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CATHODE RAY TUBE

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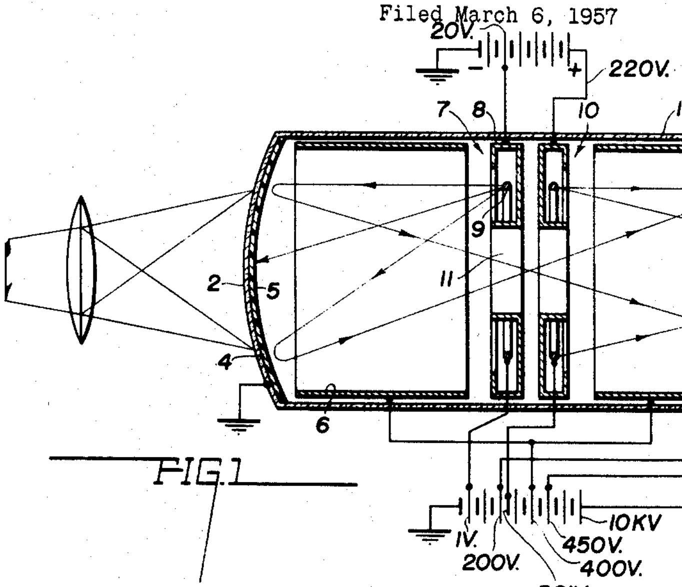

FIG.1

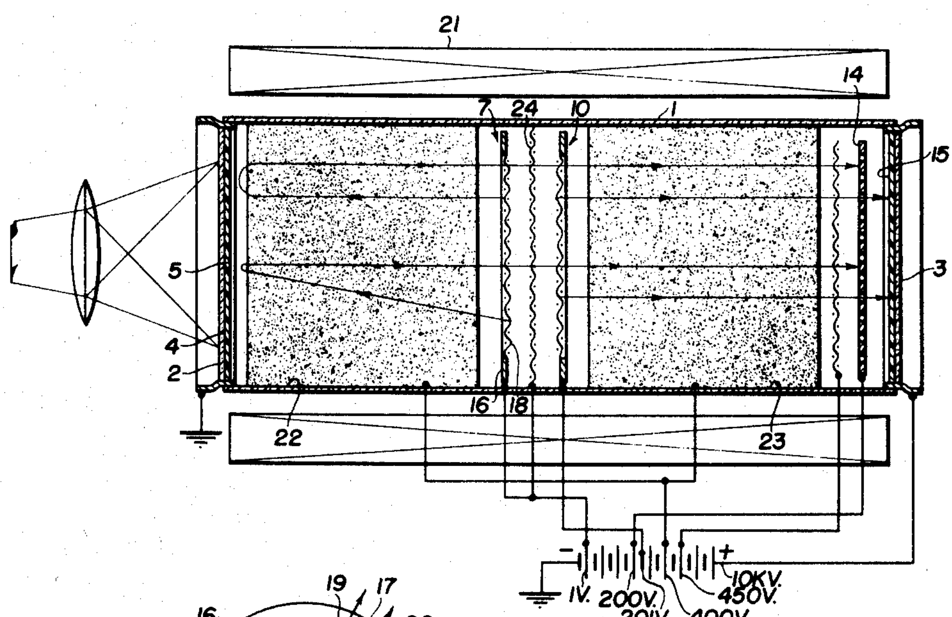

FIG.2

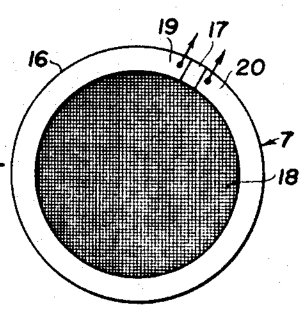

FIG.3

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CATHODE RAY TUBE

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9 Claims. (Cl. 313—65)

The present invention relates to a cathode ray tube and more particularly to an image amplifier which displays in visible form a given radiation image.

