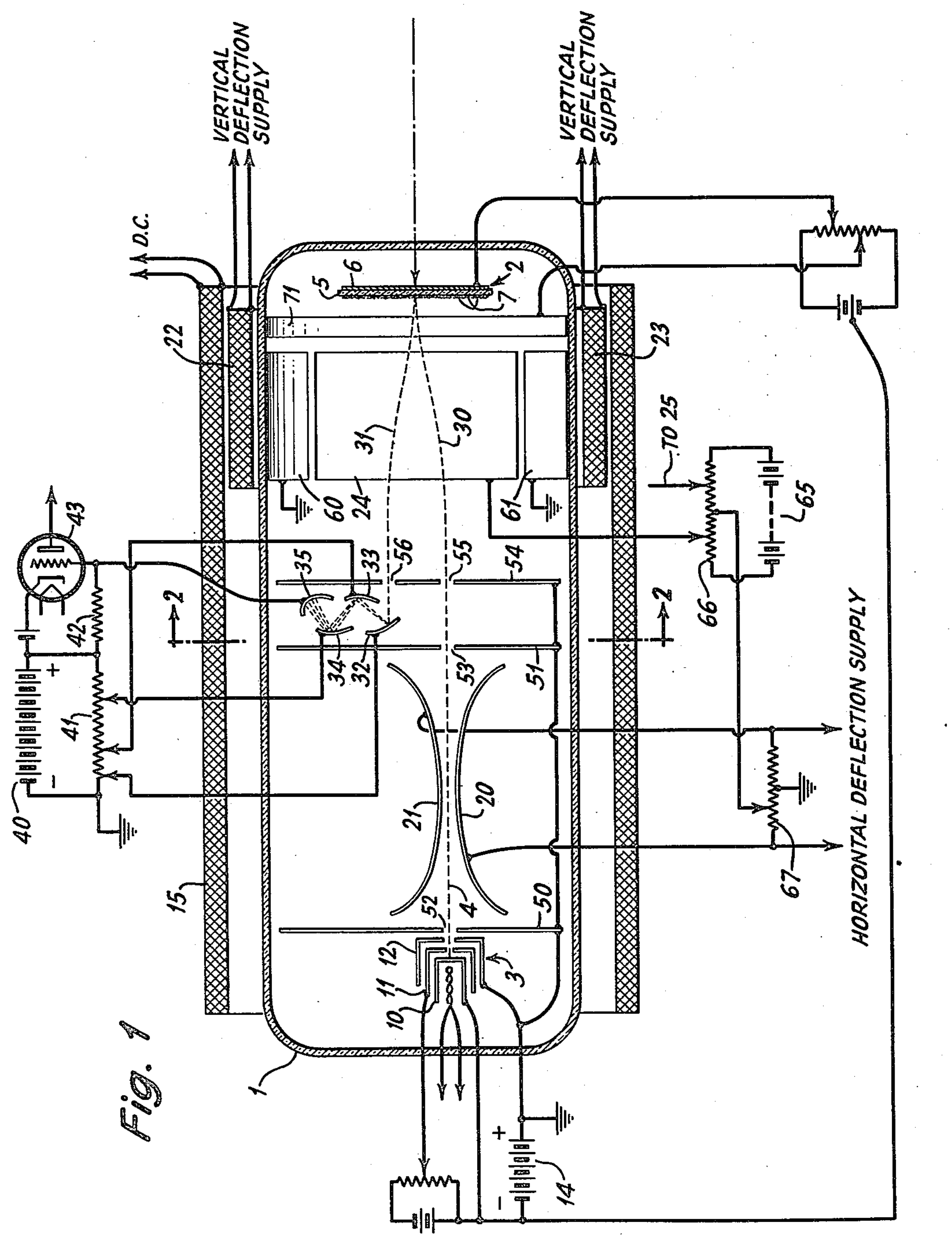
TELEVISION TRANSMITTING TUBE

Filed Jan. 29, 1941 2 Sheets-Sheet 1



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June 30, 1942. H. A. IAMS 2,288,402

