, secondary electrons liberated by the electrode 8 in direct proportion thereto are likewise representative of the electrostatic picture charge. Consequently, the signals developed across the impedance 23 may be amplified in a thermionic device such as the tube 24, whereupon the signals may be further amplified and applied to a transmitting network as well known in the art.

I have found that the electrons of the beam when suddenly subjected to an electrostatic field such as developed between the plates 20—21 acquire radial components of velocity, thereby causing these electrons to follow helical paths. This condition of beam motion is shown in Figure 7 wherein a beam directed parallel with a magnetic field H is suddenly subjected to an electrostatic field developed between the plates P1 and P2, the beam acquiring a component of velocity normal to its original velocity and parallel with the plates. If an electron beam moving in a uniform magnetic field is suddenly subjected to such an electrostatic field normal to the magnetic field, the beam will describe a helical path whose projection on a plane normal to the magnetic field is a cycloid. It is possible by deliberate design to bring the electron beam out of the influence of the electric field with a transverse component of velocity ranging from zero electron volts to 11.3 $(E/H)^2$ electron volts. The latter value is the maximum possible energy of cycloidal motion. The low value of transverse velocity is approached by arranging the length of the deflection field to be an integral number of orders of focus, path I, Figure 7 or by tapering the electrostatic deflection field at the entrance and exit portions over an axial length of at least one order of focus. Structures incorporating both of these features are disclosed in my joint Patent U. S. 2,213,175. The maximum value of transverse velocity is approached by departures from these conditions as shown in path II, Figure 7, the maximum radius of helical motion is

$$\frac{3.3\,E}{H^2}\text{ cms.} \qquad (3)$$

where E is the electric field in volts/cm. and H is the magnetic field in gausses.

In accordance with a further teaching of my invention, I provide means to develop a transverse magnetic field preferably in the region of and between the plates 20—21 to impart an equal and opposite radial component of velocity to the beam electrons with respect to that developed by the plates 20—21, thereby substantially cancelling the effect of the plates in developing helical motion of the electron beam. Such means may comprise a pair of oppositely disposed coils 19*a* corresponding to the coils 19 shown in Figure 1 to provide this compensating transverse magnetic field. Preferably these coils as well as coils 19 are supplied with direct current to maintain a transverse magnetic field of constant intensity, the polarity of the field being adjusted to substantially cancel the effects causing the spiral beam motion. The intensity of this magnetic field as well as its most effective position may be determined during tube operation. For example, the tube may be operated as a television transmitting tube, the signal developed across the impedance 23 being utilized to create a picture replica of the object 20, whereupon the position of the coils 19 or 19*a* as well as the magnetic field strength developed by these coils may be adjusted to provide maximum resolution in the recreated picture replica. I have found that the maximum beam current collection on the frame 12 surrounding the mosaic occurs for an adjustment of minimum beam spiraling so that the coils 19 or 19*a* may be adjusted to give a maximum current collection to the target frame 12 as determined by a meter in the connection between the target and the battery 7.

I have not shown an exaggerated misalignment condition of the electron gun structure in Figure 3, it being appreciated that such an electrode structure may have inherent misalignment

as a result of conventional manufacturing technique, but it will be appreciated that by utilizing an auxiliary transverse magnetic field the spiraling motion imparted to the beam by reason of such misalignment may be counteracted by proper location of the coils 19*a* which may be distributed over the periphery of the tube to obtain maximum cancellation of the helical beam motion producing effects. Furthermore, a plurality of such coils may be provided, or instead of using one or more sets of such coils, the transverse magnetic field or fields may be produced by permanent magnetic means similarly located about the normally spiraling electron beam.

It will be appreciated from the above considerations of interacting magnetic and electrostatic field effects upon an electron beam that helical beam motion magnetically produced, such as by misalignment of the electron gun structure, may be magnetically neutralized and that such motion electrostatically produced, such as by the plates 20—21, may be magnetically neutralized. Furthermore, I have also shown that such motion produced by a combination of a transverse magnetic field and an electrostatic field may be neutralized magnetically. The converse of these statements is likewise true. For example, the helical motion introduced magnetically such as by gun misalignment may be neutralized electrostatically. Referring again to Figures 1 and 2, the helical beam motion such for example as produced by the misalignment of one or more of the electrodes 3—6 in the presence of the longitudinal magnetic field developed by the coil 17 is, in accordance with my invention, neutralized by electrostatic fields between the plates 25—28. These plates are preferably located along the beam path adjacent the means inherently producing the helical beam motion. Thus as shown in Figure 1, the plates 25—28 are adjacent the electron gun 3—6. The plates 25—28 are supplied with direct current potentials such as from the battery 29 through the potentiometer 30 and 31. By varying the potentials on these plates the combined electrostatic field may be rotated and controlled in magnitude in the same manner and for the same purpose as rotation and control of field strength of the coils 19 and 25. When utilizing the plates 25—28, the coils 19 may be omitted or one or both means may be utilized to remove the objectionable helical motion from the electron beam.

