My Invention relates to a cathode ray dissector tube, and more particularly to a tube structure wherein electron beam analysis may be carried out, primarily for the purpose of the production of a train of television signals or for other oscillographic uses.

This application is a companion application to application Serial No. 30,116, filed July 6, 1935, for a Charge storage amplifier, filed contemporaneously with the present case, and I describe and claim herein the tube structure described but not claimed in the above application.

Among the objects of my invention are: to provide a cathode ray tube of high sensitivity for television transmission or general oscillographic use; to provide a cathode ray tube capable, when energized, of use when illuminated by reflected light of ordinary intensity; to provide a dissector tube having an output greater than that obtained from the usual type of photoelectric dissector; to provide a television dissector tube which will have an output when energized of sufficient power to greatly reduce subsequent amplification; to provide a photoelectric scanning tube having a charge storage electrode therein; to provide a charge storage electrode for use in a cathode ray tube; to provide a photoelectric cell whereby relatively large currents may be obtained in the dissector field of an image; to provide an amplifying means which can be applied to an oscillograph tube; to provide an amplifying tube for photoelectric currents whereby extremely high amplifications may be obtained within the tube itself; to provide a means for charging an insulated surface; to provide a cathode ray tube having the full equivalent thereof in a photoelectric mosaic without any actual mosaic structure; to provide a means for fixing charges on an insulator; to provide a means of neutralizing these charges; and to provide a simple and efficient cathode ray dissector tube.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

In my previous patents and application for U. S. Letters Patent, as follows: Patent No. 1,773,880, issued Aug. 26, 1930, Patent No. 1,844,949, issued Feb. 16, 1932, and Patent No. 1,941,344, issued Dec. 26, 1933, and Serial No. 660,686, filed Apr. 26, 1933; and others, I have described television transmitting apparatus and systems wherein an optical image of the object or picture field is projected upon a photosensitive cathode and the emitted electrons are accelerated and focused to form an electron image. By "electron image" I mean a plane through which the electron stream passes, the electron density of which varies spatially across the stream in the same manner as the illumination intensity varies across the optical image. In other words, the electron density values represent spatially the illumination of the picture field.

The electron stream forming this image may be deflected by means well known in the art, but preferably by magnetic fields, to pass over a stationary aperture in such a manner as to effect a scanning of the image. Selected portions of the electron stream passing through the aperture are collected to form a picture current or train of picture signals which may be amplified and modulated upon a radio wave or, if desired, transmitted by wire or other means.

This method of television transmission offers the advantage of having no moving mechanical parts and of being suitable for the electrical dissection of pictures, having any desired fineness of detail. The principal weakness of this method, however, lies in the fact that only a relatively small portion of the electrons emitted from the total photoelectric area pass through the aperture at any given instant, and at the present time photoelectric emission is relatively small in intrinsic value.

Furthermore, as greater detail is required apertures must be made smaller as there are practical limits to the actual size of the photoelectric emitter. Smaller apertures receive fewer electrons. It is necessary, therefore, in operation of such devices for the highest possible sensitivity to be obtained from the photoelectric surfaces, and even then high gain amplifiers are necessary in order that satisfactory picture currents can be obtained; in fact certain devices of this sort operate with a maximum aperture collection of from zero to twenty electrons for full range operation. With such small output currents, therefore, attempts to amplify the signals above certain limits will bring in background noise, Shottkey effect and other factors ordinarily negligible, which tend to make the amplified signals unsatisfactory and distorted. The received picture will therefore be lacking in the detail which it would have if such interference, due to extreme amplification, were not present.

In the present invention the fundamental principles of my previous inventions are retained. An electron image corresponding to the optical im-

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age is formed and is dissected as before. I utilize the electron image, however, to produce a charge image which is then scanned by a separate uniform electron beam to neutralize the charges, and thus produce a train of signals.

Describing my present invention in general terms as relates to method, I prefer to form a stream of electrons in space, representing in cross-sectional elementary densities the illumination of the corresponding elementary areas of the optical image. This electron stream is then scanned past an insulating surface to form a charge image of one complete line of the electron image thereon, the charge image being preferably formed perpendicular to the direction of deflection. A stream of electrons is then created having a dimension of elementary extent, and this stream is then passed over the charge image to successively neutralize the charges in the image. The electrons necessary to neutralize the charge at various points along the charge image are then utilized to produce a train of picture signals. I prefer to form the line charge image at the low frequency rate and to wipe the charges off the insulating material at a high frequency rate.

Broadly, in terms of apparatus, my invention comprises a tube having a fine wire extending across the tube in the path of the electron image, this wire being coated with a thin layer of insulating material, preferably glass. This wire will be a source of the television signal and preferably will be maintained at a voltage of the order of ten volts negative with respect to the anode. The anode will preferably be a ring shaped wall that adjacent to the window of the tube. The insulated wire is placed so as to be perpendicular to the direction of low frequency scanning. Perpendicular to the wire an electron gun is positioned to project a low voltage cathode ray of small cross section and of elementary dimension across the wire. This ray is deflected back and forth along the wire to provide the high frequency scanning.