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Fig. 2

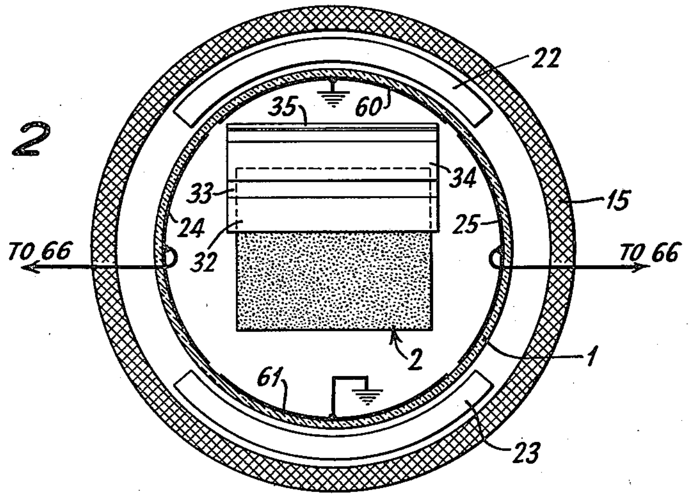
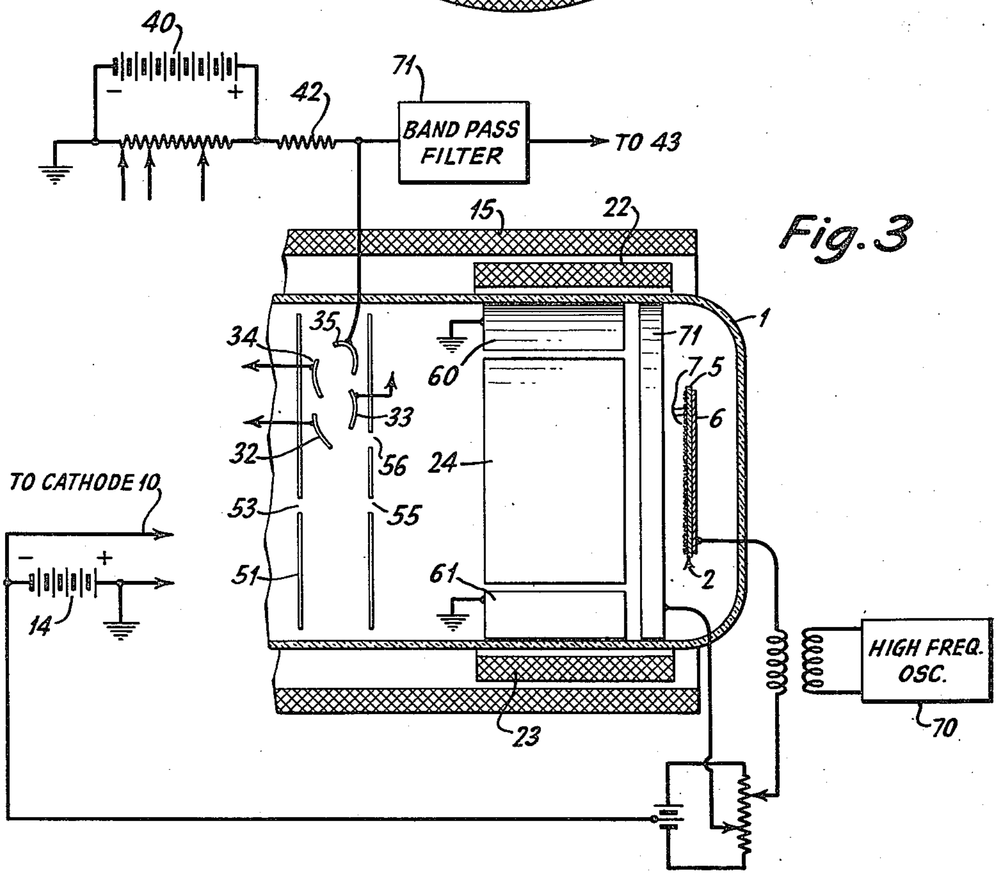


Fig. 3



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TELEVISION TRANSMITTING TUBE

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18 Claims. (Cl. 178—7.2)

My invention relates to television transmitting tubes and is more particularly directed to tubes utilizing low velocity electron scanning beams and incorporating electron multiplying arrangements.

In my U. S. Patent No. 2,213,177, issued August 27, 1940, I disclosed several forms of television transmitting tubes utilizing limited area secondary electron multiplying arrangements wherein the electron beam was projected toward a target of the electrostatic charge storage type, modulated in accordance with the electrostatic charges representative of an optical image, and returned to the electron multiplying structure along paths raised or lifted from the paths of the beam as it approached the target. During the return of the beam it is influenced by deflecting fields operating to absorb the deflection imparted to the beam in its passage toward the target. The arrangements disclosed in my above referenced patent require careful design and have certain inherent limitations as to size and useful area of the target and in addition the tube structure inherently introduces some distortion which I have found possible to eliminate by following the teaching of my present invention.