In view of the above description, it will be apparent that I obtain improved operation wherein transverse or radial velocity is inherently imparted to an electron beam, thereby causing the beam to follow a helical path by imparting substantially simultaneously therewith an equal and opposite transverse or radial velocity to the beam to substantially cancel the effects causing the helical motion. Thus while I have described several types of television transmitting tubes capable of being operated in accordance with my method, this identical method may likewise be practiced with other structure. Furthermore, my invention is of particular importance in tube structures incorporating target electrodes of the photovoltaic type or image grid type such as disclosed by Iams in U. S. Patent 2,213,179 wherein the electrostatic charge on such a grid controls the passage of an electron beam through the target. Any helical beam motion in such a tube is exceedingly detrimental in that the beam is not controlled over the entire target area in accordance with the electrostatic charges. Therefore while I have indicated the preferred embodiments of my invention and have indicated several specific applications for which my invention may be employed, it will be apparent that it is by no means limited to the use indicated or to the exact forms illustrated, but that many variations may be made in the particular structure and its mode of operation without departing from the scope thereof as set forth in the appended claims.

I claim:

1. The method of reducing distortion in a television transmitting tube of the low velocity electron beam type comprising the steps of developing an electron beam having a helical path in a longitudinal magnetic field, developing a field of constant magnitude having lines of force transverse to the axis of said helical path and orienting said field to a position at which the radius of said helical path is a minimum and approaches a substantially straight path.

2. The method of reducing distortion in a television transmitting tube of the low velocity electron beam type comprising the steps of developing an electron beam, directing said beam along a magnetic field inherently causing said beam to follow a helical path, developing a field of constant magnitude having lines of force transverse to said magnetic field, and rotating said transverse field to a position at which the radius of said helical path is a minimum and approaches a substantially straight path.

3. The method of developing an electron scanning beam comprising the steps of developing an electron beam following a helical path of finite helical radius in a longitudinal magnetic field, developing a magnetic field having lines of force transverse to said longitudinal field and to the axis of said helical path, and orienting said transverse field to a position at which the radius of said helical path is a minimum and said beam follows a substantally straight path.

4. The method of developing an electron scanning beam comprising the steps of developing an electron beam, subjecting said beam to forces causing said beam to follow a helical path, subjecting said beam to a magnetic field transverse to the axis of said helical path, rotating said transverse magnetic field about said axis until the radius of said helical path is a minimum and thereafter maintaining said transverse field substantially constant.

5. The method of developing an electron scanning beam comprising the steps of developing an electron beam, directing said beam along a path into an electrostatic field immersed in a magnetic field having lines of force substantially parallel to said path thereby causing said beam to follow a helical path, subjecting said beam to a magnetic field transverse to the axis of said helical path, rotating said transverse magnetic field about said axis until the radius of said helical path is a minimum and thereafter maintaining said transverse field substantially constant.

6. The method of operating a television transmitting tube of the low velocity electron beam scanning type comprising developing an electron beam, subjecting said beam to an electrostatic field immersed in a longitudinal magnetic field inherently causing said beam to follow a helical path, developing an electrostatic image of an optical image of which a replica is to be transmitted, utilizing a portion of said beam to neutralize said electrostatic image, developing a constant magnitude field having lines of force transverse to the axis of said helical path to neutralize the forces causing said beam to follow said helical path, and rotating said transverse field about said axis in accordance with the neutralization of said electrostatic image to a position at which the utilized portion of said beam is a maximum.

7. The method of developing television signals representative of a picture replica of high resolution comprising the steps of developing an electron beam, subjecting said beam to a longitudinal magnetic field inherently causing said beam to follow a helical path, developing an electrostatic image of an optical image of which representative television signals are to be developed, utilizing a portion of said beam to develop television signals, developing with said signals a picture replica of said optical image, developing a magnetic field transverse to said longitudinal magnetic field and transverse to said helical path, and rotating said transverse field about the axis of said helical path to a position at which the resolution of said picture replica is a maximum.

8. In a low velocity electron beam tube wherein an electron beam is subjected to forces producing a helical beam path in a longitudinal magnetic field, means to develop a field of constant magnitude transverse to said longitudinal magnetic field in the region of the origin of said helical path the magnitude of said transverse field being sufficient to substantially neutralize the forces producing said helical path.

9. In a low velocity electron beam tube wherein an electron beam is subjected to electrostatic forces producing a helical beam path in a longitudinal magnetic field, means to develop a magnetic field of constant intensity transverse to said longitudinal magnetic field in the region of the origin of said helical path said magnetic field being of sufficient intensity to substantially neutralize the forces producing said helical path.

10. Cathode ray apparatus having a target adapted to be scanned with a low velocity electron beam, an electron source oppositely disposed from said target, a magnetic coil surrounding said tube to develop a magnetic field having lines of force extending substantially longitudinally of said tube and normal to the surface of said target, means inherently directing electrons from said source toward said target along helical beam paths, and means between said electron source and said target to develop a field of constant magnitude having lines of force transverse to the field developed by said coil to neutralize the forces causing said helical beam paths and direct said beam along a path substantially parallel to the field developed by said coil.

