Aug. 27, 1940. A. ROSE 2,213,174

TELEVISION TRANSMITTING TUBE

Filed July 30, 1939 2 Sheets-Sheet 1

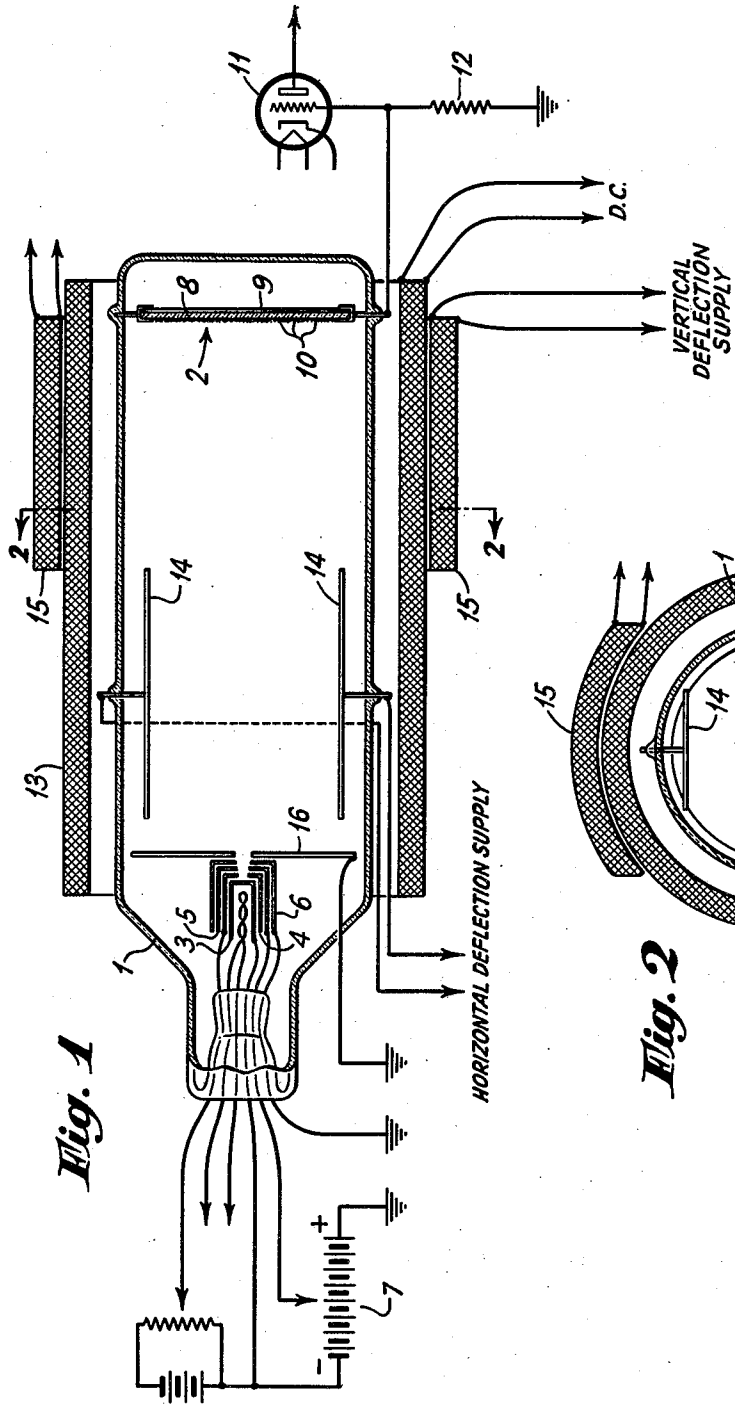


Fig. 1

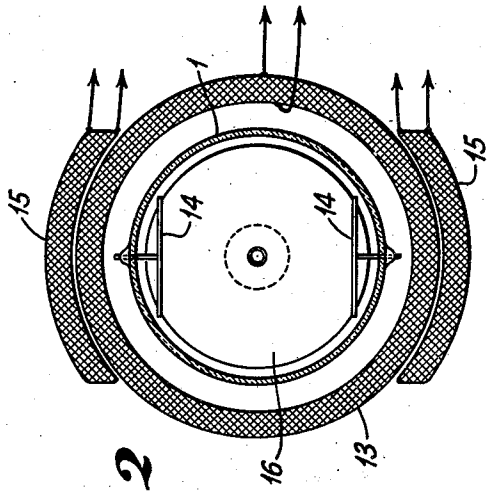


Fig. 2

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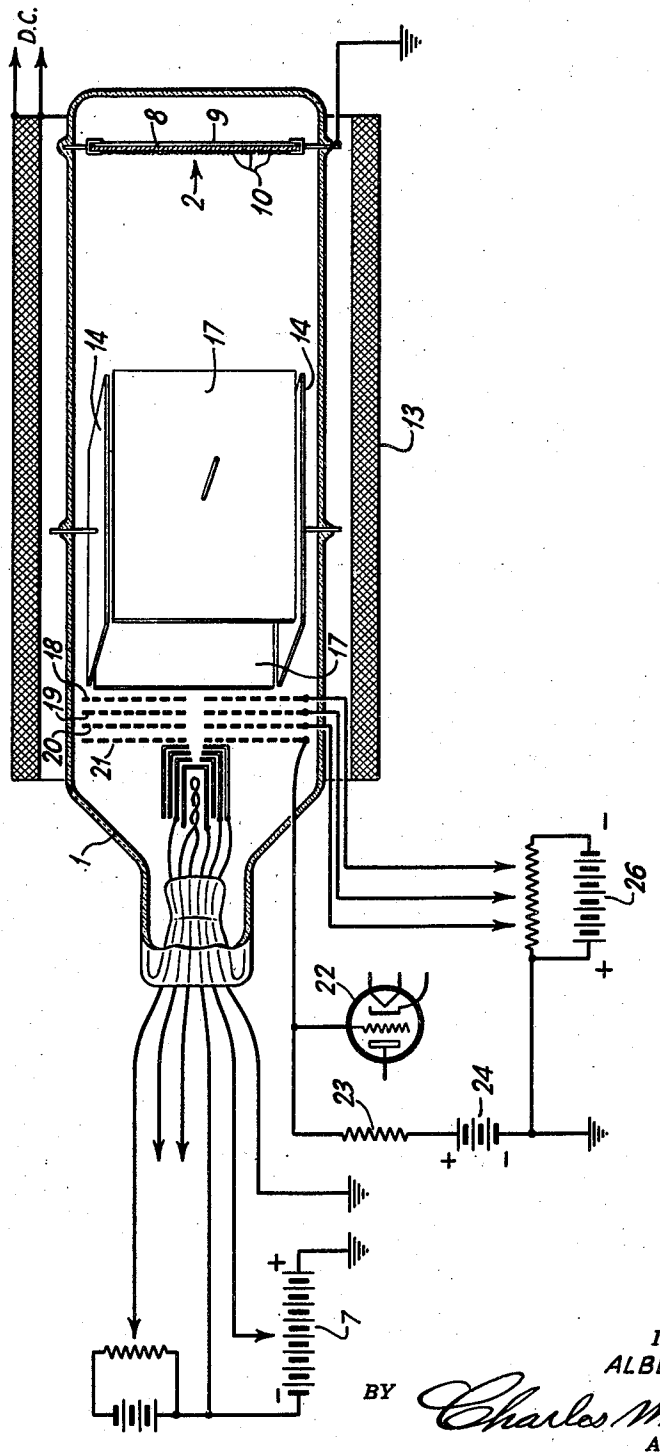


Fig. 3

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UNITED STATES PATENT OFFICE

2,213,174

TELEVISION TRANSMITTING TUBE

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Application July 30, 1938, Serial No. 222,153

7 Claims. (Cl. 250—150)

My invention relates to television transmitters and transmitting tubes and is more particularly directed to such tubes utilizing low velocity electron scanning beams.

Attempts have been made to utilize a low velocity electron scanning beam originating from a thermionically activated cathode to neutralize the electrostatic charges representative of the picture to be transmitted. In some of these arrangements the electron beam is directed against and scanned over the photo-sensitive target at a low velocity just sufficient to allow neutralization of the electrostatic charges on the target, the electrons which do not reach the target being re-directed to the gun along the same path or paths followed in their travel from gun to the target. In the operation of tubes incorporating this type of low velocity scanning, it has been found that spurious signals are produced because all of the electrons returning from the target are not collected by the anode of the gun. This is true because the closer the electrons follow their projected paths in returning to the gun the more electrons there are directed to the cathode which is necessarily at such a potential that many of the electrons return again to the target resulting in the spurious signals referred to above.

