

[54] **IMAGE INTENSIFIER TUBE EMPLOYING A MICROCHANNEL ELECTRON MULTIPLIER**[75] Inventor: **Richard S. Enck, Jr.**, Mountain View, Calif.[73] Assignee: **Varian Associates**, Palo Alto, Calif.[22] Filed: **Oct. 18, 1971**[21] Appl. No.: **189,864**[52] U.S. Cl. **315/12, 315/16**[51] Int. Cl. **H01j 29/41**[58] Field of Search **315/12, 16; 250/213 VT**[56] **References Cited****UNITED STATES PATENTS**

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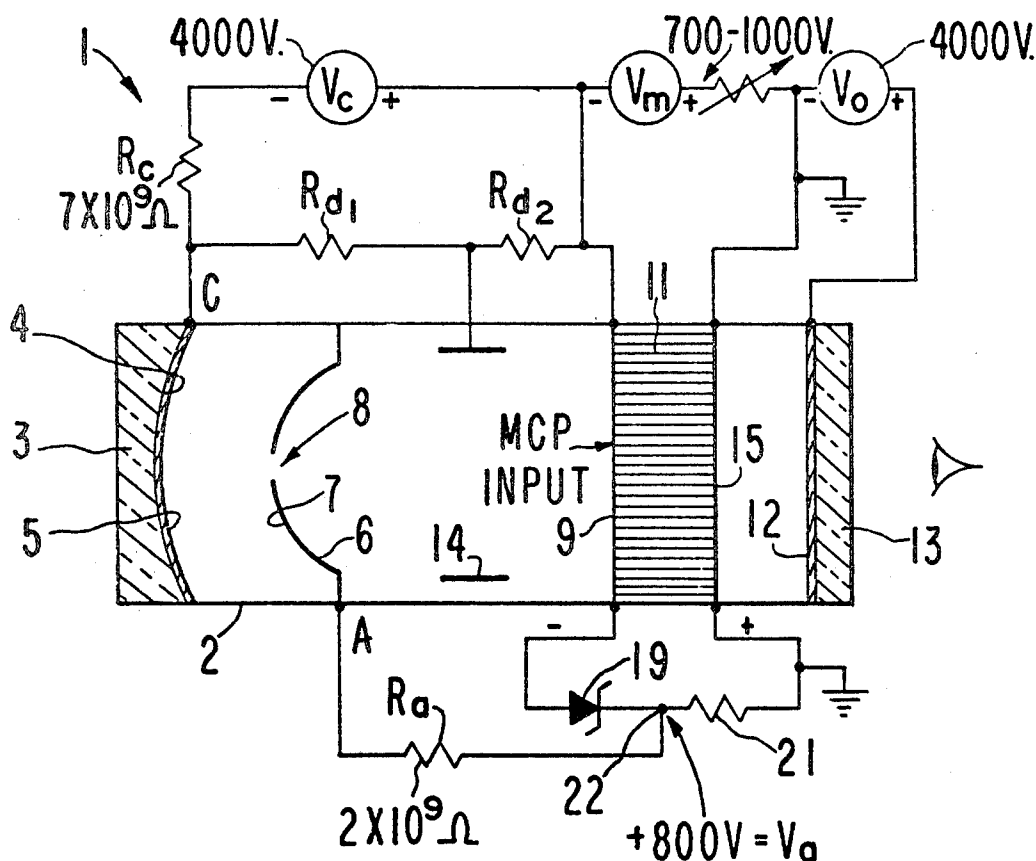
Primary Examiner—Carl D. Quarforth

Assistant Examiner—P. A. Nelson

Attorney, Agent, or Firm—Stanley Z. Cole; Harry E. Aine; Robert K. Stoddard

[57] **ABSTRACT**

In an image intensifier tube, photon images received by a photocathode are converted into electron images which are accelerated by an accelerating anode and focused upon the input face of a microchannel electron multiplier. The multiplier multiplies the current of the electron images and the output electron images are directed onto the output fluorescent screen. The operating voltages for the photocathode, and anode are referenced to the potential applied to the electron multiplier such that variations in the potential applied across or to the electron multiplier do not produce changes in magnification. The anode is biased positive with respect to the microchannel plate to form an ion trap to inhibit flow of ions from the electron multiplier to the photocathode, thereby avoiding bright spots in the output image. Voltage divider resistors are provided in the anode bias and photocathode bias circuits for dropping the anode potential generally in proportion to the drop in the photocathode potential experienced at high input light levels to prevent cut off of the image.

