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[54] **RADIATION PICKUP DEVICE INCORPORATING
 ELECTRON MULTIPLICATION**
 7 Claims, 3 Drawing Figs.

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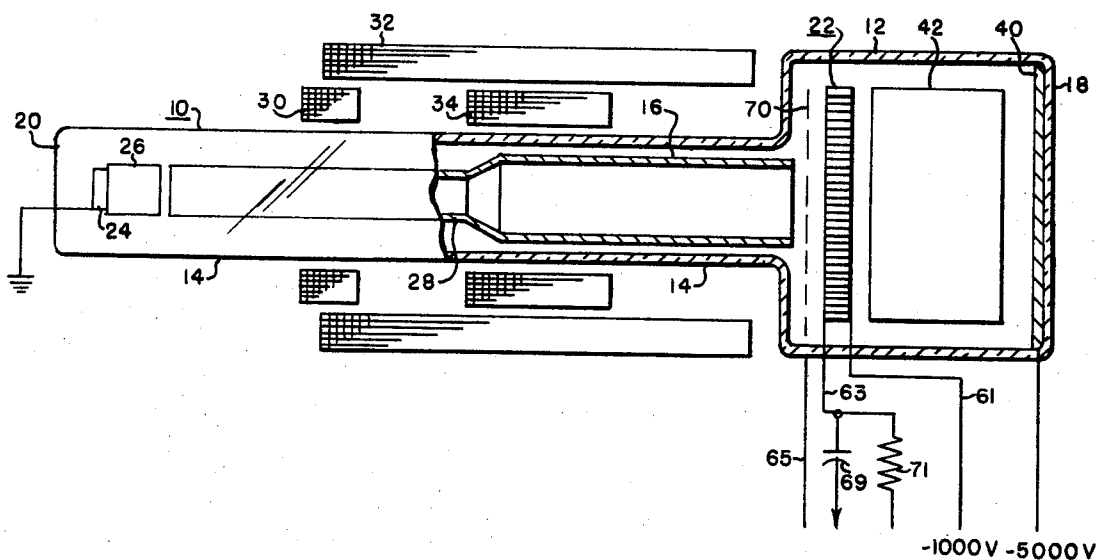
[50] Field of Search 313/103,
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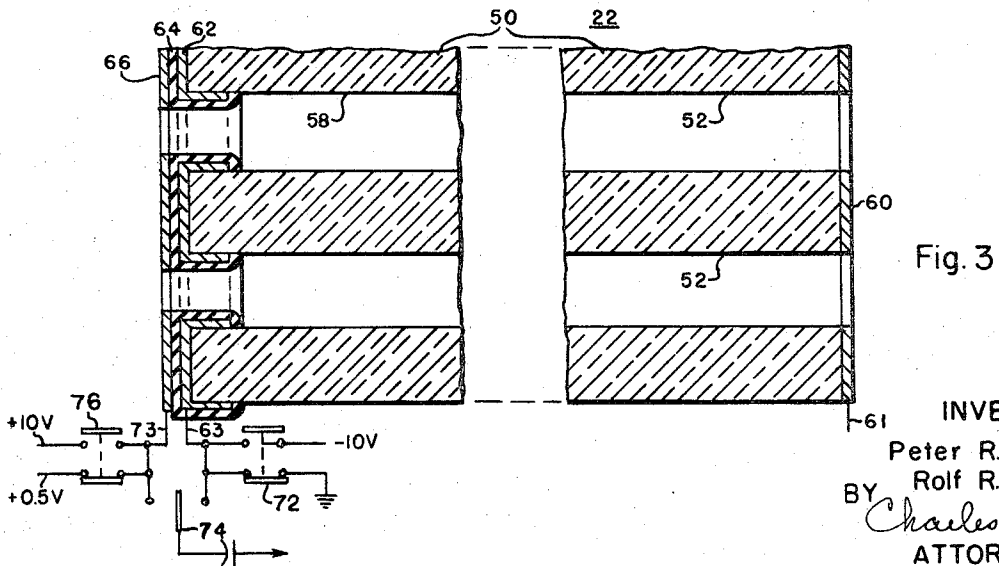
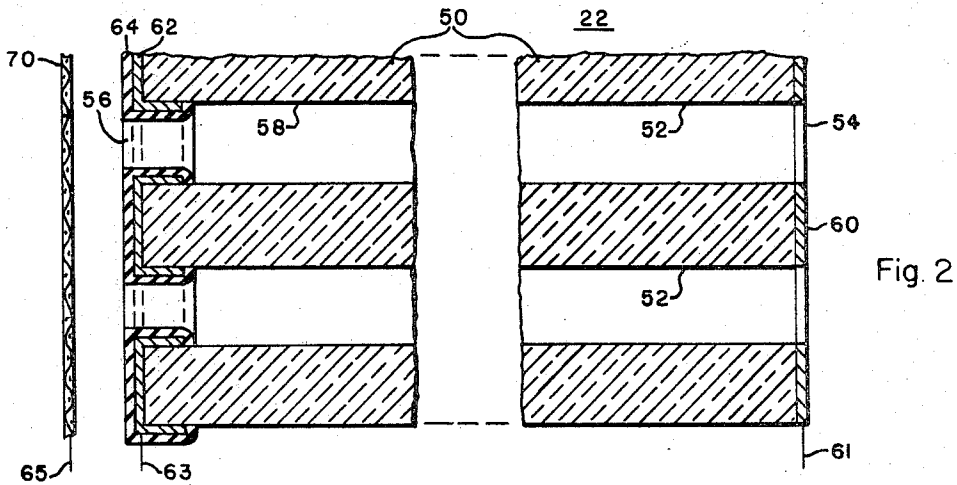
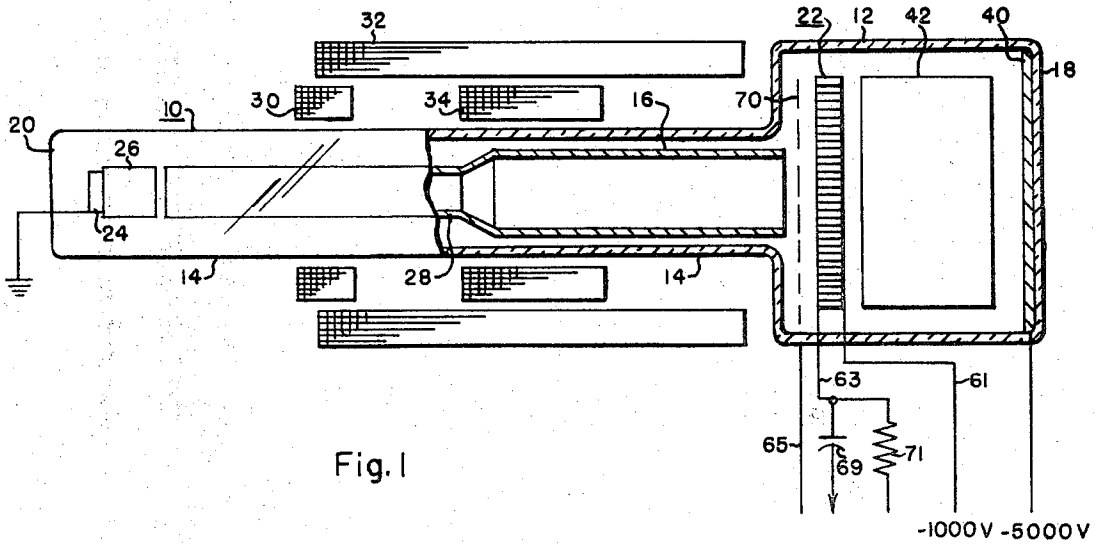
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ABSTRACT: An electronic image pickup device for detecting a radiation image and providing an electrical output corresponding to said radiation image. The pickup tube incorporates a photocathode responsive to input radiation for generating an electron image which is directed through a channel electron multiplying structure for multiplying the electron image and a storage member is incorporated into the output of said channel multiplier to provide a charge image which can be readout by electronic means. In addition, the structure disclosed provides a combination microchannel multiplier and storage electrode which permits either destructive or nondestructive readout of the stored image by the reading electron beam.