The principal object of my invention is to provide a television transmitting tube which will faithfully transmit an optical replica of a picture without the introduction of objectionable spurious signals. It is a further object of my invention to provide a more efficient electron collecting arrangement for use in low velocity television tubes. A still further object is to provide a tube of the low velocity type in which the picture modulated electron beam may be successively amplified by secondary electron multiplication.

In accordance with my invention an electrostatic image corresponding in electrostatic energy distribution to the light distribution of an optical image is formed on a mosaic electrode or target which is scanned by a low velocity electron beam from an electron gun. Those electrons of the beam which are not used in neutralizing the charges on the target are returned to an electron collecting electrode adjacent the gun along different paths from those followed by the beam in scanning the mosaic electrode. Since the returning electrons are equal in number to the number in the scanning beam minus those used to neutralize the charges on the target the returning electrons may be said to be modulated in accordance with the picture charges on the target.

According to another feature of my invention the electrons of the scanning beam which return from the mosaic electrode are successively amplified by secodary electron emission.

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

Figure 1 is a longitudinal sectional view of a television transmitting tube embodying my invention;

Figure 2 is a cross section of the tube shown in Figure 1 taken along the lines 2—2; and,

Figure 3 is a longitudinal sectional view of a tube made in accordance with a modification of my invention.

Considering broadly, the apparatus of my invention comprises an evacuated envelope having a target 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 mosaic electrode is provided on its front surface with an extremely large number of mutually insulated photoelectrically sensitive particles and 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 potentials between the electron gun and mosaic electrode are so adjusted that the electron beam is projected and directed upon the mosaic electrode at extremely low velocity, that is, a velocity approaching zero velocity at the point of impact therewith. In operation elemental areas of the mosaic electrode acquire electrostatic potentials proportional to the intensity of light incident thereon. Particles of the mosaic which are more highly illuminated acquire the most positive electrostatic charge with respect to the unilluminated particles. The positive charges representing an electrostatic image of a picture to be transmitted are neutralized by the scanning beam electrons. When the electrons of the scanning beam are directed toward those particles of the target which are negative with respect to the cathode they cannot reach those particles because of their low velocity. These electrons, since they are prevented from impinging on the target are returned to an electron collecting electrode adjacent the electron gun. The scanning means which scan the electron beam over the mosaic electrode or target are so chosen as to prevent those electrons of the beam which do not reach the target from returning to the

electron gun but rather causes them to be redirected along paths other than those followed by those electrons in traversing the distance between the electron gun and the target.

Referring specifically to my tube structure shown in Figures 1 and 2, 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 adapted to project electrons toward the mosaic electrode.

The electron gun assembly is of the conventional type and comprises a cathode 3 from which an electron stream may be drawn, 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 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 in the form of 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 3 by a battery 7.

The mosaic electrode 2 which faces the electron gun preferably comprises a substantially transparent sheet of insulation such as the mica sheet 8 having on its rear surface a translucent or semi-transparent metal film 9, the opposite surface of the mica sheet 8 being provided with an exceedingly great number of mutually separated photosensitive particles 10. In making the mosaic electrode I select the mica sheet 8 of the desired area having a uniform thickness of approximately .002" and as a first step coat one side of the sheet with a film of metal of sufficient thinness as to be substantialy transparent so that an optical image may be focused through the film of metal, through the sheet of mica and upon the opposite side of the sheet which faces the electron gun and which carries the photosensitive mosaic structure. The mosaic of mutually separated particles may be made by depositing on the front surface of the mica sheet 8 finely divided silver oxide which is reduced to provide a surface of individually separated silver globules or particles 10 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. Patent 2,065,570. The metal film 9 is connected to the input electrode of a translating device 11 and to ground through the impedance 12. The metal film 9 may, however, be omitted and an electron collector electrode, to be described later, used as the output electrode of the device.

