Oct. 2, 1956 J. A. HENDERSON 2,765,422

TELEVISION CAMERA TUBE

Filed Nov. 19, 1951

FIG. 1.

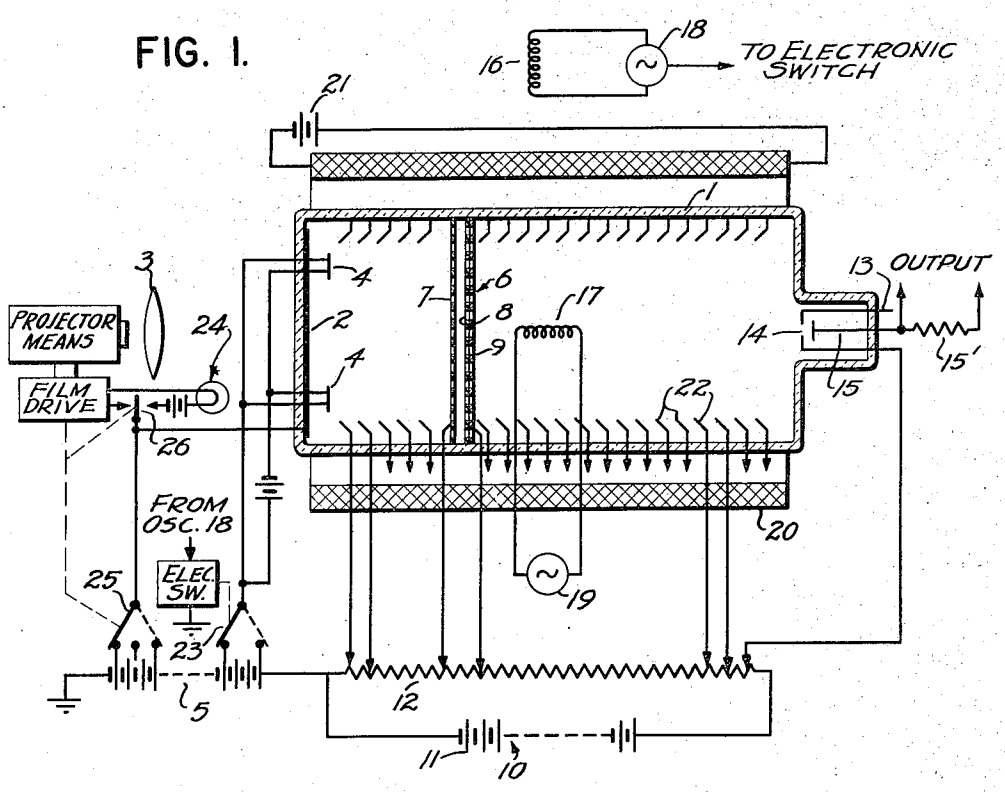


FIG. 2.

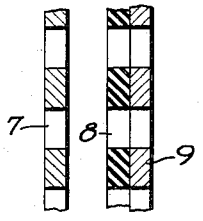


FIG. 3.

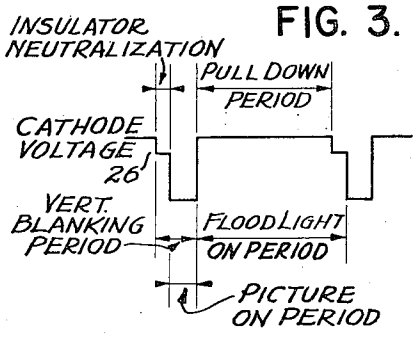
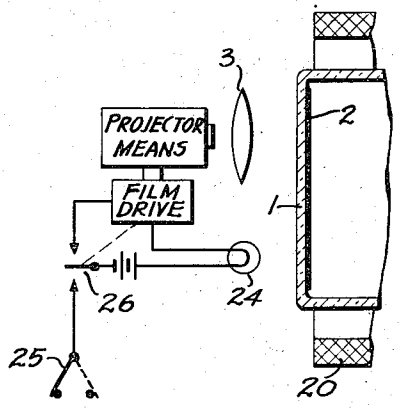


FIG. 4.



