June 29, 1943. H. A. IAMS 2,322,807

ELECTRON DISCHARGE DEVICE AND SYSTEM

Filed Dec. 28, 1940

Fig. 1

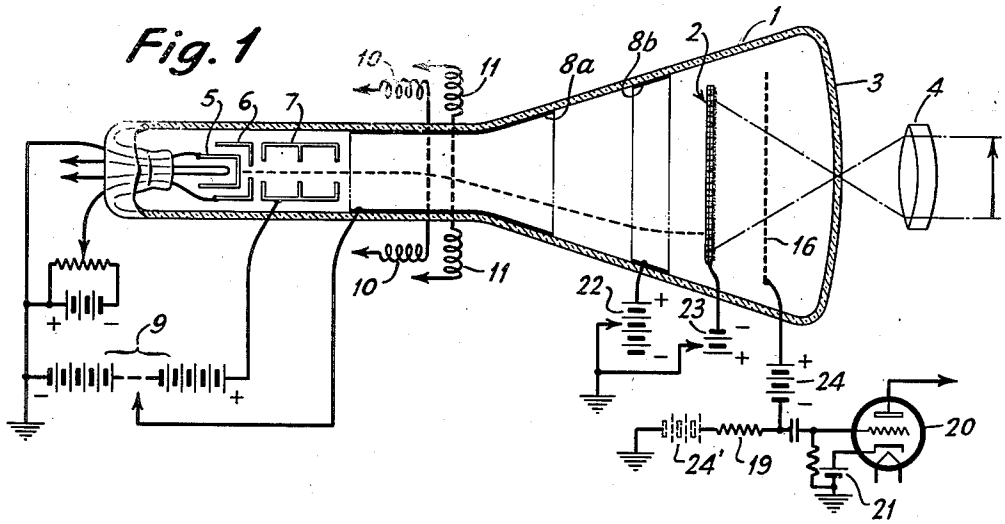


Fig. 2

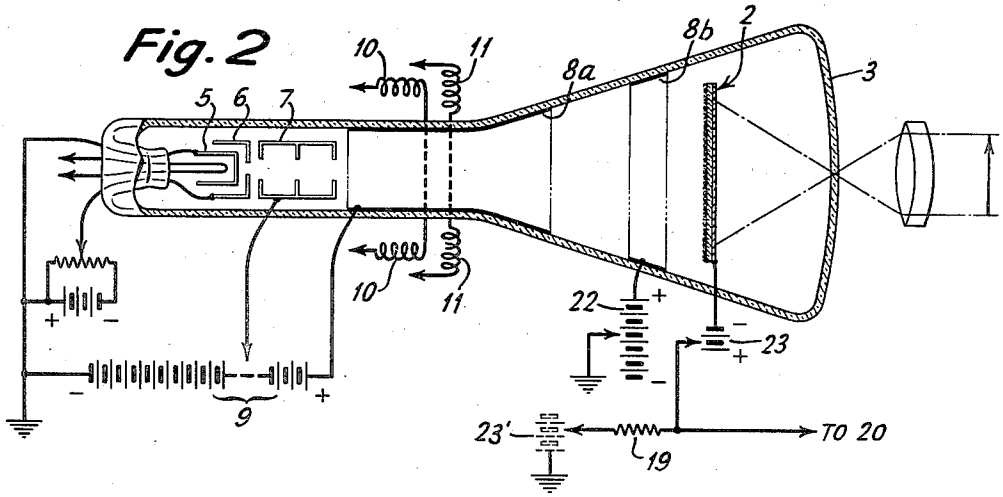


Fig. 3

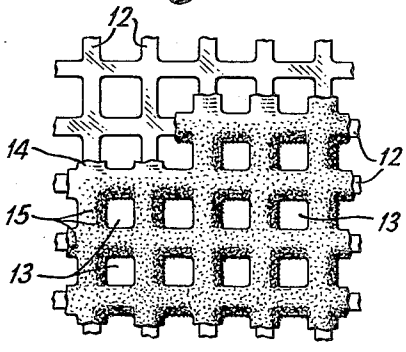
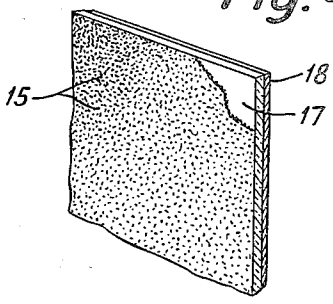