In accordance with one teaching of my invention and as best shown in Figures 1 and 2, the electrostatic image representative of an optical image formed on the photosensitive particles 10 by focusing an optical image thereon, is neutralized by electrons from the electron gun, the electrons being scanned over the mosaic electrode by an electrostatic and electromagnetic deflection field operating over different portions of the path of the scanning beam and in a uniform magnetic field. The desired deflection fields are produced by the combined action of a uniform magnetic field extending between the electron gun and the mosaic electrode, preferably produced by a magnetic coil 13 and an electrostatic and electromagnetic field produced by the combination of the deflection plates 14 and the coil 13. I have found that the electrostatic field generated by the plates 14 and the magnetic field produced by the coils 15 should be separated along the length of the tube so that each is effective over a different portion of the electron beam path. I, therefore, prefer to provide the deflection plates at the electron gun end of the tube and the coils 15 between the plates 14 and the mosaic electrode 2.

The deflection produced by the deflection plates 14 would normally be in the plane of the drawing but by the combined action of this electrostatic field and the magnetic field produced by the coil 13, the deflection is at right angles to that normally expected or in a plane perpendicular to that of the drawings. In the normal use of an electrostatic focusing field, that is without a uniform magnetic field, the electrons are deflected at an angle to their original undeflected path and continue upon the angular trajectory after they have left the electrostatic field. In my arrangement, however, with the superposition of the uniform magnetic field produced by the coil 13, the electrons are first deflected from their normal or axial path while under the influence of the electrostatic field whereupon after they pass through this field they follow a path substantially parallel to the undeflected path or parallel with the axis of the tube because of the presence of the uniform magnetic field produced by the coil 13. Following this first deflection the electrons are deflected in a direction at right angles to the first direction of deflection, while subjected to the uniform magnetic field, by a magnetic field such as produced by the coils 15. Electrons which do not reach the mosaic electrode while being scanned over predetermined paths determined by the frequency of scanning return along the approximate path of the deflected electron beam up to a point where they enter the electrostatic field generated by the plates 14 whereupon they diverge from the predetermined paths originally followed by an amount equal to the outgoing deflection still going in the general direction of the electron gun, that is, away from the mosaic electrode. Since these returned electrons diverge along different paths and are not following their original paths they are not attracted to the electron gun.

Further in accordance with my invention I provide, preferably adjacent the electron gun and surrounding same, an electron collecting electrode 16 which as shown in Figure 1 may be in the form of an apertured disc having an aperture somewhat larger than the diameter of the electron beam as it leaves the electron gun. The electrode 16 must necessarily be between the electron gun and the electrostatic deflection plates 14 so that it may be outside the paths followed by the electrons from the electron gun to the mosaic electrode but in the path of the electrons returning from the mosaic electrode along dissimilar paths. As previously indicated, the metal film 9 is connected to ground through the impedance 12 but this impedance may be connected between the collecting electrode 16 and ground, the input electrode of the translating device then being connected to the electrode 16.

A substitution of magnetic means for the electrostatic deflection means, such as the plates 14, does not render the device operative as envisaged by my invention because if this undesired substitution is made the electrons returning from

the mosaic electrode are directed along the same approximate paths over the entire trajectory between the mosaic electrode and the electron gun, and many of these returning electrons are directed toward the cathode which is at a negative potential and incapable of collecting them, whereupon they return to the mosaic electrode and produce a spurious signal effective over the entire picture area. In the modification of my invention shown in Figure 1 only those electrons not acted upon by the electrostatic deflection field produced by the plates 14 can return toward the cathode and while this may result in a small spurious signal, this signal is limited to a single line of elemental picture width, which lies in a plane parallel to the deflection plates and midway between them. This spurious signal may be reduced to a single picture element in my tube shown in Figure 3.

Further in accordance with my invention my method and means of collecting returning electrons from the mosaic electrode is admirably suited to electron multiplication of these electrons by following the teaching of my invention as shown in Figure 3. The electron gun, mosiac electrode, and deflection structure shown in Figure 3 is similar to that of Figures 1 and 2 except that here I have preferred to show full electrostatic deflection means which generate electrostatic fields which are immersed in a uniform electromagnetic field. More specifically instead of the magnetic deflection field generated by the coils 15, I may use an electrostatic deflection system comprising the plates 17 which, together with the plates 14 similar to those shown in Figure 1, form a box having a square or rectangular cross-section. An electrostatic deflection system wherein the plates are of resistance material and joined at the longitudinal edges is particularly suitable. Such a structure is disclosed by R. R. Law in his co-pending application Serial No. 189,718 filed February 10, 1938. In this modification of my invention, the trajectories or paths of the electrons passing from the electron gun to the target or mosaic electrode differ from those of the returning electrons because of the effect of the super-posed magnetic field generated by the coil 13.