In one method of operation of the present device, the photoelectrons in the electron image are accelerated at sufficient velocity to knock secondary electrons out of the insulating coating on the wire. Thus a line of the electron image will be recorded in the form of positive charges bound upon the surface of the glass coating. These will be neutralized by electrons from the electron gun as the ray therefrom is swept along the length of the wire, and the discharge will produce surges of current in the wire in accordance with the capacities between the charges on the surface of the glass and the wire within. The velocity of the scanning electrons is preferably limited so that they do not cause secondary emission. Therefore they leave the surface uniformly negatively charged and ready for the next line of photoelectron charges.

In another method of operation I employ photoelectron velocities less than those required to produce secondaries, and a higher velocity in the scanning ray electrons. In this manner the photoelectric charges upon the wire are negative and they are neutralized by production of the positive condition of the surface when scanned by the gun. It is obvious, therefore, that the photoelectric charges are stored during the period of one high frequency scanning cycle, thus giving a multiplication on the order of several hundred, the multiplication depending upon whether the positive or negative condition obtains. The method has the advantages of a mosaic without employing an actual mosaic surface, as the charges are bound and dissipated only by leakage. The method is of course adapted to a surface as well as to a wire, as a thin sheet of mica with a metal coating on the side opposite to the photocathode is of course a full equivalent of the wire described.

In the case where a surface is used, it is of course obvious that the scanning beam shall be of elemental dimension in all directions. In other words, of elemental cross section, and that both high and low frequency scanning shall be done with this beam.

In its broad aspect therefore, in terms of method, my invention comprises directing a stream of photoelectrons against an insulated surface to produce fixed charges thereon, in accordance with the illumination intensities of an optical image, and utilizing the charges to create a current representing the image. This method is broadly covered in my copending application for an Electron image amplifier, Serial No. 29,242, filed contemporaneously with the present application, the system for practicing the method being somewhat modified herein.

In the following description and discussion the word “photoelectron” is used to designate the emission from a photoelectric surface in accordance with the illumination thereof by an optical image, it being understood that the electron image formed by the photoelectrons is at all times maintained in optical image relation. “Scanning electrons” shall be taken to mean electrons existing in a stream whose cross section has uniform electron densities.

In the drawing which accompanies this application and is made a part hereof:
Figure 1 is a longitudinal section, partly in elevation, of a dissector tube utilizing a line charge image.
Figure 2 is a cross sectional view taken as indicated by the line 2—2 of Figure 1.
Figure 3 is a diagram reduced to lowest terms, showing how the tube of Figure 1 may be connected in operation.

Referring directly to the drawing for a detailed description of the specific embodiments of my invention illustrated therein, and first referring to Figures 1, 2 and 3 which illustrate a charge storage dissector tube wherein the charge is stored a line at a time, an envelope 1 is provided at one end with a photoelectric cathode 2, outside connections being made by connection lead 4 through seal 5.

I prefer in this case to make the cathode of cup shape and deposit on the wall of the tube a ring anode 5, the edges of the anode and cathode approaching but leaving a space 6 therebetween.

Across the end of the tube I prefer to position a horizontal tungsten rod 7 which is coated with a thin glass coating 8, and in order to allow the passage therethrough of this composite electrode I prefer to remove a portion of the anode film 5 to form apertures 10—10 therein where the wire passes through the wall of the tube. The opposite end of the tube is provided with a window 11 through which an optical image of an object 12 may be projected by means of a lens 14 on the cathode 2.

Positioned in the lower end of the tube in a side arm 15 and in the plane of the tungsten rod is an electron gun assembly adapted for supplying a fine line beam intersecting the composite electrode 7—8. This gun comprises an indirectly
heated cathode 17 and a perforated anode 18, the perforation being positioned so that the beam issuing therefrom intersects the composite electrode and is perpendicular thereto. The side arm 15 is also provided with a pair of horizontal electrodes 19 for deflecting plates 20 which, when energized, will cause the electron beam issuing from the electron gun to traverse the extent of the composite electrode.

10 The operation of the device is in accordance with two methods, but as the apparatus for creating the operation is similar, the diagrammatic hookup shown in Figure 3 will serve to illustrate both methods.

15 Here, the cathode 2 is connected to the anode 5 through an anode battery 20 so that the anode is positive to the photoelectric cathode. When the optical image from object 12 is focused by means of lens 14 onto the photoelectric cathode tube, it emits electrons at every elementary area thereof in proportion to the illumination these areas receive, and these electrons are drawn outwardly in space under the influence of the anode potential. The electrons emitted from the photoelectric cathode are maintained in the electron image relation by means of a focusing coil 21 whose field is produced by current from a source 22 under the control of a rheostat 24 so that the electrons focus in the plane of the storage electrode 7—9, and the electron image is scanned across the storage electrode in a direction perpendicular thereto by means of a field of a low frequency magnetic deflecting coil 25 supplied by a low frequency oscillator 26. At the same time the electron gun is energized, the cathode 17 by means of cathode battery 27, and the anode thereof by means of anode source 29, to project a beam of scanning electrons upon the insulating surface of the tungsten rod 7, and this scanning beam is deflected along the storage rod by means of charges placed upon the horizontal deflecting plates 19 from a high frequency oscillator 30. The tungsten rod is connected through an output resistor 31 having output leads 32 therefrom to a point 34 intermediate the positive and negative end of the anode battery 28.

