

Aug. 27, 1940.

H. A. IAMS ET AL

2,213,175

TELEVISION TRANSMITTING TUBE AND SYSTEM

Filed May 27, 1939

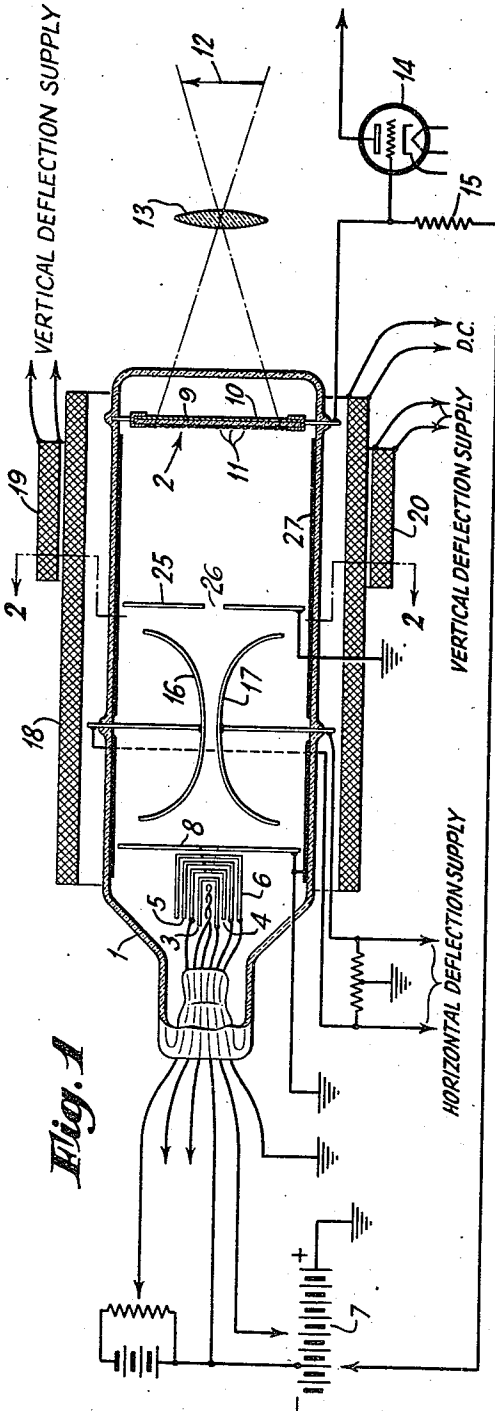


Fig. 1

Fig. 2

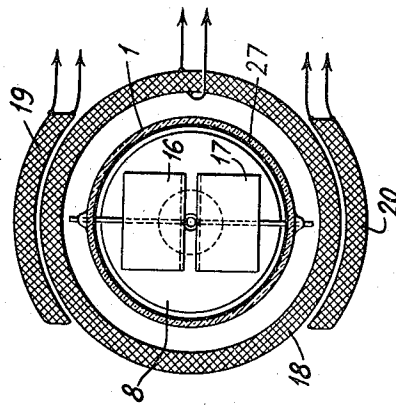


Fig. 3a

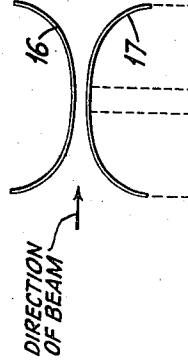


Fig. 3b

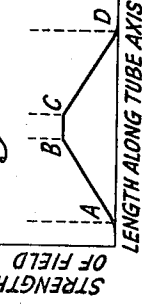


Fig. 4a

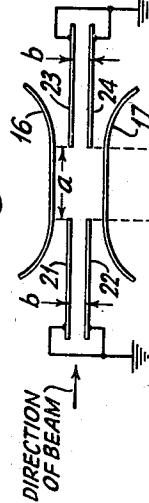
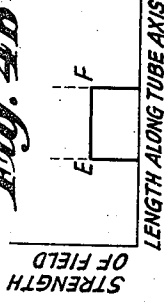


Fig. 4b



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UNITED STATES PATENT OFFICE

2,213,175

TELEVISION TRANSMITTING TUBE AND SYSTEM

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tion of America, a corporation of Delaware

Application May 27, 1939, Serial No. 276,106

13 Claims. (Cl. 250—158)

Our invention relates to television transmitting tubes and is particularly directed to tubes utilizing low velocity electron scanning beams.