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TELEVISION CAMERA TUBE

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8 Claims. (Cl. 315—11)

This invention relates to storage type television camera tubes and particularly to tubes having the dual function of electron image amplification and electron image dissection.

In U. S. Reissue Patent No. 22,009, issued January 20, 1942, to Farnsworth, there is disclosed a camera tube wherein image amplification is effected by scanning an electrical image across an aperture located in the focal plane of the electrical image. The electrons that pass through the aperture impinge on a winding encircling a thermionic cathode; therefore, the potential of the winding is determined by the number of electrons reaching it through the aperture. An anode is positioned adjacent the cathode and accelerates the electrons which the cathode emits. Thus, there is produced a triode-amplification effect and the electrons from the primary image control the amplification.

In the above-mentioned patent, double scanning is necessitated thus increasing the possibility of error in the system; and amplification is limited by the number of electrons passing through the aperture.

In another U. S. patent to Farnsworth, No. 2,292,437, issued April 11, 1942, there is disclosed a camera tube wherein electron image amplification is attained before transmission by virtue of forming an electron image on a photosensitive cathode. An electron flood is provided adjacent the cathode so that upon charging, the cathode permits a large flow of electrons to pass therethrough which forms an amplified electron image which is thereafter scanned by an image dissector.

In the invention illustrated by Patent No. 2,292,437 image amplification is limited by the storage time of the photosensitive cathode; i. e., the flow of electrons through the grid exists only while the cathode is charged. Therefore, amplification is not as great as might be desired because the storage time of the cathode is necessarily small.

It is an object of this invention to provide a tube and circuits giving improved performance over the tubes described in the aforementioned patents. In accordance with a major aspect of my invention, I obtain greater amplification by providing a storage grid intermediate to the photosensitive cathode and image dissector to retain a charge pattern thereon while passing a maximum density of flood electrons therethrough.

A feature of my invention is to provide a camera tube having relatively great sensitivity.

Another feature of my invention is to provide a camera tube having a relatively great contrast range.

Anoher and very important feature of my invention is to provide a camera tube which is particularly adaptable for motion picture pickup.

In accordance with one embodiment of my invention there is provided a storage type television camera tube system, comprising a photoemissive cathode for producing an electron image emission. An electron permeable storage screen is provided for storing a voltage pattern in response to the electron image emission. A substantially uniform electron flood is produced in the vicinity

of the storage screen and electrons are attracted from the electron flood through the electron pervious screen to produce an amplified electron image. The amplified electron image is then scanned to produce currents corresponding to successive elements of the amplified electron image.

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 illustrates diagrammatically a television camera tube arrangement embodying one form of the invention;

Fig. 2 is an enlarged diagrammatic fragmentary view of the grid and collector electrodes;

Fig. 3 is a curve used in explaining the variations of cathode voltages when the invention is used in conjunction with motion picture pick-up; and

Fig. 4 shows switching means between the film drive, source of illumination and cathode voltage switch.