In either of the structures shown in the figures, the width of the plates 14, as in Figure 1, or the plates 14 and 17, as in Figure 3, should be at least as great as the width of the effective area to be scanned on the mosaic electrode. Thus, if the entire width of the mosaic electrode is illuminated with the picture the width of the plates should be at least as great as the width of the mosaic electrode. The separation between the plates 14 and 17 respectively should be greater than the height and width of the mosaic electrode. This is true in view of the foregoing explanation since the electrons are controlled by the uniform magnetic field after they pass out of the influence of the deflection plates, having by this time received their maximum radial electrostatic deflection.

In the modification of my invention shown in Figure 3, the electrons of the beam approaching the mosaic electrode with a velocity approaching zero, but not reaching the electrode, are returned along different paths than those along which they approached the mosaic electrode whereupon the returning electrons are multiplied by secondary electron multiplication. Situated in the path of the returning electrons and preferably between the deflection plates 14 and 17 and the electron gun, I provide a series of mesh-like anodes having aligned central apertures of a diameter at least equal to or slightly greater than the diameter of the electron beam as it leaves the electron gun. Four of these apertured mesh-like anodes 18–21 are shown in the figure. The electron collecting electrode or anode 21 which serves as the final electron collecting electrode is connected to the input electrode of a translating device 22 and to the anode 6 through an impedance 23 and battery 24 so that the anode 21 may be maintained at a positive potential with respect to the anode 6. While the anode 21 is shown as being formed of mesh-like material such as interwoven wire screening, it is obvious that this anode may be constructed of a singly apertured metal disc. The anodes 18, 19, and 20 are preferably of bright metal which has a high secondary emission coefficient, and are connected through a potentiometer 25 to a source of positive potential such as the battery 26 so that they may each be maintained at progressively increasing positive potentials of sufficient magnitude to accelerate the returning electrons to a velocity sufficient to insure proper secondary electron multiplication. While I have shown but four of these anodes, it is to be understood that any desired number may be used depending upon the degree of secondary electron emission desired.

In the arrangement described in connection with Figures 1 and 2 it has been shown that a slight spurious signal may result during the operation of the device but that this spurious signal is limited to one elemental line of the picture or, at most, to a line having a width equivalent to the anode aperture. With the arrangement of Figure 3 where two sets of electrostatic plates are used and where these plates are immersed in a uniform magnetic field, the spurious signal is confined to a very small area the size of the anode aperture at the center of the picture. This is true since the electrons return toward the cathode at only one time during a scanning cycle, namely, when the electrostatic field of both sets of deflection plates is zero and the beam passes along the axis of the tube. At all other phases of the scanning cycle the returning electrons are deflected away from the electron gun anode aperture to the collecting electrode 16 as in Figure 1, or as in Figure 3 to the secondary electron emitting screens 18, 19 and 20 where the returning electrons are multiplied by impinging thereon at high velocity whereupon all of the electrons are collected by the collecting electrode 21.

It is especially desirable to have the electrons returning from the mosaic electrode or target return to the collector electrode and not strike the gun or parts of it. Thus, if the signal is collected by an anode incorporated in the gun as in prior art arrangements, the signal is subject to pick-up from the potential sources connected to the gun as well as to undesirable shot noise from the cathode emission current which does not go into the beam but strikes and is collected by the anode of the gun. By following the teachings of my invention, the introduction of electrostatic deflection provides a means for using a collecting electrode separate from the gun elements which means avoids unwanted signals from the gun electrodes and shot noise from the cathode current and thereby assures a more uniform collection of beam electrons returning from the target.

While I have indicated the preferred embodiments of my invention of which I am now aware and have indicated the specific application as directed to a cathode ray transmitting tube having a semi-transparent mosaic electrode, it will be apparent that my invention is by no means limited to the exact forms illustrated or to the use of my invention in cathode ray tubes incorporating mosaic electrodes of the type described but that many variations may be made in the particular structure used and the purpose for which it is employed, such as by replacing the mosaic electrode with target electrodes of the photoconductive or photoresistive type without departing from the scope of my invention as set forth in the appended claims.

