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ELECTRON DISCHARGE DEVICE

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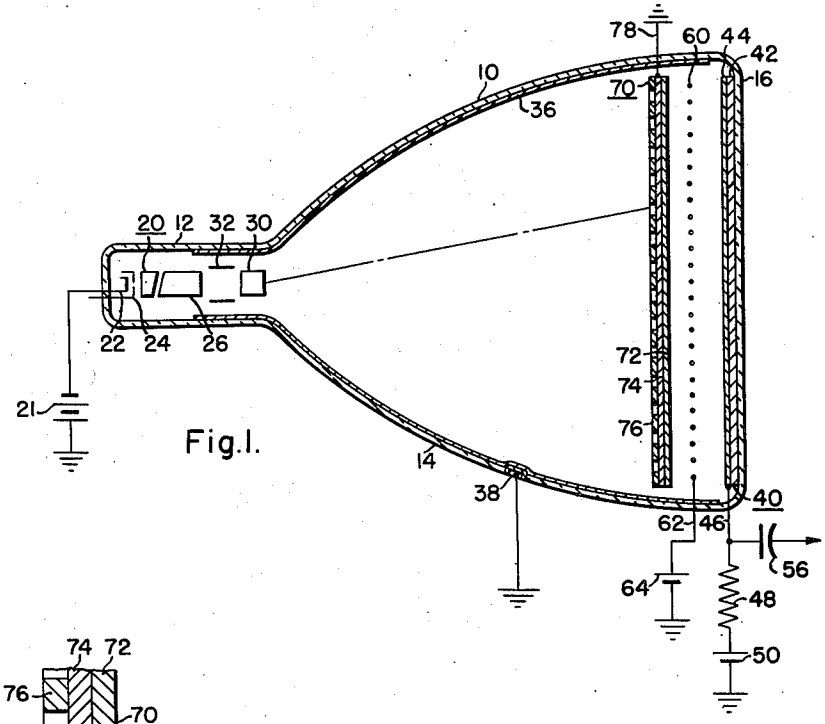


Fig.1.

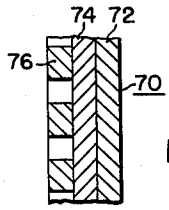


Fig.2.

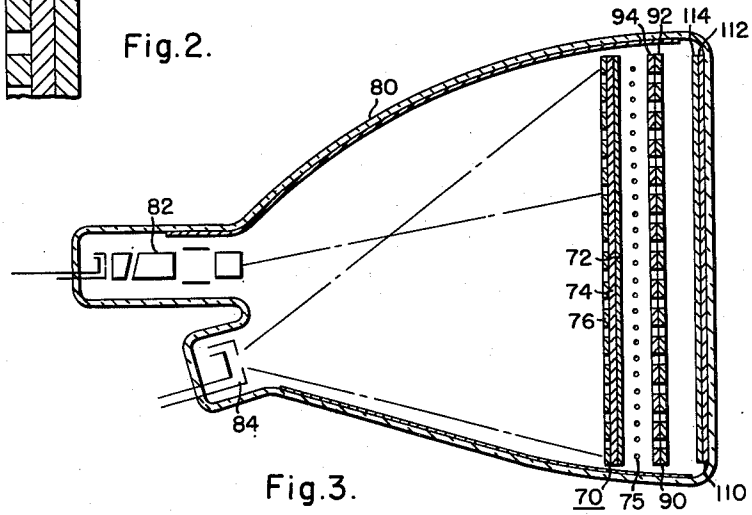


Fig.3.

WITNESSES

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ELECTRON DISCHARGE DEVICE

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My invention relates to electron discharge tubes, and, more particularly, to those tubes in which a low velocity electron beam is utilized for scanning a target.

In several types of electron discharge tubes, for example, television pickup tubes of the type known as the image Orthicon and the vidicon, a low velocity electron beam is utilized in scanning a target electrode. In the low velocity beam type of device, the electrons in the electron beam normally reach the target with essentially zero velocity. It is also required that the landing electrons strike the target nearly normal to the surface. If this condition is not fulfilled, it is not possible for electrons to be deposited on the entire target area with the result that undesirable shading will occur. It is also desirable in storage type tubes that the electron beams approach normal to the target. The problem of normalizing several electron beams of different trajectory and velocity, as required in most storage tubes, is particularly troublesome.