Objects of my invention are to provide a structure wherein more uniform secondary electron amplification of electronic picture signals may be obtained, a structure wherein distortion produced by non-uniformity of secondary emitting surfaces is minimized, a simplified symmetrical structure in combination with means for secondary electron amplification of electron picture signals, a tube wherein the image area is not limited by the necessity for widely diverging electron paths, a structure wherein electrodes of such form and shape as to minimize scanning distortion are utilized and a structure wherein the overall length of the tube may be reduced.

In accordance with my invention an electrostatic image corresponding in electrostatic energy distribution to an optical image is formed on a target electrode preferably of the photosensitive mosaic type which is scanned in one direction with a low velocity electron beam from an electron source, the scanning being accomplished by a combination magnetic-electrostatic field, the electrostatic field generating means being slightly offset from the center of the useful target area, the electrons of the beam then being scanned in the other direction and substantially simultaneously lifted to the center of the useful target area and returned in the general direction of the electron source to a point intermediate the first scanning means and the target to an electron multiplying arrangement effective over the width of the target in the direction of the first scanning. More particularly, in accordance with my invention I provide a structure utilizing electron multiplying arrangements having an effective length at least equal to and a physical length preferably greater than the dimension of scanning in one direction as measured at the target surface.

The objects mentioned above and other objects, features and advantages will be apparent from the following description taken in connection with the accompanying drawings in which:

Figure 1 is a longitudinal cross-sectional view of the tube and circuit embodying my invention;

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

Figure 3 shows a portion of the tube of Figure 1 and a circuit particularly suitable for use with such a tube.

In general, the apparatus of my invention comprises an evacuated envelope having a target preferably of the photosensitive mosaic type at one end thereof and an electron source and anode slightly offset from the effective center of the target at the opposite end of the envelope. The target, if of the mosaic type, is provided on its front surface with an extremely large number of small photosensitive particles and is so positioned that it may be scanned by an electron beam from the source and may also have focused thereon an optical image of the object of which a picture is to be transmitted. The electron source may be of the conventional type comprising a small area cathode surrounded by a conventional apertured grid and apertured electron accelerating anode structures. The potential between the electron source and the target is so adjusted that the electron beam is projected at relatively low velocity and directed upon the target with a velocity approaching zero in the vicinity thereof, the electrons being collected or rejected by the target in accordance with the electrostatic charges thereon. Thus those areas of the target 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 picture to be transmitted are neutralized by a portion of the electrons comprising the beam, the remaining electrons being reflected from the target. Intermediate the electron source and the target and preferably adjacent the source I provide means to electrostatically deflect the electron beam in combination with a longitudinal magnetic field without introducing distortional effects, I have found in accordance with my invention that I may place the electron multiplying structure intermediate the electrostatic deflection means and the target and thereby utilize a deflection structure which will not introduce defocusing or distortion of the electron beam. Likewise, intermediate the electrostatic deflection means and target and preferably over the same portion of the electron beam paths I provide means to lift the beam and simultaneously deflect the beam in a direction substantially normal to the direction of deflection imparted to the beam by the electrostatic means. Thus my new and improved television transmitting tube comprises structure which from the electron source and anode end of the envelope comprises in the following order, electrostatic means to deflect the beam in one direction such as the direction of horizontal deflection with enclosing shield electrodes if desired, electron multiplying means extending in the direction of deflection by a length at least as great as the deflection produced by said electrostatic means, separate means to simultaneously lift the electron beam and deflect the beam in another direction, an electrode to control the electron beam in the vicinity of the target and the target at the opposite end of the envelope from the electron source.

Referring particularly to my tube structure as shown in Figures 1 and 2, the tube structure includes an elongated evacuated envelope 1 enclosing at one end a target or mosaic electrode 2 and at the opposite end an electrode assembly 3 adapted to project electrons toward the mosaic electrode such as along the path 4 shown by the dashed line. The mosaic electrode 2 which faces the electrode structure 3 preferably comprises a substantially transparent sheet of insulation such as the mica sheet 5 having on its rear surface a translucent or semi-transparent electrically conducting film 6 and on the front surface of the mica sheet a mosaic comprising an exceedingly great number of mutually insulated and separated photosensitive particles 7. Various methods of making such a semi-transparent mosaic electrode are well known in the art and will not be described in detail. Obviously, other types such as photoconductive or photovoltaic targets may be utilized if desired.

The electrode structure 3 at the opposite end of the envelope 1 comprises a cathode 10 from which electrons may be drawn, a control electrode 11 connected to the usual biasing battery and an anode 12 having a beam defining aperture maintained positive with respect to the cathode 10 by a battery 14 to accelerate the electron beam such as along the path 4. The cathode 10 is connected to the mosaic electrode conductive film 6 to maintain this film at cathode potential to decelerate the electrom beam to substantially zero velocity in the vicinity of the target. The electrode structure comprising the cathode, grid and anode is preferably offset slightly from the longitudinal axis of the tube and consequently similarly offset from the center of the effective area of the mosaic electrode 2.