Certain prior art image amplifier tubes of the type disclosed in Farnsworth application Ser. No. 469,358, filed November 17, 1954, utilize a control grid coated with photoconductive material for modulating a flood beam of electrons which are projected onto a phosphor screen for reproducing in visible form a radiation image which is projected onto the photoconductive material.

The present invention differs primarily in the respect that the control grid is of the conventional storage type utilizing no photoconductive material, but instead a surface or layer of photoconductive material on the interior surface of the tube envelope is utilized as an electron mirror, and the electron image is created by the modulating action of the photoconductive layer to modulate a first flood electron beam extended through space and projected onto the control grid for impressing an electrostatic charge image thereon. A second flood beam of electrons is thereupon directed toward the charged grid and is thereby modulated prior to impingement on the phosphor screen. The photoconductive layer or surface in this instance resembles an electron mirror which serves to reflect or absorb locally electrons from a first flood source in order to produce the electron image.

It is therefore an object of this invention to provide a cathode ray tube which converts a radiation image into an electron image and thereafter converts the electron image into a visible image, such conversion process being accomplished with high gain or amplification.

It is another object of this invention to provide a cathode ray tube which utilizes an electron-emitting cathode in combination with a radiation-receiving element for forming an electron image which is used to charge a control grid, and a second cathode which emits a flood beam of electrons for modulation by the grid prior to impingement on a phosphor anode.

Other objects will become apparent from the following description.

In the accomplishment of this invention there is provided an electron discharge device comprising an evacuated envelope having two oppositely disposed end faces, a layer of transparent conductive material on one end face, a layer of photoconductive material on said transparent layer, a layer of phosphor material on the other end face, an electron permeable storage screen disposed adjacent said phosphor layer, a first cathode disposed between the end faces for flooding the photoconductive layer with electrons, a second cathode disposed between the said first cathode and said other end face for flooding the storage screen with electrons, both cathodes being electron permeable, and electron optical means for focusing electrons from the vicinity of said photoconductive layer onto the storage screen for impressing an electrostatic charge on the latter, whereby electron current from the second cathode will be modulated upon approaching or permeating the storage screen prior to impinging the phosphor screen.

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The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a longitudinal sectional illustration of one embodiment of this invention;

Fig. 2 is a longitudinal sectional illustration of a second embodiment of this invention; and

Fig. 3 is a front view of one of the cathodes used in the embodiment of Fig. 2.

Referring to the drawings, a display tube of this invention comprises an evacuated envelope **1** having transparent opposite end faces **2** and **3**, respectively. On the inner surface of the end face **2** is a film or layer **4** of transparent conductive material such as stannous oxide or silver. On this film **4** is a layer or film **5** of photoconductive material such as cadmium sulphide, cadmium selenide, or cadmium tetluride. This material should have a resistivity in the vicinity of 10^{10} ohm-centimeters, and may be formed according to the usual techniques such as by those used in fabricating the photoconductive cathode of the type 6236 camera tube which is characterized by the trademark "Vidicon." An anode sleeve **6** is positioned to the rear of the layer **5**, and an annular electron gun indicated generally by the reference numeral **7** is coaxially positioned to the rear of the sleeve. This electron gun **7** comprises the usual annular anode **8** which surrounds a ring cathode **9** composed of some suitable electron-emitting material. Ring guns of the type suitable for use in this invention are well known and may vary in design according to individual preferences. One suitable design appears in Papp application Ser. No. 625,665, entitled, "Electron Discharge Device," filed Dec. 3, 1956. Mounted to the rear or right-hand side of the annular gun **7** is another annular gun **10** of substantially the same construction. These two guns **7** and **10** are spaced apart and are coaxial with the other elements of the tube, and provide a central opening **11** which serves a purpose which will become apparent from the following.