Fig. 4



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Patented June 29, 1943 2,322,807

UNITED STATES PATENT OFFICE

2,322,807

ELECTRON DISCHARGE DEVICE AND SYSTEM

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Application December 28, 1940, Serial No. 372,077

6 Claims. (Cl. 178—7.2)

My invention relates to television tubes and systems and is concerned primarily with tubes and systems in which an electron beam having substantially zero velocity is scanned over a target to generate television signals representative of an optical image which may be recreated as a replica of the image at a distance.

This application is a continuation-in-part of my original co-pending application Serial No. 243,159 filed November 30, 1938 and entitled Electron discharge device. In the original application I pointed out that it had been customary to provide electronic image transmitting tubes of either the storage or non-storage type and to use either the resultant electrostatic charges produced from storage or to use the current image signals from the non-storage type to develop signalling impulses for transmission of an optical image replica. While the storage type of tube offered considerable increase in the magnitude of the output signal energy obtained when the storage device was scanned with an electron beam, it had been found that in many instances the signal to noise ratio was not as high as might be desired for the transmission of images having low values of light intensity. Many such storage devices incorporated a mosaic electrode of the photosensitive type which when scanned by a suitable electron beam developed local potential distributions which vary from point to point over the surface of the mosaic of photosensitive particles and since the potential of all parts of the mosaic was not the same even in darkness, the problem of collecting a uniform secondary emission current was rendered difficult.

The effect of local potential distribution on the mosaic is to generate spurious signals which are usually referred to as dark spot signals in that they generate, upon recreation of the optical image, a non-uniform gradation of light corresponding, not to the desired distribution of light and shade of the optical image, but to random areas of light and shade which do not correspond to those of the desired image.

Since the field utilized for collecting secondary electrons emitted by a mosaic electrode under scansion is modified by the electron scanning beam and consequently is of unequal intensity or effect over the scanned area of the electrode, it has been found difficult to uniformly collect the secondary electron emission from the surface of the mosaic electrode whereby it might be amplified such as by secondary emission amplification.

The above difficulties may be obviated by providing a tube and system wherein the tube generates an electron beam which is directed upon the target or mosaic electrode with a velocity approaching zero so that no secondary electrons are liberated which would inherently be distributed non-uniformly over the surface of the mosaic electrode and cause what has been referred to above as dark spot signals. As pointed out in my original application such a low velocity beam scanning tube and system is described by Albert Rose in his U. S. Patent 2,213,174 which utilizes a magnetic field to direct the beam along paths normal to the target. The use of magnetic field generating means is often disadvantageous where it is desired to combine the Rose tube with reflection optical systems, inasmuch as the magnetic means which surrounds the Rose tube occupies considerable space and intercepts considerable light. One of the principal features in the above type of tube is that the beam is constrained along paths normal to the target, and my above mentioned original application discloses means whereby such an effect may be obtained without the use of the bulky magnetic means.

It is an object of my invention to provide a tube and system capable of developing and directing a beam of low velocity electrons upon a target along paths substantially normal to the surface of the target by purely electrostatic means. It is another object of my invention to obtain a light translating and scanning system which will simplify the translation of optical effects into signalling impulses with a minimum of distortional effects, and it is a further object of my invention to provide a compact low velocity tube and system whereby distortional effects occasioned by grazing incidence of the electron beam on a target are minimized or eliminated.