Referring to Fig. 1 of the drawing, there is shown a television camera tube which embodies the invention. The tube is provided with an envelope 1, the interior of which is highly evacuated. At one end of the tube 1, there is a translucent cathode 2 in front of which is placed an optical system 3 in such a manner as to focus an optical image of an object thereon. The cathode is preferably made from a substance having high photoemissive sensitivity, e. g. caesium-antimony. To the right of the cathode 2, there are provided thermionic electron flood beam sources 4 which may be energized by conventional means, such as battery 5. Intermediate the ends of the tube and extending across the envelope, are grid and collector electrodes 6 and 7 respectively. The collector electrode 7 is preferably made of a very fine mesh conductive material; the fine mesh being desired so as not to impair or limit resolution. The grid electrode 6 consists of two layers 8 and 9; layer 8 being made of insulation material, such as quartz, having secondary-electron emissive charge-storage characteristics, and layer 9 being made of a conductive material. The meshes of the layers 8 and 9 are preferably identical to each other and finer than the mesh of the collector electrode (Fig. 2). Suitable potentials are applied to the conductive layer of the grid and collector electrode by conventional means, such as voltage supply 10, consisting of a battery 11 connected across a resistor 12. The remaining portion of the tube, that is the portion to the right of the grid 6, is a conventional image dissector comprising an anode 13 having an aperture 14 facing the grid 6. Mounted inside the anode 13 is a collector electrode 15 positioned immediately back of the aperture 14, and has its output connected to a load resistor 15'. The dissector portion is provided with exterior coils 16 and 17 positioned substantially at right angles to each other for moving the electron image in two directions over the scanning aperture 14, the magnetic fields of these coils being formed by energization by scanning voltage sources, such as oscillators 18 and 19 respectively. Suitable voltages are applied to the anode 13 and cathode 2 by the voltage supply 10 and battery 5.

The tube is provided with the usual focusing coil 20 energized by a focusing energy source 21 to provide a magnetic field between the cathode 2 and the scanning aperture 14. Accelerating rings 22 are connected to resistor 12 in graduated relationship to provide linear acceleration of the electron image between the cathode 2 and aperture 14. The number of rings illustrated are by way of example only and not intended to be accurate. The leads from the rings to the resistor 12 are shown

abbreviated with arrow heads in order to prevent confusion by the showing of excessive lead lines.

In operation, an optical image is focused upon the cathode 2, by the optical system 3. Cathode 2 emits electrons in proportion to its illumination thereby forming an electron image. The electron image is accelerated by accelerating rings 22 and focused by focusing coil 20 to provide an electron image in the plane of the insulator 8. The cathode 2 is made sufficiently negative so that the electron image may be given enough velocity to liberate secondary electrons upon impinging on the insulator 8, thus leaving a positive charge pattern on the insulator. The secondary electrons are collected by the collector electrode 7. The thermionic flood beam sources 4 supply an electron flood of substantial cross sectional area which is directed at the grid 6; the potential of the flood cathode being more positive than the charge on the insulator but less positive than the charge on the conductive layer 9. Therefore, triode action is effected with the flood being a virtual cathode, the insulator serving as the grid and the conductive layer serving as the plate. Since the flood beam is dense, the amplification is very high and the flooding electrons that pass through the grid under the control of the charge pattern, form an electron image greatly amplified. On the right hand side of the conductive layer the tube operates as a typical image dissector; i. e. the amplified electron image is accelerated and focused in the plane of the aperture. The image is then scanned to present successive elementary areas of the image at the aperture, whereby the current passed through the aperture corresponds to successive elements of the amplified electron image. Obviously for triode action to exist, the insulator must be charged while flood electrons are available. Therefore, the useful charge storage time of the insulator determines the number of images that are transmitted per unit of time if the tube is operated utilizing only the inherent leakage of the insulator. However, another and more direct method of erasing the charge on the insulator is by pulsing the flood cathode negatively via switch 23 with respect to the insulator so that flood electrons are emitted and have an increased velocity just sufficient to cause them to impinge on the insulator and remain there, thereby neutralizing the old charge and establishing a uniform equilibrium charge. The latter method is particularly useful because the negative pulsing of the flood cathode may be effected during vertical blanking of the dissector and therefore would not interfere with the normal scanning operation. The switch 23 is synchronized with the vertical blanking oscillator for properly timing the negative pulsing of the flood cathode 4 by means, such as an electronic switch.