A second accelerating anode or sleeve **12** is coaxially disposed to the rear or right-hand side of the gun **10** and is followed in order by a collector screen **13**, a storage screen **14**, and a phosphor screen **15**. The screen **13** is composed of a suitable fine mesh, metallic screen. The storage element **14** is the usual metallic screen of from 200 to 1,000 mesh size provided with a thin film of insulating material on the left-hand face, this material being, for example, quartz or the like. For a more particular description of these elements **13**, **14** and **15** reference may be made to the prior art which includes Farnsworth Patent #2,754,449, issued July 10, 1956, and entitled, "Cathode Ray Tube and System."

Circuitry for applying operating potentials to the various tube elements is illustrated with respective operating potentials being indicated. In operation, the electron gun **7** emits a flood beam of electrons toward the left, or, in other words, toward the photoconductive layer **5**. The gun **10** emits its electrons toward the right, or, in other words, toward the phosphor screen **15**.

The gun **7** is so designed that its electrons are not focused but instead cover uniformly the entire area of the photoconductive layer **5**. Assuming that no radiation of any type is falling on the layer **5**, its resistivity through the thickness thereof will be a maximum, and in this condition the photoconductor resembles a dielectric material. The low velocity electrons from the gun **7** falling on the layer **5** thereby charge the latter negatively over its entire surface.

Now assuming that a radiation image is focused onto the layer 5, the highlight areas of this image will reduce the resistance of the layer 5 in corresponding areas so that the negative charge appearing in these areas will be conducted to ground. Areas of the layer 5 receiving less than maximum image brightness will be proportionately less discharged, the result being a pattern of electrical potential on the layer 5 which corresponds identically to the pattern of the radiation image.

The electrons from the gun 7 will now be repelled by the negative areas of the layer 5 but will be collected by the more positive areas, depending upon the value of the charge. The layer 5 may thereupon be considered as an electron mirror which by virtue of its differential repelling characteristics produces an electron image which is accelerated and focused by means of the various elements 6, 8, 12 and 13 onto the storage screen or grid 14. The crossover point of this extended image coincides with the central opening 11 of the two ring guns 7 and 10. As a result of the electron image impinging the storage screen 14, an electrostatic charge image is impressed on the latter which serves to modulate the flood beam of electrons emanating from the cathode 10. As is true in all tubes of this character, the cathode 10 supplies a cloud of low velocity electrons which cover the entire area of the storage screen 14. As these electrons approach and permeate the screen 14 they will be modulated in accordance with the charge image thereon. The modulated electron beam is thereupon accelerated to high velocity for impingement on the phosphor screen 15.

The second embodiment of this invention is illustrated in Fig. 2, wherein like numerals indicate like parts.

This embodiment is very similar to that of Fig. 1 with the exception that it utilizes magnetic focusing instead of electrostatic focusing. The two cathodes 7 and 10 comprise an incomplete metallic ring 16 having a segment of insulation 17 interposed between the ends thereof. A suitable metallic screen 18 is mounted on the ring 16 and has a thermally emissive material, such as barium, coated thereon. Heater voltage is connected to the opposite ends 19 and 20 of the ring 16 for heating the latter to a temperature sufficiently high to heat the screen 18 to produce electron emission, the resistance of ring 16 being utilized for this purpose. Since the screen 18 is electron permeable, electrons which are reflected from the photoconductive layer 5 pass backwardly through the screens for impinging the storage grid 14. A focusing and accelerating coil 21 surrounds the tube and produces the usual magnetic field for projecting the electron image reflected by the photoconductive layer 5 onto the storage grid 14.

Instead of using anode sleeves as in the tube of Fig. 1, conductive coatings 22 and 23 on the inner wall of the envelope may be used.

The operation of this tube of Fig. 2 is essentially the same as that of Fig. 1, the cathode 7 emitting electrons toward the photoconductive mirror 5, which electrons are absorbed or reflected and focused in pencil-like beams onto the storage grid 14. The cathode 10 emits a broad beam of electrons which covers the entire area of the grid 14, these electrons being modulated and thereafter projected onto the phosphor screen 15.