In accordance with my invention I provide a tube and system wherein the electron beam is directed along paths oblique with respect to the surface of the target and I then direct the beam without recourse to a magnetic field upon the target at a low velocity, such as a velocity approaching zero along paths normal to the target.

These and other objects, features and advantages of my invention will become apparent upon consideration of the following description and the accompanying drawing, in which

Figure 1 is a longitudinal view of the electron discharge device and circuit shown in my original application of which this application is a continuation-in-part;

Figure 2 is a view of a device and circuit similar

to that of Figure 1 incorporating another type of target electrode; and

Figures 3 and 4 are views showing in enlarged detail a portion of electrode structures shown in Figures 1 and 2 respectively.

In the illustrative embodiment of my invention, as shown in Figure 1, the discharge device or tube comprises a highly evacuated glass envelope or bulb 1 of frusto-conical shape with a tubular arm or neck section enclosing a conventional type electron gun. The bulb 1 encloses a target or mosaic electrode 2 which may be of the image grid type as shown in Figures 1 and 3 or of the conventional semi-transparent type shown in Figures 2 and 4, the target being symmetrically positioned in the frusto-conical portion of the envelope so that it is substantially perpendicular to the longitudinal axis of the bulb 1 whereby it may be scanned by a beam of electrons from the electron gun and may also have projected on one surface the optical image of which a signal replica is to be transmitted. Since the image projected on the mosaic electrode is produced by light from an object situated outside of the tube, a portion of the tube, such as the transparent window 3, is made optically uniform and preferably curved so that it may better withstand atmospheric pressure so that the optical image may be projected upon the electrode 2 with a minimum of distortion by a lens system 4.

The electron gun assembly is of a conventional type and comprises a cathode 5 from which an electron stream may be drawn, a control electrode 6 connected to the usual biasing battery, and a first anode 7 maintained positive with respect to the cathode 5. The electron stream leaving the first anode 7 is accelerated and concentrated into an electron scanning beam directed toward the surface of the target or mosaic electrode 2 facing the electron gun by a second anode 8a which is preferably a conductive coating on the inner surface of the envelope 1, over a portion of the neck and frusto-conical sections. The first anode 7 and the second anode 8a are maintained at the desired positive potentials by a potential source, such as the battery 9. Conventional electron beam deflection means such as the deflection coils 10 and 11, may be used to deflect the beam from its path normal to the target and sweep the beam in horizontal and vertical planes respectively to scan the mosaic electrode 2. It is obvious that conventional electrostatic deflection plates may be substituted for either one or both of the deflection coils if desired.

As the electron beam from the electron gun is directed toward the mosaic electrode 2, it follows a path which is at first normal to the surface of the mosaic electrode, however, while under the influence of the deflection fields produced by the deflection coils 10—11 the beam acquires radial velocity and follows paths which are not normal but are oblique to the surface of the mosaic electrode. Since the beam approaches the mosaic at an oblique angle to its surface and while the axial velocity of the beam may be reduced to substantially zero, the radial velocity imparted to the beam by the deflection means remains substantially constant, and due to local charges on the mosaic the beam tends to "slide off" or graze the mosaic returning to the second anode 8a and causing what I refer to as creeping or crawling effects which causes distortion observable in a recreated image replica. Thus, even when recreating stationary optical images, movable areas of light and shade are visible in the recreated image, these movable areas being attributed to this form of distortion. In addition these effects produce considerable loss in resolution of the recreated image. Therefore, in accordance with my invention I provide between the deflection means and the mosaic target electrode electrostatic means at a predetermined potential to absorb the radial velocity imparted to the beam electrons and direct the beam along paths normal to the target surface. I thus produce an electron focusing lens adjacent a target scanned by a beam of electrons having substantially zero axial velocity to direct the beam electrons along paths normal to the target.