Electrode voltages which were found to be satisfactory for the above-mentioned operation of one embodiment of the invention were as follows: The photo-sensitive cathode had a voltage of approximately —30 volts which was sufficient to give the electron image enough velocity to liberate secondary electrons from the insulator; the collector electrode voltage was approximately +10 volts; the conductive layer of the grid was approximately +5 volts; the flood cathode was approximately +5 volts; and the accelerating rings had gradation voltages between —22 and +600 volts; the 600 volts appearing at the aperture. When the duration of the charge pattern on the insulator was controlled by pulsing the flood cathode, a suitable voltage was approximately —5 volts. This provided the electron flood with just enough velocity to travel to the insulator and remain thereon without liberating secondary electrons.

It is to be realized that this invention may operate satisfactorily by imposing a negative charge pattern on the insulator 8 instead of a positive charge pattern as above described. In imposing a negative charge pattern on the insulator, the electron image on cathode 2 should have only sufficient velocity to impinge on the insulator without causing secondary electrons to be liberated therefrom, thus inducing the negative charge of the electron image on the insulator. For this case, the collector electrode 7 is unnecessary and the voltages applied to the conductive layer and flood beam are, of course, adjusted to provide triode action. Since the charge pattern on the insulator is now negative the spatial charge of the flood beam should be made positive relative thereto.

Another, and very important application of my invention, is in conjunction with motion picture pick-up. In using my invention for motion picture pick-up, thermionic flood sources 4 are unnecessary and may be disconnected from the circuit via manually operated switch 23, and the photosensitive cathode 2 is preferably used to provide the electron flood beam by flooding the cathode 2 with light from a source of illumination 24. During vertical blanking time a picture is focused on the translucent cathode forming an electron image which, as previously explained, is accelerated and focused in insulator layer 8. The projector pull down time is synchronized with the scanning period and during this interval, the photosensitive cathode 2 is uniformly illuminated thus supplying the necessary flood beam for triode amplification action. The bias of the cathode (see Fig. 3) is varied by means of a switch 25 so that during the flood interval the cathode is made less negative so that the charge pattern on the insulator 8 is not dissipated. An intermediate contact may be provided to give the proper velocity to erase the image before the flood is applied, or the inherent storage time of the cathode 2 is just long enough to retain the charge pattern from one picture frame to the next frame.

The film drive is mechanically coupled to source of illumination switch 26 and cathode voltage switch 25 so that during the write on period when a picture frame is focused on the cathode 2, illumination 24 is extinguished and the cathode voltage is accordingly adjusted via switch 25. During the pull down time (the scanning time) the illumination is switched on (under the control of the film drive), and the cathode voltage properly adjusted to provide a suitable space charge (see Fig. 4). The cathode voltage is switched shortly before the end of the pull down time to permit the flood charge to sufficiently neutralize the insulator.

The camera tube for motion picture pick-up may also be operated with negative or positive charge patterns on the insulator, in accordance with the principles outlined above.

Fig. 3 shows a curve illustrating the variation of cathode voltages during the insulator neutralization period, the write on period, and the pull down period. Point 26 shows the potential of the cathode for clearing the charge of the insulator immediately preceding the write-on period. During the write-on period the cathode potential is at its most negative point such that the electron image has enough velocity to emit secondary electrons from the insulator and charge it in the positive direction. During the flood light-on period, the cathode potential is at its most positive point such that the flood electrons then reach the insulator at a very low velocity and do not disturb the charge thereon. From Fig. 3 it is seen that long pull down time is available with my invention. This, of course, is of great importance in motion picture transmission.

A few of the advantages of my invention are the increased sensitivity due to greater image amplification; wider contrast range because the insulator can charge linearity over a greater range of voltages; simplicity in obtaining a photoelectric flood when used as a motion picture pick-up tube; and the long pull down time available for motion picture projection.

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 as set forth in the objects thereof and in the accompanying claims.