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RADIATION PICKUP DEVICE INCORPORATING ELECTRON MULTIPLICATION

BACKGROUND OF THE INVENTION

The channel multiplier is an electron multiplier which consists of a body or plate of insulating material having opposite major faces provided with electrically conductive layers and channels or openings in the insulating material and extending between these major faces. The interior surface of the channels is a secondary emissive material. The secondary emissive material may be provided in the form of a coating. Primary electrons entering the channel bombard this secondary emissive coating and thereby create a substantial larger number of secondary electrons emitting from the opposite face than incident primary electrons. The channel multipliers have found application in direct view image intensifier tubes and are particularly advantageous in high gain structures. It has also been suggested that such a microchannel plate amplifier could be used as a means of pretarget signal amplification within an intensifier camera tube. In this type of device, photoelectrons liberated by an optical image focused on a semitransparent photocathode are accelerated toward and focused upon the front surface of a microchannel plate. The photoelectrons entering the channels of the microchannel plate are multiplied in the usual manner and electrons issue from the exit surface of the microchannel and are again accelerated and refocused upon a storage target where they may be further multiplied and stored until readout by the scanning reading beam of a conventional camera tube reading section.

There are several disadvantages to this type of pickup tube. The most important of which is the loss of contrast and the limitation of resolution which accompanies a transfer of an electron image from a microchannel plate multiplier to the storage target. The focusing mechanism employed to convey the electron image may be either magnetic, electrostatic or proximity focusing. The latter is the means most commonly employed since the weight and space requirements of the two conventional focusing methods are usually prohibitive. However, for proper proximity focusing the microchannel plate must be placed very close to the storage target and very high electric fields must be used between them. This requirement creates a variety of mechanical and electrical problems which result in extremely complex tube designs.

It is accordingly a general object of this invention to eliminate the focusing stage between the microchannel plate and the target and also obtaining video information directly from the microchannel plate itself.

SUMMARY OF THE INVENTION

This invention is directed to an improved electron image pickup tube which incorporates pretarget multiplication in the form of a microchannel plate type multiplier and in which the storage target is formed on the microchannel plate itself.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a sectional view of an electron imaging device incorporating the teachings of this invention;

FIG. 2 is an enlarged sectional view of a portion of the microchannel amplifier storage plate incorporated in FIG. 1; and

FIG. 3 illustrates a modified microchannel multiplier storage electrode which may be incorporated in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring in detail to FIG. 1, an electron imaging pickup tube is illustrated which includes an evacuated envelope 10. The envelope 10 includes an enlarged tubular portion 12 which is referred to as the electron imaging section and a smaller tubular body portion 14 in which a reading gun 16 is

positioned and may be referred to as the reading section of the envelope. The tubular portions 12 and 14 are connected together and the portion 12 is provided with an input window 18 closing the opposite end through which the input radiations are directed. The opposite end of the tubular section 14 is closed off by a base portion 20 through which suitable leads (not shown) are provided for application of suitable potentials to the electrodes within the electron gun 16.

The electron gun 16 is of suitable design to provide a low velocity scanning electron beam which is directed onto a channel multiplier storage electrode 22. The electron gun 16 includes at least a cathode 24, a control grid 26 and an anode 28. An alignment coil 30, a focusing coil 32 and suitable deflection coils 34 are provided about the tubular portion 14 to provide suitable focusing and deflection of the electron beam generated by the electron gun 16. In this manner the electron beam may be scanned in a suitable raster over the output side of the electrode 22.

The input radiation is directed through the input window 18 onto a suitable photoemissive layer 40 which generates photoelectrons in response to excitation by the input radiations. The photoelectrons emitted by the photocathode 40 are directed through a suitable electron imaging system 42 onto the input side of the electrode 22.

Referring in detail to FIG. 2 which shows the details of the electrode 22, the electrode consists of a flat plate 50 of a suitable insulating material such as glass having channels 52 passing through the insulating plate from the entrance or input surface 54 to the exit or output surface 56. The plate 50 may have a thickness of about 0.05 inch and the diameter of the channels may be about 0.001 inch. The inner surface of the channels 52 are treated or provided with a suitable coating to provide a surface that emits secondary electrons of greater number than incident primary electrons. This secondary emissive surface is indicated as 58. A more complete description of a suitable structure for the member 50 and the secondary emissive surface is given in U.S. Pat. 3,341,730. The surface or coating 58 provides a coating of a resistivity of about 100 megohms to permit current flow. An electrically conductive coating 60 of a suitable material such as gold is deposited on the entrance surface 54 and is in electrical contact with the insulating coating 58. The electrode 60 on the entrance surface 54 is connected to the exterior of the envelope by lead-in 61 and is provided with a suitable potential of about 1000 volts negative with respect to ground. The exit surface of the electrode 50 is also provided with a conductive coating 62 which extends back into each of the channels 52 for a distance equal to about 2 channel diameters. The electrode 62 is also brought out to the exterior of the envelope by lead-in 63 and is supplied with a potential of about ground. In addition, a coating 64 of a suitable insulating material is provided on the exit surface 56. The coating 64 extends over the entire conductive coating 62. The coating 64 may be of a suitable insulating material and of thickness of about 1 micrometer. A control grid 70 is provided between the exit surface of the electrode 22 and the reading electron gun 16. The grid 70 is connected to the exterior of the envelope 10 by lead-in 65 to a potential of about 20 volts. The coatings 62 and 64 may be deposited by any suitable technique such as sputtering or evaporation.