I claim:

1. A television transmiter comprising a mosaic target electrode having a multiplicity of mutually insulated photosensitive particles exposed on one side, an electron gun having a cathode and an anode oppositely disposed from said target to generate a beam of low velocity electrons, means including a focusing coil extending over the space separating said gun and target and a deflection coil over a portion of said space to direct said beam over predetermined paths between said electron gun and said target, means including said focusing coil to generate a magnetic field, a pair of electrostatic deflection plates wholly immersed in the field generated by said focusing coil to direct electrons of said beam not reaching said target along paths diverging from said predetermined paths and an electron collecting electrode directly adjacent said gun for intercepting said electrons.

2. A television transmitter comprising a photosensitive mosaic electrode, an electron gun including a cathode and an anode to direct a beam of electrons toward said electrode at a velocity approaching zero at the surface thereof, means to generate a substantially uniform magnetic field extending throughout the entire space between said electron gun and said mosaic electrode, beam deflection means to sweep said beam over said electrode, said beam deflection means comprising a pair of electrostatic deflection plates wholly enclosed by said means to generate a magnetic field, and a magnetic deflection coil between said gun and said mosaic electrode, and an apertured electron collecting electrode closely adjacent said electron gun and outside of the direct paths followed by the electrons between said cathode and said mosaic electrode to collect the electrons of said beam not reaching the mosaic electrode.

3. A television transmitter comprising an envelope enclosing a mosaic electrode extending across substantialy one end thereof, an electron gun including an anode near the opposite end of said envelope to generate and direct a beam of electrons toward said mosaic electrode, a pair of electrostatic deflection plates between said gun and said mosaic electrode of a width in a direction transverse to the longitudinal axis between said gun and target at least as great as the width taken in the same direction of said electrode, and an apertured electron collecting electrode between said gun and said deflection plates extending transversely of the said longitudinal axis, means to deflect the electron beam in a direction normal to the direction of deflection afforded by said electrostatic plates and means extending over the entire space between said gun and said mosaic electrode and over the space occupied by said plates to generate a uniform magnetic field over the entire space between said gun and mosaic electrode.

4. A television transmitter comprising an elongated envelope enclosing a mosaic electrode of extended width at one end thereof, an electron gun including an anode at the opposite end of said envelope to generate and direct a beam of electrons axially of said envelope and toward said electrode, a pair of electrostatic deflection plates between said gun and said electrode, said plates having a width at least equal to the width of said mosaic electrode, and an apertured electron colecting electrode aligned with said gun and between said gun and said deflection plates to collect electrons of said beam not reaching said mosaic electrode, a magnetic deflection coil between said deflection plates and said mosaic electrode and a magnetic coil surrounding said envelope and extending between and slightly beyond said collecting electrode and said mosaic electrode to generate a magnetic field and to direct electrons from said gun toward said mosaic electrode at normal incidence to the plane of said mosaic electrode.

5. A television transmitter as claimed in claim 4 having a plurality of mesh-like secondary electron emiting electrodes between said collecting electrode and said deflection plates.

6. A television transmitter comprising a tube enclosing a target electrode extending across and at one end thereof, an electron gun including an anode at the opposite end thereof to generate and direct a beam of electrons toward said target electrode, a pair of electrostatic deflection plates between said electron gun and said target electrode of a width at least equal to the width of said target electrode, said plates being separated by a distance at least equal to the dimension of said target electrode in a direction perpendicular to its width, a second pair of electrostatic deflection plates mutually perpendicular to said first mentioned pair of a width at least equal to the dimension of said target in a direction perpendicular to its width the separation between the plates of said second pair being at least equal to the width of said target electrode, and an apertured electron collecting electrode aligned with said gun and between said gun and said deflection plates to collect electrons of said beam not reaching said target electrode, and a magnetic coil surrounding said tube and extending between and slightly beyond said collecting electrode and said target electrode to generate a magnetic field having lines of force extending through said target electrode normal to its surface.

7. A television transmitter as claimed in claim 6 having a plurality of mesh-like secondary electron emitting electrodes between said collecting electrode and said deflection plates.

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