11. Cathode ray apparatus comprising a tube having oppositely disposed electron beam producing means and target means, means to produce a magnetic field having lines of force extending over the major portion of the space separating said beam producing and target means, means between said beam producing and target means inherently causing said beam to follow a helical path of finite radius, and means closely adjacent said last-mentioned means to develop a magnetic field transverse to the axis of said helical path to neutralize the forces causing said beam to follow said helical path and to cause said beam to follow a path substantially parallel with the magnetic field extending over the space between said beam producing and target means.

12. Cathode ray apparatus comprising a tube having a target adapted to be scanned by a low ve-

locity electron beam, an electron source oppositely disposed from said source, means to develop a longitudinal magnetic field extending over the major portion of the space between said target and said source, means to direct electrons as a beam from said source toward said target, said means being misaligned with said longitudinal magnetic field and causing said beam to follow a helical path in said longitudinal magnetic field and means to subject said beam to a magnetic field of substantially constant magnitude extending transversely to the said longitudinal field to substantially neutralize the forces causing said beam to follow said helical path.

13. Cathode ray apparatus comprising a target electrode adapted to be scanned by a low velocity electron beam to develop television signals, an electron source oppositely disposed from said target to liberate electrons, a magnetic coil extending over the major portion of the space between said source and said target to develop a longitudinal magnetic field having line of force substantially normal to said target electrode, a plurality of electrodes to develop a beam of the electrons liberated from said source, said electrodes being inherently misaligned with respect to said longitudinal magnetic field, thereby causing said electron beam to follow a helical path, and means to develop a magnetic field transverse to said longitudinal field and in the region of said electrodes said transverse field being of sufficient magnitude and being oriented to force said beam to follow a substantially straight path parallel to said longitudinal magnetic field.

14. Cathode ray apparatus comprising a target electrode adapted to be scanned by a low velocity electron beam to develop television signals, electron beam developing means oppositely disposed from said target, a magnetic coil extending over the major portion of the space between said beam developing means and said target to develop a longitudinal magnetic field, means subjecting said electron beam to forces causing said electron beam to follow a helical path, means to develop an electrostatic field of constant magnitude transverse to said longitudinal field to force said beam to follow a substantially straight path parallel to said longitudinal magnetic field and means to scan said electron beam in mutually perpendicular directions over said target electrode.

15. Cathode ray apparatus having a target adapted to be scanned with a low velocity electron beam, an electron source and anode oppositely disposed from said target to develop an electron beam and direct said beam along a path toward said target, a magnetic coil surrounding said tube to develop a magnetic field having lines of force extending substantially longitudinally of said tube and normal to the surface of said target, electrostatic means immersed in said magnetic field to displace said beam in a direction normal to its path said electrostatic means causing said beam to be directed toward said target along helical beam paths, and means adjacent said electrostatic means to develop a magnetic field transverse to the field developed by said coil to neutralize the forces causing said helical beam paths and direct said beam along a path substantially parallel to the field developed by said coil.

16. Cathode ray apparatus of the low velocity electron beam type comprising a tube having oppositely disposed electron beam producing means and target means, means to produce a magnetic field having lines of force extending over the major portion of the space separating said beam producing and target means, magnetic means to deflect said beam in two mutually perpendicular directions over the surface of said target, electrostatic means between said beam producing and target means to lift the electron beam and the electrons of said beam not reaching said target in a direction normal to the beam path said electrostatic means in combination with said magnetic field inherently causing said beam to follow a helical path of finite radius, magnetic means closely adjacent said last-mentioned means to develop a magnetic field transverse to the axis of said helical path to neutralize the forces causing said beam to follow said helical path and to cause said beam to follow a path substantially parallel with the magnetic field extending over the space between said beam producing and target means, and means to scan said beam in two mutually perpendicular directions over the said target means.

17. In an electron beam tube, means to produce an electromagnetic field, means to project a beam of electrons into the axis of said electromagnetic field with a velocity component normal thereto and means to distort said electromagnetic field at the entrance point of said beam thereinto to eliminate the velocity component of said beam normal to said axis at said entrance point.

18. In an electron beam tube, means to produce an electromagnetic field, means to project a beam of electrons into said electromagnetic field with a velocity component normal thereto and means to produce an electromagnetic field having an axis transverse to the axis of the first field and adapted to neutralize the velocity component of said beam normal to the first-mentioned field at the entrance point of said beam thereinto.

19. In an electron beam tube, means to produce a focusing electromagnetic field, means to project a beam of electrons through said electromagnetic field with a velocity component normal thereto and means to produce a compensating electromagnetic field having an axis transverse to the axis of said focusing electromagnetic field and adapted to eliminate the velocity component of said beam normal to the axis of said focusing electromagnetic field.

20. In an electron beam tube, means to produce an electromagnetic field, means to project a beam of electrons into the axis of said electromagnetic field with a velocity component normal thereto and means to neutralize the velocity component of said beam normal to the axis of said electromagnetic field at the entrance point of said beam thereinto.

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