40 In one method of operation the photoelectrons are accelerated by means of the anode potential from the anode 5 to a sufficient velocity to knock secondary electrons out of coating 9 as the image is scanned thereacross. These secondary electrons are of course picked up by the anode 5, leaving charges which will represent a line of the electron image recorded in the form of positive charges bound upon the surface of the glass coating. After these charges have been formed the electrons from the electron gun assembly comprised in the beam projected thereby, sweep across the length of the wire and discharge the positive charges on the wire. This discharge of the charges upon the wire in sequence as the beam sweeps across will produce in the tungsten rod 7 surges of current in accordance with the capacity between the surface charges and the rod beneath, these currents passing through output resistor 31 and appearing as potential changes in output leads 32. The potential placed upon anode 18 of the electron gun is made such that the velocity of the scanning electrons is less than that required to produce secondary emission from the surface upon impact therewith. The surface therefore, after scanning by the electron beam, will be left negatively charged and thus ready for the next line of photoelectron charges.

45 The other method of operation is to reduce the potential on anode 5 to a point where secondary electrons are not produced. The charges produced on insulating surface 9 by the photoelectrons will therefore be negative charges and will be bound thereto, and I then prefer to raise the voltage on the electron gun 18 to a point where these electrons will cause secondary emission from the surface 8 which will then discharge the charges on the surface in the opposite direction and will leave the surface positively charged, ready for the next negative charge to be supplied by the photoemission.

50 It is obvious from the above description that the photoelectric charges will be stored during the period of one scanning cycle of the scanning beam, thus giving a considerable multiplication, the multiplication being substantially equal in both cases inasmuch as the charges are stored round bound upon the insulating surface. It is obvious that the charge pattern, in case a line storage is used, will have a value which is determined by the period of the high frequency scanning.

55 It is obviously within the scope of this application and the claims appended hereto, to make the charge storage surface rectangular and of an area comparable to the whole of the electron image, and then scan the charge image with an electron beam moving in two dimensions. In this latter case the charge will be stored during the entire low frequency scanning cycle. In this latter instance I prefer to utilize a thin sheet of mica backed with a metal film for the charge storage of electrode, the full functional equivalent of a photoelectric mosaic being produced, thus avoiding the difficulties entering into satisfactory mosaic production.

I claim:

1. A thermionic tube comprising an envelope containing a photoelectric cathode having a surface of picture area capable of emitting electrons when illuminated, a single linear electrode having a complete covering of insulating material and extending across one major dimension of said surface and spaced therefrom, a cathode and anode cooperating to produce an electron beam defined to an elemental dimension in the direction of extent of said linear electrode, and a pair of deflection plates positioned to deflect said beam along said linear electrode when energized.

2. A thermionic tube comprising an envelope containing a photoelectric cathode having a surface of picture area capable of emitting electrons when illuminated, a single wire having a complete covering of insulating material and extending across one major dimension of said surface and spaced therefrom, a cathode and anode cooperating to produce an electron beam defined to an elemental dimension in the direction of extent of said linear electrode, and a pair of deflection plates positioned to deflect said beam along said linear electrode when energized.

3. A thermionic tube comprising an envelope containing a photoelectric cathode having a surface of picture area capable of emitting electrons when illuminated, a single wire supported by the side walls of said envelope, completely covered by an insulating material and extending across one major dimension of said surface and spaced therefrom, a cathode and anode cooperating to produce an electron beam defined to an elemental dimension in the direction of extent of said linear electrode, and a pair of deflection plates posi-
4. A thermionic tube comprising an envelope containing a photoelectric cathode having a surface of picture area capable of emitting electrons when illuminated, a single wire supported by the side walls of said envelope, completely covered by an insulating material and extending across one major dimension of said surface and spaced therefrom, said wire having a connection extending through said envelope, a cathode and anode cooperating to produce an electron beam defined to an elemental dimension in the direction of extent of said linear electrode, and a pair of deflection plates positioned to deflect said beam along said linear electrode when energized.

5. A thermionic tube comprising an envelope containing a photoelectric cathode having a surface of picture area capable of emitting electrons when illuminated, a single conductor having a complete covering of insulating material and extending across at least one major dimension of said surface and spaced therefrom, a cathode and anode cooperating to produce an electron beam defined to an elemental dimension in the direction of extent of said linear electrode, and a pair of deflection plates positioned to deflect said beam along said linear electrode when energized.

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