In my original application referred to above I described only one particular form of target of the image grid type but my invention is suitable for use with targets of the conventional charge storage type such as shown by Rose in the patent therein referred to. Such a charge storage mosaic electrode may be of the type described in the above-mentioned Rose patent. Thus, my invention is applicable particularly to the types of tubes shown in Figures 1 and 2 incorporating target electrode structures shown respectively in Figures 3 and 4. The target of Figure 3 for use in a tube of the type shown in Figure 1 may comprise a foundation 12 which may be of perforated metal sheet or of a wire mesh having apertures 13, the foundation being coated with a film or layer of insulating material 14. The layer of insulating material 14 is provided with a great number of mutually insulated and separated particles 15 preferably on the side facing the window 3 and within the insulated apertures 13. This assembly is positioned in the tube of Figure 1 to receive on the photosensitive particles 13 the optical image from the lens system 4. In operation electrons from the electron emitting cathode 5 are directed toward the apertures 13 with an axial velocity approaching zero in the plane of the apertures. The passage of beam electrons through the apertures is controlled by the electrostatic charges developed by light on the photosensitive particles 15, and thus, electrons of the beam pass through the apertures 13 in accordance with the intensity of light surrounding the apertures and are collected by a light permeable collecting electrode 16 which may be of a form of wire mesh or wall coating on the inner surface of bulb 1 between the mosaic electrode 2 and the window 3. The collecting electrode 16 is maintained slightly positive such as at 25 volts with respect to ground by a battery 24 shown optionally connected at 24' which is connected to the translating device 20 and to ground through the output impedance 19.

As indicated above the mosaic electrode may be of the type shown in Figure 4 for use in a tube of the type shown in Figure 2. This electrode may comprise an insulating foundation 17 supporting a great number of mutually insulated and separated photosensitive particles 15 on the side facing the electron gun and on the opposite side a semi-transparent signal plate 18 through which light representative of the optical image is focused as shown in Figure 2. Since electrons do not pass through the mosaic of the type shown in Figures 2 and 4, provision of a collecting electrode such as the electrode 16 of Figure 1 is unnecessary, the low velocity elec-

trons not reaching the mosaic as well as the photoelectrons liberated from the mosaic being collected such as by an auxiliary anode described below. In Figure 2 the signal plate preferably is connected through the battery 23 to the translating device 20 and to ground through the impedance 19 although the battery 23 may be between the impedance 19 and ground as shown at 23' by the dashed lines.

In accordance with my invention I provide means, such as the auxiliary anode or electrode 8b with an associated circuit to provide in combination with the second anode 8a and the mosaic electrode 2 an electrostatic field lens to direct electrons from paths oblique with respect to the surface of the mosaic electrode to paths normal to this surface. The electrode 8b is located out of the path of the electron beam and surrounds a portion of the beam path adjacent the mosaic electrode 2. The electrode 8b may to advantage comprise a conductive ring adjacent or upon the wall of the envelope and is preferably about one-half inch in length along the beam path and at its closest edge about one inch from the mosaic electrode 2. Further in accordance with my invention I connect the mosaic electrode foundation 12 or semi-transparent metal signal plate 16 to a potential closely approaching the potential of the cathode 5, alhough for purposes of control I have shown the variable potential source 23 which may be in circuit with the mosaic electrode foundation or semi-transparent plate whereby a control potential of several volts may be applied to this electrode, and I further provide means, such as the potential source or battery 22 connected between cathode potential and the electrode 8b, to develop an electrostatic field or thin electron beam focusing lens adjacent the mosaic electrode. The first and second anodes 7 and 8a may be operated at positive potentials with respect to the cathode, that of the anode 8a being lower than that of the first anode as in Figure 1 or higher as in Figure 2. Thus the second anode 8a may be operated at 150 volts positive with respect to the cathode 5, and the first anode 7 at about 800 to 1000 volts positive with respect to the cathode 5 by the battery 9 as shown in Figure 1, or these potentials may be reversed as shown in Figure 2.