Television transmitting tubes of the low velocity electron beam scanning type have been made in which a combination magnetic-electrostatic deflection system including electrostatic plates wholly immersed in a uniform axial magnetic field shifts the beam in a plane parallel to the plates. Tubes of this type produce a distortion or defocusing effect evidenced in the image recreated on a viewing tube by unequal resolution at the center and at the edges of the recreated television image. The resolution at the center can be made very high, but decreases with increasing distance from the center. The cause of this distortion or defocusing effect was unknown until we found by exhaustive research, mathematical analysis and the construction of mechanical models representing the motion of electrons in such a combination field, that this defocusing effect was due to an interaction of the electrostatic and magnetic fields which increases the amplitude of the helical paths of the electrons while under the influence of the two fields, and only after our discovery of the cause of this distortion could a satisfactory solution be approached.

The principal object of our invention is to provide a television transmitting tube having a combination electrostatic-magnetic deflection field which will transmit an optical replica of a picture without the introduction of electronic defocusing difficulties. It is a further object of our invention to provide a tube of the type described for the transmission of an optical image replica wherein the replica can be transmitted with equal fidelity over its entire area. Another object of our invention is to provide low velocity electron beam scanning tube having substantially the same resolution over the entire picture area.

In accordance with our invention, an electrostatic image corresponding in electrostatic energy distribution to the light distribution of an optical image is formed on a target or mosaic electrode which is scanned by a low velocity electron beam from an electron gun, the scanning being accomplished in a combination magnetic-electrostatic field without introducing large amplitude components of deflection transverse to the normal path of the beam. More particularly in accordance with one teaching of our invention the electron beam is directed through an electrostatic field which uniformly increases over a portion of the beam path with increasing distance from

the gun and over a further path which uniformly decreases in field intensity with increasing distance from the gun, these increasing and decreasing electrostatic fields being wholly immersed in an axial magnetic field. In accordance with further teaching of our invention the electron beam is suddenly subjected to and suddenly removed from a constant electrostatic field wholly immersed in an axial magnetic field, the axial distance traveled by the beam in the constant field being of predetermined length.

A better understanding of our invention will be obtained and other objects, features and advantages will appear from the following description taken in connection with the accompanying drawing in which:

Fig. 1 is a longitudinal sectional view of a television transmitting tube embodying our invention,

Fig. 2 is a cross section of the tube shown in Fig. 1 taken along the line 2—2,

Fig. 3a is a longitudinal cross section of certain structure shown in Fig. 1,

Fig. 3b is a graph showing the electrostatic field distribution of the structure of Fig. 3a,

Fig. 4a is a modification of the electrostatic deflection structure shown in Fig. 1, and

Fig. 4b is a graph showing the electrostatic field distribution of the structure of Fig. 4a.

Considered broadly, the apparatus of our 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 photoelectrically 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. 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 proportional to the intensity of the light incident thereon; thus, particles of the mosaic which are more highly illuminated acquire the more positive electrostatic charges with respect to the unilluminated particles, and these positive charges which represent an electrostatic image of a pic-

ture to be transmitted are neutralized by the low velocity electron scanning beam. Intermediate and extending wholly between the electron gun and target electrode we provide a uniform axial magnetic field and means within the axial field to generate an electrostatic field to scan the beam over the target without producing undesirable deflection or distortion effects.

Referring specifically to our tube structure shown in the drawing, the tube comprises an evacuated envelope 1 enclosing 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 concentrated into an electron scanning beam focused on 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. Closely adjacent the electron gun and between the anode 6 and the target we provided a centrally apertured electron collecting or shield electrode 8 to which the electrons of the beam not reaching the target are directed and collected, the aperture being provided to allow an unimpeded electron flow between the electron gun and target.