What is claimed is:

1. A storage type television camera tube for transmitting image signals, comprising a translucent photosensitive cathode upon which an optical image may be projected, to form an electron image, an electron permeable grid having an insulator layer on one side thereof for storing a voltage pattern in response to said electron image emission, and a conductive layer on the other side, means for uniformly illuminating said cathode to produce an electron flood of substantial cross-sectional area on said one side of the grid, means to apply a voltage positive with respect to said flood source to said conductive layer, whereby said flooding electrons passing through the grid under the control of the charge pattern thereon form a substantially amplified electron image and means for utilizing said amplified electron image to produce currents corresponding to particular elements of said amplified electron image.

2. A storage type television camera tube for transmitting image signals, comprising a translucent photosensitive cathode upon which an optical image may be projected to form an electron image, a fine mesh grid consisting of a secondary-electron emissive charge-storage layer on one side thereof and a conductive layer on the other side, means for accelerating and focusing the electron image in the plane of the storage layer, a collector electrode positioned to collect secondary electrons liberated from said grid by the electron image, whereby a positive charge pattern is formed on said grid, means for uniformly illuminating said cathode to produce an electron flood of substantial and uniform cross sectional area on said one side of the grid, circuit connections to apply suitable voltages to said conductive layer and cathode to produce triode action between the flood beam, the grid and the conductive layer, the flood beam being a virtual cathode, the charge-storage layer serving as the grid and the conductive layer serving as the plate, said flooding electrons passing through the grid under the control of the charge pattern thereon to form an electron image substantially amplified by virtue of the triode action; an output electrode having an aperture, a collector electrode for receiving the electrons that pass through said aperture, means for accelerating and magnetically focussing the amplified electron image in the plane of the aperture, and means for scanning the image to present successive elementary areas of the image at the aperture, whereby the current passed through the aperture corresponds to successive elements of the amplified electron image.

3. A storage type television camera tube for transmitting image signals, comprising an evacuated envelope substantially in the shape of a cylindrical body, a translucent photosensitive cathode positioned at one end thereof and upon which an optical image may be projected to produce emission therefrom to form an electron image on said cathode, a fine mesh grid extending across the cylindrical body portion intermediate the ends thereof, said grid consisting of a secondary-electron emissive charge-storage layer on one side thereof toward said one end and a conductive layer on the other side, means for accelerating and magnetically focusing the electron image in the plane of the storage layer and liberating secondary electrons therefrom, a conductive collector electrode positioned within said envelope on said one side of the grid to collect secondary electrons liberated therefrom, whereby a positive charge pattern is formed on said grid, means for illuminating said cathode to produce an electron flood of substantial cross sectional area on said one side of the grid, circuit connections to apply suitable voltages to said conductive layer and cathode to produce triode-action between the flood beam and the conductive layer, the flood beam being a virtual cathode, the charge-storage layer serving as the grid and the conductive layer serving as the plate, said flooding electrons passing through the grid under the control of the charge pattern thereon to form an electron image substantially amplified by virtue of the triode action; an output electrode having an aperture and positioned at the opposite end of the said tube, a collector electrode for receiving the electrons that pass through said aperture, means for accelerating and magnetically focusing the amplified electron image in the plane of the aperture, and means for scanning the image to present successive elementary areas of the image at the aperture, whereby the current passed through the aperture corresponds to successive elements of the amplified electron image.

4. An arrangement of the character described comprising photoelectric means upon which an optical image may be projected for producing an extended electron image, storage electrode means pervious to electron flow mounted to receive said electron image, means for projecting said electron image onto said storage means for developing a corresponding electrostatic charge image on the latter, means for exciting said photoelectric means to cause the latter to emit a beam of electrons of substantially uniform cross-section which beam is flooded over said storage means and which is modulated by said charge image upon passing through said storage means, and means operatively coupled to said photoelectric means for varying the potential of said beam whereby said charge image may be completely neutralized, said photoelectric means thereby having utility in developing an electron image, in producing a flood beam, and in neutralizing said charge image.