In the operation of the pickup tube shown in FIGS. 1 and 2, radiation from a scene is focused onto the photosurface 40 which emits electrons which are in turn accelerated by a potential between the photocathode 40 and the electrode 22 of about 5,000 volts. The electron image emitted from the photocathode 40 is focused by suitable means 42 onto the electrode 22. These photoelectrons strike the walls of the channels 52 and cause emission of secondary electrons from the inner surfaces 58. The microchannel electrode structure is provided with a more positive potential on the electrode 62 with respect to the electrode 60 and because of the conductivity of the surface 58 within each of the channels 52 a small current referred to as a strip current flow from the electrode 60 to the electrode 62. In this manner, a uniform potential

gradient is established along the channel 52 which tends to accelerate the electrons within the channel 52 toward the exit surface 56. This field accelerates the secondary electrons emitted from the surface 58 and continuing multiplication in this manner is obtained within the channel as the secondary electrons continue to strike the surface 58 in their path along the channel 52 to create further secondary electrons and thus obtain an amplified electron image within the channels 52. The final impact of the secondary electrons moving down the channels 52 takes place on the insulating film surface 64. As before, secondary electrons are produced, but in this case providing that the secondary electrons arriving at the insulating film 64 have sufficient energy, a larger number of secondaries will be emitted than electrons incident on film 64. This will tend to charge the insulating film 64 in a positive direction in that electrons cannot flow through the insulating film 64 to neutralize the positive charge. The insulating film 64 should be of a material with high secondary emission coefficient such as potassium chloride, magnesium oxide, sodium bromide, sodium chloride. Under normal microchannel plate operating potentials, that is, 800 to 3000 volts, the secondary electrons will arrive at the insulating surfaces 64 with an energy above the first crossover potential. In this manner, a charge image is established on the insulating surface 64 proportional to the input radiation.

This charge image established on the insulating surface 64 may be read out by the use of the reading electron beam generated by the electron gun 16. This beam is focused on the exit surface 56 of the microchannel storage electrode 22 and impinges on the layer 64. The beam is scanned across the surface 56 to form a television raster with the gun cathode 24 operating at near ground potential. The electrons will land only on the positively charged areas on the storage surface 64 discharging it to ground. This discharge will generate a capacitive discharge current in a load resistor 71 which is connected to the lead-in 65 and electrode 62 to thus derive a video signal through a capacitor 69 representative of the charge image on the electrode 22.

In the structure illustrated in FIG. 2, the electrode 70 is necessary to control the maximum voltage excursion on the surface of the insulating film 64. FIG. 3 illustrates a modified structure which may be incorporated into FIG. 1 and eliminates the necessity of the control mesh 70. In addition, the structure shown in FIG. 3 permits the reading electron beam from the electron gun 16 to readout the charge image in a nondestructive manner so that the spatial charge pattern continues to generate the same video signal from one frame to another. In other words, the arrangement shown in FIG. 3 would provide the additional facility of multicopy readout. The arrangement in FIG. 3 also may be switched from the multicopy readout or nondestructive readout to destructive readout as described with respect to FIG. 2.

Referring in detail to FIG. 3, the structure shown is identical to that in FIG. 2 with the exception of an additional conductive coating 66 of a suitable material such as gold which is evaporated onto the insulating coating 64 but only on the portion of the insulating coating 64 on the surface 56 of the microchannel structure. Minimum penetration of the conductive layer 66 into the channel openings 52 is provided. A electrical lead-in 73 is brought out from the conductive coating 66. The lead-in 63 is connected to a suitable switch 72 for selective application of two voltages 10 volts negative or ground. A switch 74 is also provided for selective coupling the output to either lead-in 63 or 73. A switch 76 is also provided for selective application of suitable voltages, such as 10 volts positive and 0.5 volt negative to the lead-in 73.