More particularly and in accordance with my invention I operate the electrode 8b at a low positive potential, such as 25 volts, with respect to the cathode 5 by the battery 22. The mosaic electrode foundation or signal plate is connected to the battery 23 which maintains this electrode at approximately 1 volt negative with respect to the cathode 5 and in the circuit of Figure 1 the collecting electrode 16 is connected to a battery 24 to maintain it at approximately 25 volts positive with respect to the cathode 5. The collecting electrode is also connected to the input of the translating device 20 and to ground through an output impedance 19. Although I have shown the battery 24 between the collecting electrode 6 and the impedance 19, it is preferable to connect this battery between the lower end of the impedance 19 and ground as shown in dotted lines in Figure 1. With the voltages given above, the electron beam is first accelerated and focused upon and then deflected over the mosaic electrode but following deflection is decelerated to a very low velocity as it approaches this electrode. During the period of deceleration following deflection of the electron beam the beam passes through an electrostatic field in the space between the second anode 8a and the mosaic electrode 2, this field being generated by the electrode 8b and the potential at which it is maintained with respect to the highly positive second anode 8a and the mosaic foundation or signal plate operated at or near ground potential. I have found that this field must be generated by an electrode surrounding a portion of the beam path and must not be interposed in the path of the electron beam, such as would be true of a wire mesh or apertured electrode extending across the electron beam paths. Thus, the electrostatic field or lens adjacent the mosaic should be of continuous curvature, the field between the electrodes 8a and 8b and the mosaic electrode directing the beam axially or normal to the target surface.

In operation of my tube and system the electrons of the beam are deflected from a path normal to the target or mosaic electrode along paths which are oblique to this electrode but when passing through the continuous electrostatic field generated by the electrode 8b the electrons of the beam are acted upon by forces which increase in intensity with increasing distances from the normal undeflected path of the beam so that electrons when following the normal undeflected path and which impinge the axial center of the target are not deviated from this axial path but in accordance with the increase of angular deflection of the beam the forces acting thereon increase so that the beam is at all times normally incident on the target or mosaic electrode. Since it is usual operating practice to scan a pattern in rectangular co-ordinates, the directing action of the electron lens developed by the differences in potential between the second anode 8a, the electrode 8b and target may be greater at the corners of the rectangularly scanned pattern than at points midway between the corners. It is, therefore, desirable to provide the electrode 8b of larger diameter than the diagonal of the rectangular pattern to be scanned. However, a rectangular or oval electrode 8b aligned with the rectangular pattern to be scanned may be utilized so that over-compensation adjacent the corners of the pattern may be avoided.

While I have indicated the preferred circuit embodiments of my invention of which I am now aware and have indicated only one specific application; namely, for use in television transmitting circuits for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated but that many variations may be made in the tube with which my invention is useful and 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 system comprising a tube structure including a signal plate, a light sensitive target adjacent the extended surface of said signal plate, a cathode and an anode to form and direct an electron beam toward said target in a direction normal to the surface thereof, means along the path of said beam to direct said beam along paths oblique with respect to the extended surface of said target, means to project an optical image on said target to develop thereon charges having a spacial distribution corresponding to the degree of light and shade of said image, means including an electrical connection between said cathode and said signal plate causing said electron beam to approach said target with substantially zero velocity and in the absence of

compensating means said electrons to be collected over various areas of said target in accordance with the obliquity of said paths and not in accordance with said charges, and compensating means consisting of an electrode removed from and surrounding said oblique paths and a potential source connected between said electrode and said cathode to direct electrons from said oblique paths to paths normal to the extended surface of said target.

2. A television transmitting system comprising a tube structure including a cathode to emit electrons, an anode to accelerate and form the emitted electrons into a beam, a light sensitive target intercepting the axial path of said beam normal to the surface of said target, a signal plate in capacitive relation with said target, and an electrode adjacent said target surrounding and wholly removed from the path of said electron beam, means to deflect said electron beam from said axial path to diverging oblique paths within said electrode, means including a connection between said cathode and said signal plate to decelerate said beam to an axial velocity approaching zero in the vicinity of said target and means consisting of the said structure of said tube and a potential source connected between said electrode and said cathode to bend the electron beam from said oblique paths to paths normal with respect to said target whereby electrons of said beam may be acted upon in accordance with the potential of elemental areas of said target.