In previous devices utilizing single beams it is necessary to use a magnetic focusing coil, magnetic alignment coils and magnetic deflection coils in order to insure the proper landing of the electrons. The resulting structure is heavy, bulky and expensive to produce. This factor is the main limitation in the use of large area target surfaces. By making the tube length several times its diameter the normalizing problem becomes easier. However, with a large diameter target, the tube can become too long to be practical.

It is accordingly an object of my invention to provide an improved electron discharge device in which a low velocity electron beam is utilized.

It is another object to provide a pickup tube in which a low velocity electron scanning beam is employed which utilizes electrostatic deflection and focusing.

It is another object to provide an electron discharge device in which a low velocity electron scanning beam is used with a large diameter target without the requirement of large bulky magnetic coils.

These and other objects are effected by my invention as will be apparent from the following description taken in accordance with the accompanying drawing in which like reference characters indicate like parts in which:

FIGURE 1 is a longitudinal cross sectional view of an electron discharge device made in accordance with my invention;

FIG. 2 is an enlarged section view of a portion of the normalizing electrode employed in FIG. 1, and

FIG. 3 is a longitudinal cross sectional view of another embodiment of my invention.

Referring in detail to FIGS. 1 and 2, the tube embodying my invention is a pickup device comprised of an evacuated envelope **10** which may be in the general form of a cathode ray tube or of any suitable shape or configuration. The envelope **10** is comprised of a neck portion **12**, a flared portion **14** and a face plate member **16**. Positioned within the neck portion **12** of the envelope is a suitable electron gun **20** for generating an electron beam. The electron gun **20** is comprised of at least a cathode **22**, a control grid **24** and an anode **26**. Suitable electrostatic or electromagnetic deflection means may be positioned within the region of the neck portion **12** for deflecting the electron beam from the gun **20** in both a horizontal and vertical direction to scan a raster. In a specific embodiment shown, a pair of electrostatic deflection plates **30** is provided for the horizontal deflection, and a pair of electrostatic deflection plates **32** is provided for the vertical direction. These pairs of electrostatic deflection plates **30** and **32** are provided with suitable voltages as is well known in the art to deflect the electron beam and thus scan a raster in a desired manner.

A conductive coating **36** of a material such as aqueous suspension of graphite is provided on the interior surface of the flared portion **14** of the envelope **10** and extends back into the neck portion **12**. A contact button **38** is provided through the wall of the flared portion **14** of the envelope **10**, and a suitable potential is applied. In the specific embodiment, the contact button **38** may be connected to ground. It should also be noted that the anode **26** of the electron gun **20** is also held at ground potential by means of spacer elements (not shown) in contact with the conductive coating **36**. The cathode **22** of the electron gun **20** is connected to the negative terminal of a voltage source represented by a battery **21**. The battery **21** may be of the order of 4,000 volts. The positive terminal of the battery **21** is connected to ground.

Positioned at the opposite end of the envelope **10**, with respect to the electron gun **20**, is a target member **40**. In the specific embodiment shown, the face plate **16** is utilized as the support for the target member **40**. The target member **40** is comprised of a transparent conductive coating **42** of a material such as stannic oxide deposited on the interior surface of the face plate **16** with a target coating or film **44** of a normally insulating photosensitive material provided on the conductive coating **42**. In the specific target **40** shown in the embodiment, a photoelectric material such as amorphous selenium is utilized as the target film **44**. This photoelectric material exhibits the property of an insulator, resistivity of at least 10^{12} ohm centimeters, when not radiated, and the property of a conductor when radiated with photons or electrons. For example, radiation with light induces photoconductivity which reduces the resistance of the film corresponding to the intensity of the light. Although I have shown only the use of a photoelectric material as the target film **44** for obtaining a charge image on a target **40**, it is obvious that my invention applies to any type of target structure in which a low velocity scanning beam is utilized.

The conductive coating **42** of the target **40** is provided with a lead-in **46** to the exterior portion of the envelope **10** which is connected through a resistor **48** to the positive terminal of a suitable voltage source represented by a battery **50**. The battery **50** may be of a voltage of about 30 volts with the negative terminal of the battery **50** connected to ground. The conductive coating **42** of the target **40** is also connected by the lead-in member **46** to condenser **56**. The other terminal of the condenser **56** is connected to an output circuit.

Positioned parallel to the target member **40** is a planar accelerating grid **60**. This grid may be of any suitable form, such as mesh, of a conductive material. The accelerating grid **60** is also provided with a lead-in conductor **62** to the exterior of the envelope **10** and is connected to the positive terminal of a suitable voltage source represented by a battery **64**. The negative terminal of the battery **64** is connected to ground, and the potential of the battery **64** may be of the order of 500 volts.