To direct the electrons and maintain the electron beam in a focused condition between the electron source and the target I provide a focusing coil 15 wholly enclosing and preferably extending beyond the space between the cathode 10 and mosaic electrode 2. This focusing coil is so designed as to provide a field strength in an axial direction of about 50 to 75 gausses which I have found sufficient to maintain the electron beam in a focused condition. The effect of the magnetic field is to cause the electrons which are emitted by the cathode with initial transverse velocities to follow helical paths or trajectories of small amplitude so that while I have referred to the beam as being in focus throughout the length of the beam path, this is not literally true, since the beam has a number of focal points along the path, the electrons actually following helical trajectories. The length of a single helix or pitch of the helical electron path may be varied by varying the strength of the magnetic field or by varying the velocity of the electron beam. The path of a beam under the influence of a magnetic field such as generated by the focusing coil 15 suddenly receiving large transverse velocity components from electrostatic deflection means is distorted and the electrons suddenly receiving such transverse velocity components follow helical paths of great amplitude so that the electrons cannot be controlled or focused at the target.

Tubes of the prior art, such as referred to in my above-mentioned patent and utilizing electron multiplying arrangements, incorporate electrostatic deflection means which introduce considerable distortion, inasmuch as it is difficult, to provide deflection means which avoid imparting to the beam large transverse velocity components. In accordance with my present invention, I provide the electron multiplying structure intermediate the electro-static deflection means and targets and can, therefore, use a preferable form of electrostatic deflection systerm.

Referring again to Figure 1, I provide a pair of electrostatic deflection plates cvomprising the plates 20—21 directly adjacent the electrode structure 3 and aligned with the offset electron beam path 4, the plates 20 and 21 being flared outwardly from the electron path at each end thereof as described by Albert Rose and me in our U. S. Patent 2,213,175. Such a deflection structure is not wholly suitable for use in the tube shown in my first-mentioned patent because the electrons not reaching the target are redirected through a similar deflection plate structure to an electron multiplier so that if the plates such as the plates 20 and 21 are flared outwardly at each end, the returning electrons would impinge on the flared portions of these paths. The effect of the flared plates is to provide an electrostatic deflecting field which first increases and then decreases in intensity along the path of the electron beam through the plates. Further in accordance with my invention and as shown best by Figure 2, I provide magnetic deflection means such as the coils 22—23 to deflect the electron beam in a direction perpendicular to the deflection produced by the plates 20—21, and over the same portion of the beam path I provide means such as the beam lifting electrodes or "plates" 24—25 to lift or raise the center of the scanning pattern to the center of the effective area of the target 2. The lifting or raising of the beam is imparted simultaneously with the deflection produced by the deflection coils 22—23 and I have found that when the electrodes 24—25 are formed as cylindrical surfaces a minimum of distortion is produced and the tube is easily constructed. Thus in operation the electron beam is first deflected in a plane parallel with a plane midway between the deflection plates 20—21, as along the path 4. The deflected electrons are lifted, however, along the path 30 to a plane displaced from the plane of deflection and simultaneously deflected in a direction normal to that produced within the plates 20—21 by the deflection coils 22—23. Electrons not reaching the target are similarly lifted or raised to a third plane while returning in the general direction of the electron source as shown by the path 31. The returning electrons are then intercepted by a secondary electron emitter 32 which extends in a direction normal to the drawing of Figure 1 for a length at least equivalent to the deflection produced by and within the deflection plates 20—21. This deflection is equivalent to the effective width of the target and the beam is not displaced in this direction of deflection after passing through the deflection plates 20—21. I further provide secondary electron emitting electrodes 33 and 34, each of these electrodes likewise being of a length at least equal to the said length of deflection or target width, and an electron collecting electrode 35 of similar length beyound the electrode 34 to collect the secondary emission from the preceding electrode. Each of the electrodes 32—34 may be of silver which during the processing of the mosaic electrode 2 are oxidized and upon introduction of alkali metal such as caesium for purposes of photosensitizing the mosaic these electrodes become highly secondary electron emissive. All of the electrodes 32—35 are in the form of elongated cylindrical surfaces. To maintain the electrodes 32-35 at proper operating potentials I provide a potential source or battery 40 and potentiometer 41 to maintain the electrodes at progressively increasing positive potentials, the electrode 35 being connected to the positive end of the battery 40 through an output impedance 42 and to the input circuit of a thermionic amplifier 43.