The mosaic electrode 2 which faces the electron gun preferably comprises a substantially transparent sheet of insulation such as the mica sheet 9 having on its rear surface a translucent or semi-transparent electrically conducting film 10, the opposite surface of the mica sheet being provided with an exceedingly great number of mutually separated photosensitive particles 11. In making the mosaic electrode we make the mica sheet 9 of the desired area having a uniform thickness of approximately .002 inch and as a first step coat one side of the sheet with a film of metal of sufficient thinness as to be substantially transparent so that an optical image such as represented by the arrow 12 may be focused on the photosensitive particles 11 by a lens system 13. The mosaic of mutually separated particles may be made by depositing on the front surface of the mica sheet 9 finely divided silver oxide which is reduced to provide a surface of individually separated silver particles or globules 11 which are subsequently oxidized and sensitized with caesium or other alkali metal during the evacuation process. Such an electrode structure and a method of sensitization is disclosed by S. F. Essig in U. S. Patents 2,020,305 and 2,065,570. The conducting film 10 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 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.

In accordance with our invention we provide between the collecting electrode 8 and the mosaic electrode deflection plates such as the plates

16—17 having a particular formation, as later described, which are connected to a source of deflection potential and to ground through a center tapped resistance of 1 to 10 megohms. The electrostatic field produced between the plates in combination with an axial magnetic field deflects the electron beam over the mosaic electrode 2 in a direction perpendicular to the plane of the drawing of Fig. 1. The axial magnetic field is preferably generated by a magnetic coil 18 which is of slightly larger diameter than the envelope 1 and extends over and beyond the space between the collecting electrode 8 and the mosaic electrode 2. Deflection of the electron beam in a direction normal to that produced by the plates 16—17 in the field produced by the coil 18 is accomplished by a pair of deflection coils 19—20. This deflection is preferably the frame or vertical deflection, since in standard television systems the frame deflection is of lower frequency than the horizontal line deflection and the magnetic deflection coils 19—20 should preferably be operated at the lower of the two frequencies.

We have found, as a result of considerable research and by the construction and test of a large number of tubes that with the use of an electrostatic deflection field in combination with a uniform axial magnetic field it is desirable to have the electron beam leave or emerge from the deflection plates with only its original axial velocity and with no components of velocity transverse to the axis other than that resulting from the initial transverse emission velocity from the cathode. The axial magnetic field causes the electrons which are emitted by the cathode with initial transverse velocities to follow helical paths of small amplitude. The length of the path of a single helix or the pitch of the helix along the tube axis may be varied by varying the strength of the magnetic field or by varying the axial velocity of the electrons, that is by varying the potential difference applied between the cathode and the other electrodes at ground potential. However, if the beam emerges from the deflection plates with some transverse velocity acquired from the plates, the helices along the path of the beam from the plates to the target have increased amplitude, and this action results in distortion, decrease in focus and consequent loss of resolution. The path of a beam suddenly receiving transverse velocity components from the deflection plates upon entering the combination magnetic-electrostatic field is such that its helical path projected on a plane normal to the axis of the tube is a series of cycloids. The axial length of these cycloids is equal to the length or pitch of the individual helices as defined above. The average transverse velocity of drift of the electrons produced by suddenly subjecting the electrons to the electrostatic field is proportional to

$$\frac{E}{H}$$

where E is the strength of the electrostatic field and H the strength of the magnetic field, and the instantaneous transverse velocity of the electrons varies from zero to

$$\frac{2E_m}{H}$$

However, with the gradual increase of E, as the electrons enter the field whose maximum value

is E_m the electron drift tends to assume the average velocity of

$$\frac{E_m}{H}$$

with no fluctuation between zero and

$$\frac{2E_m}{H}$$

We have found that the reverse action takes place when the electrons emerge from an electrostatic field which gradually decreases along a portion of the beam path with increasing distance from the electron gun so that no increased amplitude is imparted to the emerging electrons other than that possessed by reason of the initial emission transverse velocity.