Positioned adjacent to the accelerator grid **60** on the side facing the electron gun **20** is a normalizing electrode member **70**. The normalizing electrode **70** is essentially a structure which has the property of transmissive secondary electron emission. The structure is more specifically described in U.S. Patent No. 2,905,844 entitled Electron Discharge Device by Ernest J. Sternglass and issued on September 22, 1959. The general structure of the normaliz-

ing electrode 70 consists essentially of a secondary emissive layer 72 of an insulating material deposited on an electron scattering layer 74 of a high atomic number material with a fine mesh support structure 76 provided for the large area film. The conductive support mesh 76 is also provided with a leadin member 78 to the exterior of the evelope and is maintained at ground potential.

The normalizing electrode 70 may be constructed by utilizing a support mesh of a conduction material such as copper or nickel having a large percentage open area. An organic film of a material such as nitrocellulose, may be settled on the mesh by covering the mesh 76 with water and applying the organic material in a suitable solution on the surface of the water. As the organic material expands out on the surface of the water, the solution evaporates leaving only the organic film material. The water is then removed allowing the organic film material to settle onto the mesh 76. The organic film may then be dried, and a support film, such as silicon monoxide or aluminum, is evaporated on the organic film. The structure is baked in air. The scattering layer 74 of a high atomic number greater than 25, such as gold, is evaporated onto the free surface of the support film. The thickness of the scattering layer 74 may be of the order of 100 angstroms or less. The secondary electron emissive layer 72 is then evaporated onto the electron scattering film 74. The secondary electron emissive layer is of a suitable insulator material, such as potassium chloride. The thickness of this layer may be of the order of 600 angstrom units.

It is also possible to construct the normalizing electrode so as to dispense with the support mesh 76. A material, such as aluminum oxide, may be used as the secondary emissive layer and requires support only about its periphery. A support ring of suitable material, such as nickel, may be utilized. One possible method of preparing the aluminum oxide film is to anodize a thin film of about 10 microns in thickness of aluminum in a solution of ammonium citrate. This produces a coating of aluminum oxide on each side of the aluminum film. The aluminum and the aluminum oxide on one side may then be removed by using sodium hydroxide and hydrochloric acid leaving only a thin aluminum oxide film of a thickness of 1000 A. A full description of this method is given in U.S. Patent No. 2,898,499 entitled Electron Discharge Device by E. J. Sternglass and W. H. Feibelman and issued on August 4, 1959. An electron scattering layer may be provided on the aluminum oxide similar to the layer 74.

In the operation of the device shown, the cathode 22 of the electron gun 20 is at a potential of a negative of 4000 volts with respect to ground, and the electron beam generated by the electron gun 20 is caused to scan a raster on the normalizing electrode 70 in a conventional manner by means of the electrostatic deflection plates 30 and 32. The normalizing electrode 70 is at ground potential. The electron beam generated by the electron gun 20 will strike the electron scattering layer 74, and the incident electrons will be scattered at different angles with respect to the incidence angle of the electrons. The electrons, after passing through the electron scattering material layer 74, will enter the secondary emissive layer 72 at an angle with respect to normal. The longer the path of the electron within a given secondary emission layer 72, the greater will be the amount of secondary emission from the layer 72. The majority of secondary electrons generated at the surface of the normalizing electrode 70 facing the target 40 are only of low energy of the order of 0 to 5 electrical volts. By selection of proper voltages and thicknesses of the layers 72 and 74, the incident electrons may be absorbed by the normalizing electrode 70. The low energy electrons generated by the normalizing electrode 70 will be accelerated by the accelerating grid 60 at a potential of 500 volts positive and decelerated by the potential of 30 volts positive so that low velocity landing (landing energies below first crossover) is obtained. The high fields and close spacing provided between the normalizing electrode 70 and the accelerating grid 60 and between the accelerating grid 60 and the target 40 insure substantially normal landing. It is, therefore, seen that without any charge image placed on the target 40, the surface of the target film 44 facing the normalizing electrode 70 is charged to the normalizing electrode potential of ground. The conduction coating 42 on the other surface of the target film 44 is at a potential of about 30 volts positive with respect to ground. It is thus seen by means of the effective or secondary scanning beam generated by the normalizing electrode 70, the electrons strike the surface of the target 40 normal thereto and at a velocity below first crossover so that the secondary emission from the target 40 is less than unity. A potential difference is thus generated and exists between the conductive plate 42 and the scan side of the target film 44. If a light image is now focused onto the photosensitive target film 44, the target film 44 will tend to act as a leaky capacitor, and the scanned surface will change from ground potential of normalizing electrode 70 or effective cathode potential to some positive potential less than the positive potential applied to the conductive coating 42. It is thus seen due to the high lateral resistance of the film 44 that each elemental area will have a potential on the scanned surface roughly proportional to the intensity of the light on the target film. After this light image is stored in the form of an electric charge image on the scan surface of the target, the scanning electron beam from the normalizing electrode 70 will deposit just enough electrons on each element to restore charge on the scanned surface to the potential of the normalizing electrode 70. A corresponding pulse generated in the capacitively coupled plate circuit constitutes the image signal. This resulting current pulse may be applied to an output circuit and applied to a kinescope or any other system for transmission. The signals derived from the target 40 by the circuit is a replica of the light image incident on the target film and can be amplified, enlarged and varied in contrast, according to well known television techniques.