For optimum operation of the tube shown in Figures 1 and 2 I enclose the deflection plates 20—21 in a substantially field-free space and I therefore provide apertured electrodes 50—51, one at either end of the deflection plates 20—21, the aperture 52 of the electrode 50 preferably being slightly larger than the maximum diameter of the electron beam and the aperture 53 being elongated and of a length greater than the maximum deflection produced within the plates 20—21. The electrode 51 likewise serves as one shield member for the space occupied by the electrodes 32—35, the apertured shield member 54 forming the other shield member. I have found that the use of the shields as the member 51 and 54 is desirable to shield the electrodes 32—35 from the deflection plates and also to limit the collection of photoelectrons by these electrodes. Electrostatic fields generated by the plates 20—21 would otherwise produce non-uniform collection of beam electrons returning from the target. The shield member 54 may be provided with a single aperture to pass the electron beam as well as to pass the returning beam electrons, although this electrode may have two apertures as shown, the aperture 55 for the electron beam deflected in one direction by the plates 20—21 and the aperture 56 to pass the returning electrons to the secondary emitting electrode 32. Each of the apertures 55—56, as well as the aperture 53 as noted above, is elongated, the length being at least as great as the effective target width which is equal to the deflection produced within the deflection plates 20—21. The electrodes 50, 51 and 54 are preferably operated at the mean potential of the deflection plates 20—21, such as at ground, which is the potential applied to the anode 12 so that a field-free space is formed within the deflection chamber in the absence of deflection fields, that is, between the electrodes 50—51 and likewise within the electron multiplying chamber between the electrodes 51 and 54. Photoelectrons liberated from the mosaic electrode 2 under the influence of light incident thereon are collected by the shield member 54 and to minimize photoelectron electron multiplication I provide the aperture 56, or the single aperture combining the function of both apertures 55 and 56, with a height equal to or less than 10% of the effective target height, these dimensions being in the plane of the drawing of Figure 1.

To provide a more uniform electrostatic field in the vicinity of the lifting plates or electrodes 24—25 I provide additional electrodes 60—61 likewise within the space partially enclosed by the deflection coils 22—23 and forming with the lifter plates or electrodes 24—25 a discontinuous circular cylindrical surface wherein the electrodes 24—25 and 60—61 completely surround a portion of the electron beam paths except for adequate space between these electrodes provided for purposes of insulation. These electrodes may be formed as conductive wall coatings as shown or may be metal plates formed with cylindrical surfaces. The electrodes 60—61 are likewise operated at ground potential to maintain, in the absence of lifter plate potentials, a field-free space within the lifting plate region.

The lifting plates or electrodes 24—25 are operated respectively above and below ground potentials such as by a potential source or battery 65 across which I provide a potential divider 66. While I have shown the polarity of the battery 65, reversal of the magnetic field generated by the coil 15 will necessitate a reversal of this polarity which is chosen in accordance with the field direction to lift the electron beam from the offset electron source and deflection plate structure to the effective center of the target area, this lifting being accomplished over that portion of the path designated with the numeral 30. It is also desirable that the electron beam pass between the lifter plates in a region of constant potential, even though the beam is deflected horizontally by the deflection plates. I therefore prefer to apply a small amount of the horizontal deflection potential across the lifter plates 24—25 so that the beam as well as the returning electrons while passing between the lifter plates passes through a zero potential gradient with respect to ground.

To accomplish this mode of operation I connect the center of the potential divider 66 to a point on a second potential divider 67 connected across the horizontal deflection supply applied to the deflection plates 20—21. While I have shown this connection as being made to the left of the grounded center tap of the divider 67, the connection is made to the opposite side of the center tap if the direction of the axial magnetic field produced by the coil 15 is reversed. I have found that when the electron beam is in sharp focus at the first electrode, such as the electrode 32 of the series 32—35, any small variations in the secondary electron emitting properties of the electrode 32 over the extended length thereof produce blemishes in the reproduced television picture. In the processing of secondary electron emitting surfaces it is very difficult to obtain surfaces which have uniform secondary electron emitting characteristics over the entire area thereof and I have found such inequalities produce a minimum of difficulty when the electron beam is in focus at the target, but the returning electrons are out of focus in the plane of the first multiplying electrode 32. I have already pointed out that the effect of a longitudinal magnetic field produced by the focusing coil 15 is to cause certain electrons to follow helical paths of small amplitude so that the beam has a number of focal points along the beam path, the electrons actually following helical trajectories. I have likewise pointed out that the length of a single helix or the pitch of the helical electron path may be varied by varying the strength of the magnetic field or by varying the velocity of the electrons. I therefore prefer to locate the electrode 2 with respect to the other electrodes of the tube and especially with respect to the defining aperture of the anode 12 to minimize the effect of variations in the secondary emission properties of the electrode 32. I therefore locate the electrode 32 so that its secondary electron emitting surface is positioned to intercept that portion of the returning electron beam when it is out of focus with respect to the focused condition at the target. Thus the beam is out of focus at the surface of the electrode 32 when the distance measured in centimeters along an axial direction between the defining aperture in the anode 12 to this surface is expressed by the following equation:

$$(n+n')\frac{21V^{1/2}}{H}$$

where n is an integer, n' is a fraction of n (preferably equal to the fraction ½), V is the axial velocity of the electrons measured in volts (potential of battery 14), and H is the magnetic field strength measured in gausses. Thus if the distance between the anode 12 and the emitting surface of the emitter 32 is made unequal to the length of an integral number of pitch revolutions of the beam along said axis the electrons are defocused upon reaching the emitter. Preferably this distance is equivalent to an integral number of pitch revolutions plus one-half of a pitch revolution along said axis so that said beam is in a maximum out-of-focus condition when it impinges on the emitter 32. The beam may be focused upon the target irrespective of the out-of-focus condition in the plane of the emitter 32 parallel with the target without causing refocus of the returning electrons upon the emitter because the fields between the emitter and target are effective to the same degree on both the electrons of the beam approaching the target and on the electrons reaching the emitter 32. The net effect of the fields is thus to cancel any focusing action between the emitter and the target planes leaving the returning electrons in a defocused condition upon reaching the emitter 32. The operating parameters are therefore chosen to provide an out-of-focus condition of the electron beam at the secondary electron emitting surface of the electrode 32 and the beam may be brought to focus at the target by adjusting the potentials applied to the electrodes between the electrode 32 and the target. For this purpose I may provide an additional electrode 71 adjacent the target or mosaic electrode 2 whereby the focus of the electron beam may be varied notwithstanding the out-of-focus condition at the electrode 32. The electrode 71 may be in the form of a narrow coating of electrically conducting material deposited on the tube wall adjacent the front surface of the target. This electrode serves the additional purpose of providing a substantially uniform electrostatic field over the scanned area of the target. Such a uniform field controls the rotation of the entire scanning pattern which rotation may be produced by the magnetic field of the coil 15.

It is very desirable in the construction and operation of the tube shown in Figures 1 and 2 to provide minimium collection of photoelectrons by the secondary electron emitting electrodes and especially by the electrode 32 inasmuch as the photoelectrons which may be collected at any instant of time are not representative of the desired picture signal. While serious difficulty from this cause may be avoided by the use of an entrance aperture such as the width of the aperture 56 in the shield electrode 54 equal to or less than 10% of the target height, the arrangement shown in Figure 3 is suitable for eliminating the effect of photoelectron collection by the secondary electron emitting electrode 32. In accordance with this teaching of my invention, I separate the signal due to varying collection of photoelectrons from the signal due to the electrons of the beam returning from the target. In accordance with this teaching, I apply a high frequency alternating potential to the metal film electrode 6 of the target electrode assembly such as by interposing an alternating potential source 70 in the connection between the electrode 6 and the cathode 10. The frequency of the alternating current potential source 70 is chosen to be greater than the maximum signal frequency produced by scanning the target with the electron beam and may to advantage be of the order of 10 megacycles or more. An amplitude of several volts is sufficient to prevent the electron beam from reaching the target during the negative half cycles of the alternating voltage. Thus, when the scanning beam is directed upon illuminated portions of the target, current is acquired from the beam by the target on the positive portions of the alternating current wave, but not on the negative portions. Thus, that portion of the electron beam not reaching the target but returning to the secondary emitter 32 is unmodulated during the time the beam is scanning unilluminated portions of the target, but this portion of the beam varies in amplitude at the impressed alternating current frequency during the time the beam is directed upon lighted portions of the target. Meanwhile, the photoelectron emission from the target is not interrupted by the alternating current voltage applied to the electrode 6. It is obvious from the foregoing that the output such as applied across the output impedance 42 consists of three components, one with a modulated carrier wherein the amplitude of modulation is representative of the picture signal desired, another due to the remaining unmodulated beam current, and third component representative of collection of photoelectrons, the signal for which suppression is desired. The third component has no carrier. To suppress the components without a carrier I provide a band pass filter 71 preferably interposed between the electron-collecting electrode 35 and the input circuit of the translating device 43, this filter being tuned to pass the modulated alternating current wave applied to the electrode 6 from the source 70 but to reject the low frequency signals caused by the varying collection of photo-electrons or variations of beam current introduced either by adjustment or by other causes. Thus, in accordance with this teaching of my invention, I have provided a circuit suitable for use with the tube shown in Figure 1 wherein suppression of spurious signals due to photo-electron collection are eliminated.