Therefore, in accordance with one teaching of our invention, the deflection plates used in combination with an axial magnetic field are so shaped as to provide, when energized by deflection potentials, gradually increasing and decreasing entrance and exit electrostatic fields. Referring to Figs. 3a and 3b, the deflection plates 16-17, as also shown in Fig. 1, are flared outwardly from the axis of the tube at the opposite ends of the plates so that the electrostatic deflection field at the leading edges of the plates, such as at point A, produces substantially no electrostatic field, the shape of the plates being such that the field gradually increases as the beam proceeds from the electron gun and toward the central portion of the plates, point B. With further travel of the beam through the plates 16-17, such as from points C to D, it passes through a gradually decreasing field. With such an arrangement, substantially none of the transverse velocity acquired by the electrons of the beam while under the influence of the plates is retained by the beam upon leaving the plates. This mode of action is true only in a combination magnetic-electrostatic field because if the magnetic field is absent, the desired function of the electrostatic plates as used in conventional electrostatically deflected tubes is to introduce transverse velocity of the electrons of the beam, which is retained by the electrons upon leaving the electrostatic field. In contrast to the above and in accordance with our invention, the transverse velocity acquired by the electrons in the region of the plates is reduced to substantially zero upon leaving the plates.

We have found that the end portions of the plates; that is, from points A to B and points C to D should have the profile of a hyperbola, the plates from points C to D likewise being of hyperbolic curvature. We have found, however, as the result of tests made on tubes constructed in accordance with our invention that the conditions of operation may be closely approximated if the curvature of these plates is not truly hyperbolic, as long as the entrance and exit fields increase and decrease gradually. The curvature of the end portions may therefore vary from that of a true hyperbola without materially increasing the transverse velocity of the electrons in the emergent beam.

It is not necessary to have the curvature of the plates shown in Fig. 3 continuous; thus, the points B and C may be separated by any desired distance depending upon the other parameters of the tube such as the size of the target, the velocity of the beam through the deflection plates and the maximum deflecting potentials applied to the plates. Furthermore, the length of the curved

portions of the plates, such as from points A to B and C to D, are preferably maintained equal to an integral number of cycloids or pitch distances in the path of the beam between these respective points. For this condition the length from A to B and from C to D along the axis of the tube would be equal so as to encompass an integral number of cycloids or pitch distances. The length of the plates over which they are flat, that is, from points B to C, is not critical. Since the field generated in this portion of the system is uniform, this length may be varied irrespective of the number of cycloids over this portion of the beam. The length or pitch of the helices in the axial magnetic field and the length of the cycloids in the combination field may be determined by the expression

$$K \cdot \frac{\sqrt{V}}{H}$$

where K is a constant equal to approximately 21, when V represents the axial velocity of the electron beam in volts, and H represents the strength of the field in gaussses. We have found that the desired separation between the plates 16-17 at their point or points of closest approach to each other, such as at all points between B and C, is a function of accuracy of alignment of the axis of the electron gun and plates with the tube axis, but it is not critical. The width of the plates 16-17, that is, the dimension in a direction perpendicular to the plane of the drawing should be at least as wide as the mosaic electrode 2 taken in the same direction if the entire width of the mosaic electrode is to be utilized. Thus, the width of the plates should equal or exceed the width of the optical image focused on the mosaic electrode.

As pointed out above, the instantaneous transverse velocity of electrons suddenly subjected to an electrostatic field varies from zero to

$$\frac{2E}{H}$$

We have found that if the electrons emerge from an electrostatic field at a time when the instantaneous transverse velocity is zero, the electrons will have no increase of transverse velocity other than that possessed by the electrons upon entrance into the field. Therefore, in accordance with a further teaching of our invention, the electrons may be made to enter and leave the electrostatic field at a time when their instantaneous transverse velocity is zero, neglecting the initial transverse velocity received at their points of origin. Thus, the entrance and exit fields may be so located with respect to the cycloidal phase of motion of the electrons that the electrons upon emerging from the electrostatic field have no appreciable transverse velocity, and this condition may be made uniform for any position of the beam at which it leaves the electrostatic field.