It is therefore seen by the utilization of my invention, it is possible to obtain a low velocity electron scanning beam by substantially conventional cathode ray tube techniques. This system permits the utilization of large diameter targets without resorting to heavy and bulky magnetic coils or to an excessively long tube structure to insure proper landing of the electron beam on the target.

FIG. 3 shows another embodiment of my invention within a display storage tube such as described in an article entitled "Characteristics of Transmission Control Viewing Storage Tube With Halftone Display" by M. Knoll and H. Hook and R. P. Stone in Proc. of IRE, volume 42, No. 10, October 1954. The tube consists of an evacuated envelope 80 having a large area light producing screen 110. The screen 110 consists of a layer of a suitable phosphor material 112 with a conductive, electron permeable, light reflective layer 114. The layer 114 also provides means of applying suitable positive potential to the screen 110 which may be of the order of 10,000 volts.

Two electron guns 82 and 84 are provided at the opposite end of the envelope 80. Positioned between the electron guns 82 and 84 and the screen 110 is a storage grid 90. The grid 90 is a foraminated grid member of similar area as screen 110 and adjacent thereto for controlling electron flow. The grid consists essentially of a conductive apertured back plate 92 with a charge storage layer 94 of a suitable material on the side facing the electron guns 82 and 84. The layer 94 may be of a material of the type described in the above-mentioned copending application or of any suitable dielectric material.

Positioned between the storage grid 90 and the electron guns 82 and 84 is the normalizing electrode 70. At ground potential the structure of the electrode 70 has

previously been described with respect to FIGS. 1 and 2. An accelerating grid **75** is positioned between the storage grid **90** and the normalizing electrode **70** and is at a positive potential of the order of 500 volts.

In the erase operation of the tube shown in FIG. 3, the flood gun **84** is on and the write gun **82** is off. The flood gun **84** has its cathode potential at about negative 4,000 volts with respect to normalizing electrode **70**. A positive potential of 30 volts is applied to the conductive layer **92** of the storage grid **90**.

At these potentials the electrons from the flooding gun **84** strike the normalizing electrode or dynode **70** giving rise to emission of secondary electrons from the opposite side. The electrons from the electrode **70** are first accelerated and focussed by the grid **75** held at a positive potential of 500 volts and strike the storage grid **90** at electron energies below first crossover of the layer **94** where secondary emission is less than unity. This bombardment tends to charge the surface of layer **94** in a negative direction until the potential on the surface is substantially equal to the ground potential of the electrode **70**.

In the write operation of the tube, the flood gun **84** is off and the writing gun **82** is on and is caused to scan a rester on the normalizing electrode **70** and the beam would be intensity modulated in accordance with charge image to be stored on storage grid **90**. The electron gun **82** is operated at a negative potential of about 4000 volts with respect to the normalizing electrode **70**. The potential of about 350 volts positive with respect to electrode **70** is applied to the conductive layer **92** of the storage grid **90**, and the accelerating grid **75** is held at a potential of 500 volts positive with respect to electrode **70**. At this potential the secondary electrons generated in the electrode **70** are accelerated to the storage grid **90** and strike the surface of layer **94** and place a charge image thereon by charging the surface in a positive direction. The bombarding energy of the electrons at this potential is above the first crossover so that secondary emission is greater than unity, and the resulting electron deficiency charges the storage grid **90** in a positive direction.