5. An arrangement of the character described comprising photoelectric means upon which an optical image may be projected for producing an extended electron image, storage electrode means pervious to electron flow mounted to receive said electron image, means for projecting said electron image onto said storage means for developing a corresponding electrostatic charge image on the latter, means for exciting said photoelectric means to cause the latter to emit a beam of electrons of substantially uniform cross-section which beam is flooded over said storage means and which is modulated by said charge image upon passing through said storage means, means operatively coupled to said photoelectric means for varying the potential of said beam whereby said charge image may be completely neutralized, said photoelectric means thereby having utility in developing an electron image, in producing a flood beam, and in neutralizing said charge image, and circuit means for applying potentials to said photoelectric means and said storage means of such magnitude and polarity that (*a*) during the development of said extended electron image said photoelectric means will be more negative than said storage means an amount sufficient to cause greater than unity secondary emission from said storage means, (*b*) during the generation of said flood beam said photoelectric means will be sufficiently positive with respect to said storage means whereby the electrons of said beam will not be collected by said charge image but instead will pass through said storage means, and (*c*) during neutralization of said charge image said photoelectric means is made sufficiently negative with respect to said charge image that the electrons issuing from the former will be collected by the latter to remove said charge image.

6. An arrangement of the character described comprising photoelectric means upon which an optical image may be projected for producing an extended electron image, storage electrode means pervious to electron flow mounted to receive said electron image, means for projecting said electron image onto said storage means for developing a corresponding electrostatic charge image on the latter, means for exciting said photoelectric means to cause the latter to emit a beam of electrons of substantially uniform cross-section which beam is flooded over said storage means and which is modulated by said charge image upon passing through said storage means, means operatively

coupled to said photoelectric means for varying the potential of said beam whereby said charge image may be completely neutralized, said photoelectric means thereby having utility in developing an electron image, in producing a flood beam, and in neutralizing said charge image, circuit means for applying potentials to said photoelectric means and said storage means of such magnitude and polarity that (*a*) during the development of said extended electron image said photoelectric means will be more negative than said storage means an amount sufficient to cause greater than unity secondary emission from said storage means, (*b*) during the generation of said flood beam said photoelectric means will be sufficiently positive with respect to said storage means whereby the electrons of said beam will not be collected by said charge image but instead will pass through said storage means, and (*c*) during neutralization of said charge image said photoelectric means is made sufficiently negative with respect to said charge image that the electrons issuing from the former will be collected by the latter to remove said charge image, and switch means operatively coupled to said circuit means for sequentially varying the potentials of said photoelectric means and said storage means in the order named.

7. An arrangement of the character described comprising a photoelectric cathode upon which an optical image may be projected for producing an extended electron image, a reticulate storage electrode made of insulating material mounted to receive said electron image, accelerating electrodes for projecting said electron image onto said storage electrode for developing a corresponding electrostatic charge image on the latter, a flash lamp for illuminating said cathode to cause the latter to emit a beam of electrons of substantially uniform and enlarged cross-section which beam is flooded over said storage electrode and which is modulated by said charge image upon passing through said storage electrode, a potential-distributing circuit operatively coupled to said storage electrode and to said cathode for applying potentials thereto of such magnitude and polarity that (*a*) during the development of said extended electron image said cathode will be more negative than said storage electrode an amount sufficient to cause greater than unity secondary emission from said storage electrode, (*b*) during the generation of said flood beam said cathode will be sufficiently positive with respect to said storage electrode that the electrons of said beam will not be collected by said charge image but instead will pass through said storage electrode, and (*c*) during a predetermined period of time following the generation of said flood beam said cathode is made sufficiently negative with respect to said charge image that the electrons issuing from the cathode will be collected by the charge image to neutralize the latter, and a switching circuit operatively coupled to said potential-distributing circuit for sequentially varying the potentials of said cathode and said storage electrode in the order named.

8. The arrangement of claim 7 including in combination scanning means for deriving a signal from the flood beam after modulation by said storage electrode, said scanning means being synchronized in operation with said switching circuit such that neutralization of said charge image will occur immediately following the completion of a scanning action which produces a complete picture signal.

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