Referring to Figs. 4a and 4b which show a cross section and the field distribution of a deflection system constructed in accordance with this second teaching of our invention, the plates 16-17 may be similar to those shown in Figs. 1 and 3a. Within the space separating the plates 16-17 of Fig. 3a we provide two pairs of plates 21-22 and 23-24 which are maintained at the average potential of the deflection plates 16-17 which is preferably ground potential or the same potential which is applied to the anode 6 and the collector electrode 8 of Fig. 1. The two pairs of

plates 21—22 and 23—24 are in telescopic relation with the plates 16—17 and are separated along the tube axis by a predetermined distance a as shown in the drawing, and by a distance b normal to the axis. Furthermore, the plates 21 and 23 and the plates 22 and 24 are preferably coplanar. Since in accordance with the further teaching of our invention it is desired to subject the electrons of the beam to the electrostatic field of the plates 16—17 at a time when the instantaneous transverse velocity of the electrons is zero and to remove the electrons from this deflection field under similar conditions of zero instantaneous transverse velocity, the separation a along the axis should contain an integral number of cycloids. If this condition is fulfilled, the electrons may be made to enter and leave the electrostatic deflection field at a time when their transverse velocities are zero by adjusting the potential applied to the cathode by the battery 7. The separation b of the plates 21—22 and 23—24 normal to the tube axis determines the fringing fields existing adjacent the points E and F, which fields extend slightly within the plates 21—22 and 23—24. The separation b should therefore be made as small as possible, and we have found that this separation is preferably no greater than $\frac{1}{2}$ the length of the cycloids or spirals. If these conditions are fulfilled, the electrons of the beam enter the electrostatic field produced by the plates 16—17 at a point at which this field is a maximum such as indicated in Fig. 4b at E. Similarly, the electrons suddenly leave the electrostatic field produced between the plates 16—17 as shown at point F, Fig. 4b.

It will be clear from the above that our construction of electrostatic deflection plates as shown in Fig. 4, when used in combination with an axial magnetic field, will impart no transverse velocity to the electron beam which is retained by the beam after it passes out of the electrostatic field between the plates 16—17. As a consequence, the electron beam will proceed to the target or mosaic electrode 2 along spiral paths whose amplitude is dependent only upon the initial transverse velocity acquired by the electrons of the beam at their source of origin. We have found that it is very difficult, if not impossible, to provide an emission surface or source of electrons in which all of the electrons are liberated in an axial direction. As a consequence, the electron beam, while under the influence of the axial magnetic field, will follow spiral paths, but since the transverse velocity of emission is very low, the amount of defocusing or distortion caused by the spiral motion of the electrons is negligible.

In order to provide a static electrostatic field free space, and by static we mean the condition under zero deflection, in the region of the plates 16—17 of Fig. 1 and between all of the plates shown in the structure of Fig. 4a, we provide an electrode 25 between the plates 16—17 and the mosaic electrode 2. The electrode 25 is provided with a slot 26 having a width equal to or slightly greater than the minimum separation of the plates 16—17 of Figs. 1 and 3 or equal to or slightly greater than the separation b as shown in the structure of Fig. 4. The electrode 25 is connected to the same potential as the collecting electrode 8 or to ground as shown in the drawing. The electrode 25, as in the case of the electrode 8, may be termed a shield electrode since it provides a shield to prevent the electrostatic field generated by the deflection potentials

applied to the plates 16—17 from fringing out toward the mosaic electrode. To obviate any collection of electrons on the wall of the tube between the collecting electrode 8 and the electrode 25 or between the electrode 25 and the mosaic electrode 2, which would introduce an undesirable field in this space, we have found it desirable to coat the inner wall between these electrodes with a film 27 of electrically conducting material which is likewise connected to the electrodes 8, 25 or to ground.

In operation of tubes made in accordance with our invention we have found that the operating parameters such as the size of the electrodes, the separation of electrodes and operating potentials, may be varied over wide limits. However, to limit the structure to practical proportions we have found that the potential applied between the cathode 3 and the anode 6 is preferably between 50 and 250 volts. Tubes operating with a potential below 50 volts have shown decreased beam focusing properties, and the use of potentials below this value necessitates greater accuracy in the alignment of the electron gun electrodes and the deflection plates. Certain tubes operating with potentials above 250 volts have given unstable operation. The axial magnetic field is preferably between 50 and 150 gauss. Below 50 gauss some distortion due to stray electrostatic fields may be produced, and the use of a field stronger than 150 gauss necessitates increased deflecting power and use of heavier coils and results in poorer focus of the electron beam near the edges of the mosaic electrode. The width of the target or mosaic electrode is preferably made between 5 and 7 centimeters, since the width of the plates must be of the same or greater width and would necessitate a tube of larger overall diameter. The length of the deflection plates is preferably between 10 and 20 centimeters, for when using a length less than 10 centimeters, some distortion and defocusing of the beam is produced. Lengths of the deflection plates above 20 centimeters unduly increase the tube length and the length of the focusing coil.