In the read operation, the gun **82** is turned off and the flood gun **84** is turned on. The potential applied to layer **92** of storage grid **90** is positive 20 volts. At this potential, the field around the grid **90** is such that electrons may pass through the opening in the storage grid in accordance with the charge image written on the surface of layer **94**. The electrons passing through the openings in grid **90** strike the phosphor screen **110** with sufficient energy to produce a light image corresponding to the charge image on grid **90**.

To produce the next image it is necessary to erase and write the charge image in the manner described.

In some applications it is desirable to leave the flooding gun **84** on during the read operation and also turn the writing gun **82** on. By this operation the secondary writing beam from the electrode **70** will also pass through the storage grid **90** and superimpose a desired light pattern or image on the light image due to the electrons passing through the storage grid **90** from the flood gun. This type of operation may be referred to as "write through." In this "write through" type operation the charge image on grid **90** is disturbed only a negligible amount. The normalizing electrode makes possible the necessary normal approach and passage without disturbing the charge pattern on the storage grid.

While I have shown my invention in two embodiments, it will be obvious to those skilled in the art that it is not so limited, but is susceptible to various other changes and modifications without departing from the spirit and scope thereof.

I claim as my invention:

1. An electronic storage tube comprising a storage electrode for providing a spaced distribution of charged elements corresponding to an image, means for directing electrons of low velocity to the surface of said storage electrode so that the electrons approach said electrode substantially normal to the surface of said storage electrode, said means comprising a primary source of electrons of high velocity, a transmissive type secondary emissive electrode positioned between said primary source of electrons and said storage electrode for intercepting the electrons of high velocity from said primary source of electrons and generating low energy secondary electrons in response to bombardment of electrons from said primary source and an accelerating grid positioned between said storage electrode and said secondary emissive electrode for directing the low energy secondary electrons from said secondary emissive electrode to approach said storage electrode at a low velocity and substantially normal to the surface thereof by substantially electrostatic means.

2. An image pickup tube comprising a light sensitive input screen capable of providing a surface distribution of charged elements representative of a light image projected thereon, means for scanning said light sensitive input screen with a low velocity electron beam, said means comprising an electron gun for generating and producing an elementary electron beam of high velocity, a transmissive type secondary electron emitter positioned between said electron gun and said input screen and adjacent said input screen for intercepting said high velocity electron beam and generating low energy secondary electrons from the side facing said screen and an accelerating grid positioned between said input screen and said secondary electron emitter for accelerating the low energy secondary electrons generated in said transmissive type secondary electron emitter to said input screen and substantially normal to the surface thereof by substantially electrostatic means.

3. A storage display tube comprising an output screen for generating light in response to electron bombardment, a storage grid positioned adjacent said light output screen, means for placing a charge image no said storage grid corresponding to the light image desired on said output screen, said means comprising a transmissive type secondary emissive electrode positioned on the opposite side of said storage grid with respect to said output screen, an electron gun for generating an elemental electron beam of a first velocity for scanning a raster on said secondary emissive electrode on the opposite side of said secondary emissive electrode with respect to said output screen and thereby generating a secondary emissive electron beam of electrons of a second velocity substantially lower than said first velocity on the opposite surface of said secondary emissive electrode, an accelerating grid positioned between said secondary emissive electrode and said storage grid for accelerating said secondary emissive electrons into incidence with said storage grid at an energy above the first crossover potential of said storage grid and means for producing a light image on said output screen corresponding to the charge image on said storage grid comprising a flooding electron beam for flooding the entire surface of said secondary emissive electrode and thereby generating a flooding secondary emissive electron beam of electrons of said second velocity from said secondary emissive electrode and means for accelerating the flooding electron beam from said secondary emissive electrode through the apertures in said storage grid into incidence with said output screen.

4. An electron tube comprising a storage grid for providing a spaced distribution of charged elements representative of an image, means for scanning said storage electrode with a low velocity electron beam substantially normal to the surface of said storage electrode, said means comprising a primary source of a high velocity electron beam, a transmissive type secondary emissive electrode positioned between said primary source of elec-

trons and said storage electrode for intercepting the electrons directed onto one surface from said primary source and generating low energy secondary electrons from the opposite surface in response to the bombardment by electrons from said primary source and an accelerating grid positioned between said storage electrode and said secondary emissive electrode for directing the secondary electrons to the surface of said storage electrode at low approach velocity and substantially normal to the surface thereof by substantially electrostatic means.

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