The operation of the arrangement shown in FIG. 3 in multicopy readout may be described in three phases, namely, exposure, read and erasure. In the exposure operation, the reading beam may be cutoff. The front surface electrode 60 may be at a 1000 volts negative, the exit surface electrode 62 at ground potential and the electrode 66 at a 10 volts positive. The input radiation directed onto the photocathode 40 again

generates photoelectrons which are focused onto the electrode 22 and impinge on the surfaces within the microchannels 52. These photoelectrons will be multiplied in the usual manner and will create a positive charge pattern on the surface of the insulating coating 64 in a similar manner as that described with respect to FIG. 2. The potential distribution on the insulating film surface 64 will vary between ground and +10 depending on the current incident upon each incident upon each individual microchannel 52 and assuming the crossover potential for the insulator is greater than 10 volts.

In the read operation, the reading beam from the gun 16 is turned on with the cathode at approximately ground potential. The image section is cutoff or the lens is capped. The exit surface electrode 62 is switched to a 10 volts negative and the electrode 66 is switched to 0.5 volt positive. Due to capacitive coupling, the potential of the surface of the insulating layer 64 is decreased by about 9.5 volts and the positive potential pattern previously existing on the insulating film 64 now becomes a reversed potential pattern with potentials varying from ground to -10 volts. This negative potential pattern will modulate or regulate the amount of the scanning beam current landing on the electrode 66 with the switch 74 connected to the lead-in 73, a video signal is thus continuously generated in the electrode 66 without destroying or erasing the original charge pattern on the insulating coating 64.

In the erase operation, the exit surface electrode 62 is switched to ground potential, the signal electrode 66 is switched to +10 volts and the scanning beam is turned on. In this operation, the scanning beam lands on the positive charge pattern on the insulating surface 64 so as to charge the insulating surface to substantially ground potential. If the switch 74 is moved to lead-in 63, the video signal is now taken from the exit surface electrode 62, and destructive readout is obtained and the electrode 66 now acts as simply a control electrode.

It is obvious from the above description that the electrical and mechanical problems associated with the camera tube prior art design is considerably simplified by the above structures. The resulting structure also provides improved contrast transfer and improved resolution. Further, the facility of multicopy readout as provided in the device shown in FIG. 3 provides a very important new property in microchannel electron discharge devices and considerably broadens the field of potential application of this device.

We claim:

1. An electron imaging device comprising a channel electron multiplier responsive to input radiations for generating and amplifying electrons along individual channels within said electron multiplier, said channel multiplier including an input surface onto which input radiations are directed and an output surface from which an output signal corresponding to said input radiations as amplified by said channel multiplier is derived and means for directing a reading electron beam over said output surface to derive a signal representative of said input radiations amplified by said channel multiplier.

2. An electron image device comprising a channel electron multiplier responsive to input radiations for generating and amplifying electrons along individual individual channels within said electron multiplier, said channel multiplier including an input surface onto which said input radiations are directed and an output surface from which an output signal is derived and means for scanning a reading electron beam over said output surface to derive a signal representative of said input radiations amplified by said channel multiplier, said output surface of said channel multiplier including a first conductive coating provided over the output surface and extending into each of said channels for a minor distance and a coating of insulating material provided on said first electrically conductive coating on the output surface and extending into said channels so as to cover said first conductive coating therein.

3. The device set forth in claim 2 in which a second electrical conductive coating is provided over a portion of the surface of said insulating coating.

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4. The device set forth in claim 2 in which electrons directed along each of said channels by a potential gradient along said channels accelerates said electrons and bombard said insulating coating projecting into said channel multipliers and thereby establish a charge image on the surface of said insulating coating which may be read out by means of said reading electron beam.

5. The device set forth in claim 3 in which the electrons generated within said channel multipliers are accelerated into bombardment with said insulating coating and thereby establishing a charge image on the insulating coating projecting into each of said channel multipliers, means for establishing suitable potentials on said first and second conductive coatings and said insulating coating such that the scanning electron beam will be modulated by the charge on said insulating coating and collected by said second conductive coating to

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thereby derive an electrical signal without destroying the charge image on said insulating coating.

6. The device set forth in claim 3 in which means is provided for operating said first conductive coating and said second conductive coating and said insulating coating at suitable potentials so as to permit said reading electron beam to impinge on said insulating coating in an amount corresponding to the charge image thereon and means for deriving a signal from said first conductive coating in which said charge image is destructively read out therefrom.

7. The device set forth in claim 1 in which means is provided for converting said input radiation into electrons which are in turn accelerated into incidence with the channels within said channel multiplier.

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