While we have indicated the preferred embodiments of our invention of which we are now aware and have indicated the specific application as directed to cathode ray transmitting tubes having target electrodes of the photosensitive mosaic type, it will be apparent that our invention is by no means limited to the purpose of television transmission, to the exact forms illustrated or to its use in cathode ray tubes incorporating target electrodes of the mosaic type, but that many variations may be made in the particular structure used, such as by replacing the mosaic electrode with target electrodes of the fluorescent, photoconductive, or photovoltaic type, without departing from the scope of the invention as set forth in the appended claims.

We claim:

1. A cathode ray tube having electron beam generating means, a target in the path of the electron beam, beams extending over the space between said beam generating means and said target to generate a magnetic field having lines of force parallel with the longitudinal axis extending between said beam generating means and said target, and electrostatic deflection means between said beam generating means and said target proportioned to produce, when energized with beam deflecting potentials, an electrostatic field which increases uniformly in intensity along

a portion of the beam path with increasing distance from said beam generating means and which decreases uniformly in intensity along another portion of the beam path with increasing distance from said beam generating means.

2. A cathode ray tube having an electron source, an oppositely disposed electron receiving target, an apertured cold electrode adjacent said source through which the electrons flow as an electron beam toward said target, means to generate a magnetic field having lines of force parallel with the axis between said cold electrode and said target and extending over the space separating said cold electrode and said target, a pair of apertured shield electrodes in planes substantially normal to said axis and separated one from the other along the length of said axis and electrostatic means wholly immersed in said field and between said shield electrodes to generate a deflection field which increases uniformly in intensity with increased distance from said cold electrode over a portion of the beam path and decreases uniformly with increased distance from said cold electrode over another portion of the beam path.

3. A cathode ray tube having a thermionic cathode to emit electrons, an apertured cold electrode adjacent said cathode through which the emitted electrons flow to form a beam, a target electrode in the path of said beam, means extending over the space between said anode and said target to generate a substantially uniform axial magnetic field, means including a pair of apertured shield electrodes between said anode and said target to provide an electrostatic field free space and a pair of electrostatic deflection plates wholly immersed in said axial magnetic field and within said electrostatic field free space, said plates being shaped so that their separation is greater at the ends thereof adjacent said anode and said target than at points intermediate said ends to generate an electrostatic field which uniformly increases and decreases in intensity between said plates with increased distance from said anode.

4. A cathode ray tube having an evacuated envelope, an electron gun and an oppositely disposed target in said envelope, means surrounding the envelope to generate a substantially uniform magnetic field along the longitudinal axis and extending between said gun and said target, two apertured shield electrodes spaced one from the other in planes normal to the longitudinal axis and between said gun and said target a pair of oppositely disposed deflection plates between said shield electrodes, one of said plates being on each side of the longitudinal axis between said gun and said target, each of said plates being flared outwardly from said axis at the opposite ends thereof.

5. A cathode ray tube as claimed in claim 4 wherein both of the said deflection plates have end portions in the direction of the gun and target whose profile is hyperbolic.

6. In combination with a cathode ray tube having means to generate a uniform magnetic field, an electrostatic deflection structure wholly immersed in said field comprising a pair of plates having a uniform separation from one to the other over a predetermined length of said field and outwardly flared portions on either side of said predetermined length.