While I have indicated the preferred embodiments of my invention with particular reference to a tube and system adapted to the generation and control of signals representative of images for which television is desired, it will be apparent that my invention is not limited to the various embodiments herein set forth, but that many variations may be made in the particular structure used and the associated system as well as for the purpose for which my invention is employed without departing from the scope thereof, as set forth in the appended claims.

I claim:

1. A television transmitting tube comprising an evacuated envelope, an electron source, means adjacent the source to accelerate electrons in a direction longitudinally of said envelope, an extended area target having its effective center offset from the initial path of said beam, means adjacent said target to decelerate said electrons to a longitudinal velocity of substantially zero adjacent said target, a magnetic coil extending over the entire path between said source and target to generate a longitudinal magnetic field, a pair of deflection plates adjacent said source and said means to deflect electrons from said source in one direction over the width of said target, means between said plates and said target to deflect the said electrons in a direction perpendicular to said target width, electron lifting means to lift the said electrons to scan the electrons over the effective height of said target in said perpendicular direction, a secondary electron emitter having a length at least equal to the effective width of said target positioned between said deflection plates and said target to liberate secondary electrons when impinged by a portion of said electrons not reaching said target and an electron collecting electrode likewise having a length at least equal to the effective width of said target and adjacent said secondary electron emitter.

2. A tube as claimed in claim 1 including a plurality of secondary electron emitters between said first-mentioned secondary electron emitter and said collecting electrode.

3. A television transmitting tube comprising an evacuated envelope, a light sensitive target adjacent one end of said envelope, a cathode and anode offset from the effective center of said target to develop an electron beam, means to generate a magnetic field having lines of force parallel with the center line between and intercepting said gun and target, electrostatic field generating means wholly immersed in said field and adjacent said anode to generate a deflection field which increases uniformly in intensity with increased distance from said anode over a portion of the beam path and decreases uniformly in intensity over another portion of the beam path to deflect the beam over the width of said target, beam lifting means to lift the beam to the effective center of said target over a portion of the beam path between said electrostatic means and said target, means to simultaneously deflect the beam over the same said portion of the beam path in a direction normal to that produced by said electrostatic means, means to substantially prevent said electron beam reaching said target in the absence of light projected thereon, elongated secondary electron emitting means positioned in a direction transverse to said center line, in a direction parallel to the direction of scanning across the width of said target, and between said electrostatic means and said beam lifting means to receive and multiply electrons of said beam not reaching said target and a collecting electrode adjacent said emitting means to collect secondary emission therefrom.

4. A television transmitting tube as claimed in claim 3 including means between said electrostatic means and said emitter to shield said emitter from the electrostatic field generated by said electrostatic means.

5. A television transmitting tube comprising an evacuated envelope, a cathode and anode to develop an electron beam, a light sensitive target of extended area oppositely disposed from said cathode and anode, means substantially coextensive with said target to prevent the electron beam reaching said target in the absence of light projected thereon, magnetic means to constrain the electron beam and direct it along a path normal to the extended area of said target, a pair of electrostatic deflection plates associated with said magnetic means to deflect the beam from said path in a plane parallel with said plates, a pair of oppositely disposed electrodes partially enclosing a portion of the beam path between said plates and said target each of said electrodes having cylindrical surfaces with their concave surfaces facing each other, said electrodes when energized being adapted to lift the electron beam to a plane parallel with but spaced from said first-mentioned plane to scan the target over the width thereof, a second pair of oppositely disposed electrodes having cylindrical surfaces adapted to be maintained at the same potential, said first-mentioned and second pair of electrodes forming a substantially closed cylindrical electrode system around said portion of the beam path, means effective over said portion of the beam path to deflect the beam in a direction normal to that produced by said deflection plates and a plurality of secondary electron emitters having a length at least equal to the width of said target scanned by said beam in the first direction of deflection, said emitters being located between said plates and said substantially closed cylindrical electrode system whereby electrons of said beam not reaching said target are lifted to a plane displaced from said first- and second-mentioned planes and intercepting one of said secondary emitters.