In some instances it is desirable to use an isolating grid 24 between the two cathodes 7 and 10 (Fig. 2) for assuring leftward emission by the cathode 7 and rightward emission by the cathode 10.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention.

What is claimed is:

1. An electron discharge device comprising an evacuated envelope enclosing a layer of photoconductive material and a layer of phosphor material spaced from said photoconductive layer, a cathode disposed between said layers for flooding said photoconductive layer with electrons, and electron-optical means for focusing electrons from the vicinity of said photoconductive layer toward said layer of phosphor material.

2. An electron discharge device comprising a photosensitive image-receiving element, said element including photoconductive material, a first source of electrons, means flooding said element with electrons from said first source, an image-displaying element responsive to electron impingement, said first source being disposed between said image-receiving and image-displaying elements, an electron permeable control member disposed adjacent said image-displaying element for modulating the electron current flowing to said image-displaying element, electron-optical means for focusing electrons reflected from said image-receiving element onto said control member for impressing an electrostatic charge-image on the latter, and a second source of electrons disposed between said first source and said image-displaying element for flooding said control member, whereby the electron current permeating said control member will be modulated in accordance with the aforementioned charge-image.

3. An electron discharge device comprising a layer of photoconductive material adapted to receive a radiation image, a display screen of phosphor material spaced from said layer, a storage screen for controlling electron flow to said display screen, two sources of electrons disposed between said photoconductive layer and said storage screen, one of said sources flooding said layer with electrons and the other of said sources flooding said storage screen with electrons, both sources being permeable to electron flow, and electron-optical means for focusing the electrons reflected by said layer onto said storage screen for impressing a charge-image onto the latter.

4. An electron discharge device comprising a layer of photoconductive material adapted to receive a radiation image, a display screen of phosphor material spaced from said layer, a storage screen for controlling electron flow to said display screen, two sources of electrons disposed between said photoconductive layer and said storage screen, one of said sources flooding said layer with electrons and the other of said sources flooding said storage screen with electrons, both sources being permeable to electron flow, means rendering said layer negative with respect to said one source, and electron-optical means for focusing the electrons reflected by said layer onto said storage screen for impressing a charge-image onto the latter.

5. An electron discharge device comprising an evacuated envelope having two oppositely disposed end faces, a layer of transparent conductive material on one end face, a layer of photoconductive material on said transparent layer, a layer of phosphor material on the other end face, an electron permeable storage screen disposed adjacent said phosphor layer, a first cathode disposed between said end faces for flooding said photoconductive layer with electrons, a second cathode disposed between said first cathode and said other end face for flooding said storage screen with electrons, both of said cathodes being electron permeable, and electron-optical means for focusing electrons from the vicinity of said photoconductive layer onto said storage screen for impressing an electrostatic charge on the latter, whereby electron current from the second cathode will be modulated upon permeating said storage screen prior to impinging said phosphor screen.

6. The device of claim 5 wherein said cathodes are ring-shaped with the centers thereof open, and said electron-optical means comprises electrostatic accelerating and focusing elements which direct the electrons from the vicinity of said photoconductive layer through the open centers of the cathodes and onto the storage screen.

7. The device of claim 5 wherein said cathodes comprise electron-emissive screen material and said electron-

optical means comprises a focusing coil which images the electrons from the vicinity of the photoconductive layer onto the storage screen.

8. The device of claim 5 but including circuit means for rendering the photoconductive layer negative with respect to said first cathode.

9. An electron discharge device comprising an evacuated envelope having two oppositely disposed end faces, a layer of transparent conductive material on one end face, a layer of photoconductive material on said transparent layer, a layer of phosphor material on the other end face, a cathode disposed between said end faces for flooding said photoconductive layer with electrons, and electron-optical means for focusing electrons from the vicinity of said photoconductive layer toward said layer of phosphor material.

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