7. In combination, a cathode ray tube having means to generate a beam of electrons and means to generate a uniform magnetic field, an

electrode structure wholly immersed in said field and partially surrounding the path of said beam of electrons comprising a pair of oppositely disposed and separated plates, a second pair of oppositely disposed plates extending within the space separating said first-mentioned pair and a third pair of oppositely disposed plates extending within said first-mentioned pair and separated from said second pair of plates, the plates of said second pair and the corresponding plates of said third pair being coplanar, said second and third pairs of plates providing a field-free space over the path of said beam exposed to said first pair of plates in the absence of beam deflection potentials applied between said first pair of plates.

8. In combination, a cathode ray tube having a target of the mosaic type, means for developing a beam of electrons directed at said target, an electrode structure between said target and said means comprising a first pair of oppositely disposed plates partially surrounding the path of said beam adapted to receive deflection potentials for deflecting said beam, two pairs of mutually separated plates extending within said first pair of plates to develop a field-free space between the plates of said first pair of plates in the absence of deflection potentials applied to said first pair of plates, the plates of one pair being coplanar with the corresponding plates of the other pair, the two pairs of plates being separated by a predetermined distance along the path of the beam said predetermined distance being less than the length of said first pair of plates along the path of the beam.

9. A cathode ray tube having an envelope, an electron gun and an oppositely disposed target electrode within said envelope, a magnetic coil surrounding the space between said gun and said target electrode to generate a magnetic field parallel with the axis between said gun and said target electrode to direct electrons emitted from said electron gun with components of velocity transverse to said axis along helical paths toward said target, a pair of oppositely disposed deflection plates, one on either side of the said axis to deflect the beam in a plane parallel with the plates, two pairs of plates symmetrically disposed with respect to said first pair, each pair extending within the space separating the plates of said first-mentioned pair and spaced apart along the said axis by a distance equivalent to the length of an integral number of pitch revolutions of the beam along the helical paths.

10. In a cathode ray tube system, a tube having a cathode to emit electrons, an anode to accelerate the electrons emitted from said cathode, a target in the path of said electrons, a pair of oppositely disposed deflection plates, one on either side of the longitudinal axis between said cathode, anode, and target, and two pairs of plates in telescopic relation with said first pair of plates, the two pairs of plates being separated along the said axis by a predetermined distance, means to generate a magnetic field extending over the space separating said anode and said target having lines of force parallel with the said axis to cause electrons emitted from said cathode with velocities transverse to said axis to follow helical paths toward said target and means to apply a difference of potential between said cathode and said anode such that the electrons of the beam describe an integral number of pitch revolutions along the helical paths while passing

between the predetermined distance separating the said two pairs of plates.

11. In a cathode ray tube system, a tube having a cathode to emit electrons, an anode to accelerate and form the electrons into a beam, a target oppositely disposed from said cathode and anode to receive electrons, a pair of oppositely disposed deflection plates, one on either side of the longitudinal axis between said cathode, anode and target, and two additional pairs of plates in telescopic relation with said first pair of plates separated one from the other by a predetermined distance along the said axis, means to apply a difference of potential to said cathode with respect to said anode and target and means to generate a uniform axial magnetic field between said anode and said target of sufficient intensity to cause electrons emitted by said cathode with velocities transverse to said axis to follow a helical path and an integral number of pitch revolutions along the helical path between said predetermined distance between the said two pairs of plates.

12. In a cathode ray tube system, a tube having an electron gun to form a beam of electrons,

a target oppositely disposed from and in axial alignment with said gun, a pair of oppositely disposed deflection plates, one on either side of the path followed by the electron beam between said gun and target, two pairs of plates in telescopic relation with said first pair, each of the plates being separated from the other plates of the respective pairs by a distance b , means to generate an axial magnetic field extending over the space separating said gun and said target to cause the electrons of the beam to follow a helical path toward said target and a source of electric potential connected between said cathode and said plates sufficient to cause the pitch of the helical path within said two pairs of plates to be no greater than 10 times the distance b .

13. A cathode ray tube as claimed in claim 4 wherein the aperture of said shield electrode nearer said target is elongated and having a width in the direction of the separation of said deflection plates substantially equal to the minimum separation between said deflection plates.

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CERTIFICATE OF CORRECTION.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 66, claim 1, for the word "beams" read --means--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 12th day of November, A. D. 1940.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

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