3. A television transmitting system comprising a tube structure including a cathode and anode to generate an electron beam, a mosaic of photosensitive particles over an extended surface in the path of said electron beam, means to develop electrostatic charges representative of a picture to be transmitted on said photosensitive particles, a signal plate capacitively associated with said mosaic, means to deflect the electron beam over paths oblique with respect to the extended surface of said mosaic, and an electrode wholly removed from and surrounding the oblique paths of said electron beam and between said deflection means and said target, means including an electrical connection between said cathode and said signal plate to reduce the longitudinal velocity of said beam to substantially zero adjacent said mosaic whereby electrons following an undeflected path are incident upon said mosaic in accordance with electrostatic charges thereon but those following said oblique paths are subject to be reflected from the extended surface of said mosaic, and means consisting of said tube structure and a potential source connected between said electrode and said cathode to direct electrons following oblique paths within said electrode toward said mosaic with uniformly low longitudinal velocity along paths normal to the extended surface of said mosaic whereby electrons of said beam following said oblique paths may be acted upon by said mosaic in accordance with electrostatic charges thereon irrespective of the deflection of said electron beam over said oblique paths.

4. A television transmitting system comprising a tube structure including a photo-emissive mosaic over an extended surface, a signal plate capacitively associated with said mosaic, a cathode and anode axially spaced from said mosaic to develop and project an electron beam having relatively high axial velocity toward said mosaic, and an electrode surrounding and removed from a portion of the beam path adjacent said mosaic, means to deflect the electron beam from a path normal to said target to paths oblique with respect to said target, means to develop electrostatic charges on said mosaic representative in charge intensity to elemental areas of an optical image, means to decelerate said electron beam to a velocity approaching zero in the direction between said anode cathode and mosaic, means including said electrode and a potential source connected between said electrode and said cathode to cause electrons of said beam to be acted upon in accordance with said electrostatic charges by directing said beam normally of the extended surface of said mosaic, said last-mentioned means being the sole factor in combination with other of said tube structure directing said beam normally of said surface.

5. A television transmitting system including an electron beam tube wherein the beam is focused on a target solely by electrostatic means said tube comprising a photosensitive charge storage electrode, an oppositely disposed electron gun comprising elements to form and electrostatically focus an electron beam on said storage electrode and an electrode adjacent said target and surrounding a portion of the path of said beam, said electrode having a diameter greater than the maximum linear dimension of said target, means to form an image consisting of electrostatic charges representative of an optical image on said target, means to scan said beam along paths oblique with respect to and intercepting the longitudinal axis between said gun and target, means to cause electrons of said beam to approach said storage electrode with an axial velocity approaching zero and in the absence of compensating means to graze said target and return toward said electron gun along different paths than said oblique paths, and compensating means including a source of potential connected between said electrode adjacent the target and an element of said gun to displace the electrons of said beam from said oblique paths to paths which adjacent said target are normal to the surface thereof thereby preventing the return of electrons along said different paths and to develop signals in proportion to the intensity of said charges.

6. A television transmitting system comprising a tube structure adapted to electrostatically focus a low velocity electron beam without recourse to magnetic focusing means said tube structure including a photosensitive target, an electron gun oppositely disposed from said target to direct toward and focus on said target an electron beam, and a circular electrode adjacent said target and between said gun and said target, means to deflect said beam over said target said beam during deflection following paths which are oblique to the undeflected path, means including a connection between said target and said electron gun to cause electrons of said beam to impinge on said target with substantially zero velocity in the direction of said undeflected path and means consisting only of said electrode said tube structure and a potential source connected between said electrode and said electron gun to direct electrons from said oblique paths to paths normal to said target

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