6. A television transmitting tube comprising an evacuated envelope, a photosensitive mosaic target of extended area in said envelope to liberate electrons in response to light, an electron source and anode oppositely disposed and offset from the effective center of said target to develop a beam of electrons, a pair of electrostatic field generating plates adjacent said source and anode, said plates curving outwardly at each end thereof from the path between said anode and said target, a magnetic coil to generate a longitudinal magnetic field extending between said source and said target, the combined magnetic field and electrostatic field of said plates being effective

termediate said target and said anode to deflect said beam in one direction over the width of said target, a pair of electrodes intermediate said plates and target to lift electrons of said beam to impinge on said target across the effective center thereof, a secondary electron emitter between said plates and said electrodes and at a predetermined distance from said anode to receive electrons of said beam not reaching said target, an auxiliary electrode adjacent said target to provide a substantially uniform electrostatic field over the surface of said target, means to generate a magnetic field extending in a direction parallel with said axis and over the space between said cathode and target to cause electrons emitted from said cathode with velocities transverse to said axis to follow helical paths toward said target, and sources of potential connected between said cathode and anode and between said cathode and auxiliary electrode of such values that electrons of the beam describe an integral number of pitch revolutions along the helical paths while passing between the predetermined distance separating said anode and target and that the electrons of the beam describe a number of pitch revolutions equal to $(n+n')$ while passing between the predetermined distance separating said anode and secondary emitter where n is an integer and n' a fraction of n, each of said predetermined distances being measured along the said axis.

15. In a cathode ray tube system a tube having a cathode to emit electrons, an anode to accelerate the electrons along an axis and define an electron beam cross-section, a light sensitive target oppositely disposed from said anode to receive electrons of the beam, an electrode in capacitive relationship with said light sensitive target, means to maintain said cathode and said electrode at substantially the same potential, deflection means to deflect the electron beam to scan said beam in one direction over said target, means to deflect the electron beam in a second direction over said target and a secondary electron emitter between said first deflection means and said target spaced from said anode in the direction of said axis by a predetermined distance to receive electrons of said beam not reaching said target, a magnetic coil surrounding said tube and extending over the space separating said anode and said target to direct electrons of said beam alon ghelical paths, means to maintain a difference of potential between said cathode and anode and means to energize said coil to produce a magnetic field measured in gausses substantially equal to

$$\frac{(n+n')21V^{1/2}}{d}$$

where n is the pitch length of said helical paths, n' is a fraction of n, V is the potential difference in volts applied between said cathode and anode and d is the predetermined distance between said anode and said secondary electron emitter measured in centimeters along said axis.

16. In a cathode ray tube system a tube having a cathode and anode to develop an electron beam, an electron emitting photosensitive target in the path of said beam, means to scan said beam over said target, means to liberate photoelectrons from and develop electrostatic charges on said target representative of a picture to be transmitted to collect electrons in accordance with the magnitude of said charges, means to maintain said target at a potential with respect to said cathode insufficient to allow impingement of said beam upon said target in the absence of light thereon, means exposed to said target to receive electrons of said beam not reaching said target said electrons constituting a current representative of elemental charge areas of said electrostatic image, means to modulate the said current at a relatively high frequency without modulating the photoelectric current comprising the photoelectrons liberated from said target means to develop signals representative of said currents, and means to separate the signals developed from the current representative of said elemental charge areas from those representative of said photoelectric current.

17. In a cathode ray tube system a tube having a cathode and anode to develop an electron beam, a photo-emissive target to intercept and collect a portion of said beam, means to deflect said beam over the width of said target, means to prevent electrons of said beam reaching said target in the absence of light projected thereon electrode means to collect photoelectrons liberated by said target in response to light projected thereon and electrons of said beam not reaching said target, said means comprising an electrode having a width substantially equal to the width of said target scanned by said beam, means to deflect said beam in a direction normal to said first-mentioned deflection, means to modulate at a relatively high frequency the electron current consisting of the electrons of said beam not reaching said target without modulating the electron current consisting of said photoelectrons, means to develop signals representative of said currents and means to separate the signals developed from each of said currents.

18. In a cathode ray tube system a tube having a cathode and anode to develop an electron beam, a photosensitive mosaic to liberate photoelectrons in response to light representative of an optical image, an electrode in capacitive relation with said mosaic, an electrical connection between said electrode and said cathode to maintain said electrode at substantially cathode potential, means to deflect said beam in two mutually perpendicular directions over said mosaic, a secondary electron emitter exposed to said target to receive photoelectrons liberated from said mosaic and electrons of said beam not reaching said mosaic, means to maintain said cathode and said electrode at substantially the same direct current potential, means to apply a high frequency alternating potential between said cathode and said electrode to modulate thte electron current consisting of electrons of said beam not reaching said mosaic without modulating the electron current consisting of photoelectrons intercepted by said emitter, means to develop signals representative of said electron currents, and means to derive from said signals signals representative of only said first-mentioned current.

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