6 Claims, 3 Drawing Figures

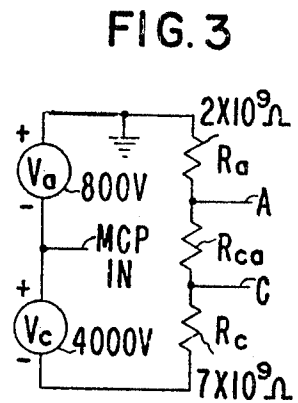
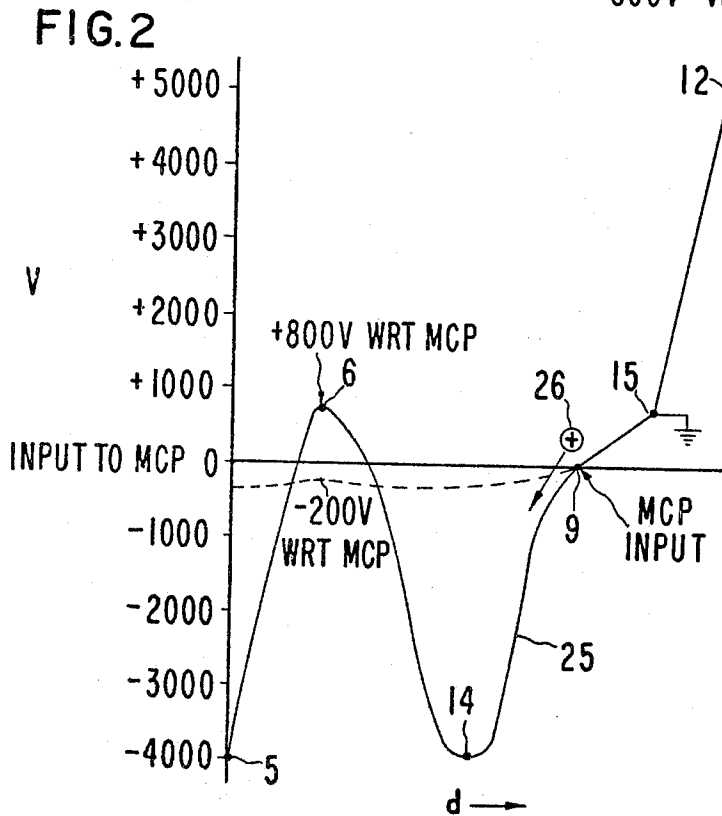
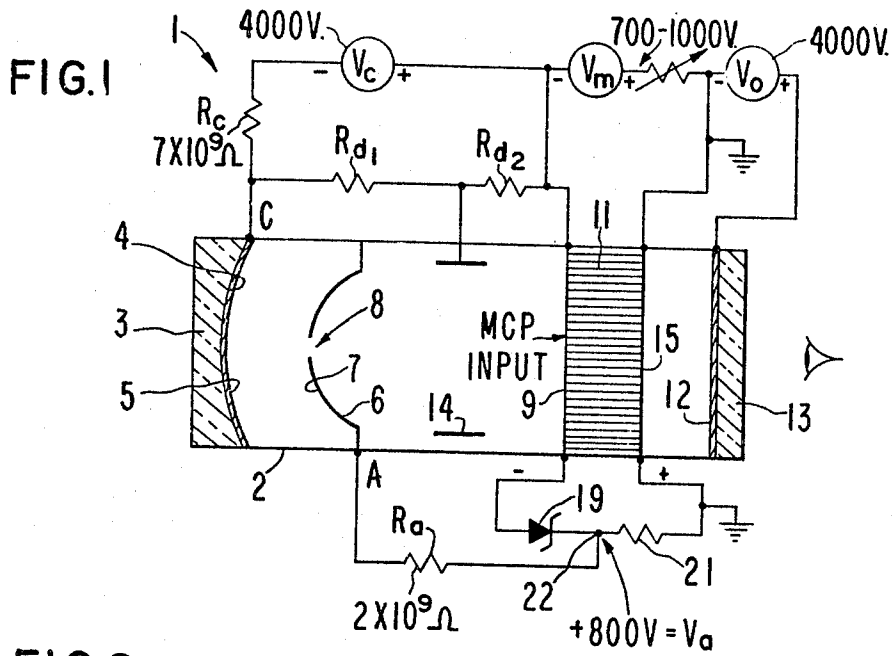


IMAGE INTENSIFIER TUBE EMPLOYING A MICROCHANNEL ELECTRON MULTIPLIER

GOVERNMENT CONTRACT

The invention herein described was made in the course of or under a contract with the department of defense.

DESCRIPTION OF THE PRIOR ART

Heretofore, it has been proposed to build a light image intensifier tube employing a microchannel electron multiplier to provide increased gain for the image intensifier tube. More particularly, the tube comprised a photocathode disposed at the input end of the tube for receiving a photon image and for converting same into an electron image which was emitted into the tube. A cathode luminescent (fluorescent) screen was provided at the output end of the tube to receive the electron image and to convert same into a light or photon image for viewing or use. An anode was disposed adjacent the photocathode for accelerating the electron images and for focusing the accelerated electron images upon the input face of a microchannel electron multiplier plate. The electron multiplier plate multiplied the electron current of the electron images and the output electron images of the multiplier were directed onto the output fluorescent screen. A distortion corrector electrode was interposed between the anode and the microchannel electron multiplier for correcting pin cushion type distortion in the electron image as focused on the microchannel electron multiplier. The potentials supplied to the photocathode, anode, and distortion corrector electrode were all referenced to the potential of the microchannel electron multiplier such that variations in the potential applied across the microchannel multiplier did not result in variations in the electron optics causing unwanted changes in the magnification of the tube.

The problem with this prior art image intensifier tube was that positive ions produced near the output end of the microchannel electron multiplier, due to electron-residual gas collisions, could flow back to the photocathode through the anode to produce localized secondary electron emission from the photocathode which contributed to the electron image as a spot of increased electron density and as focused upon the output screen manifested itself as a spurious bright spot in the output image. Therefore, it is desired to provide means for preventing the flow of positive ions, at low input light levels, from the multichannel electron multiplier to the photocathode.

SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of an improved image intensifier tube employing a microchannel electron multiplier.

In one feature of the present invention, a positive bias potential is applied, at low input light levels, to the anode relative to the potential applied to the microchannel multiplier plate such that positive ions created in the microchannel multiplier plate cannot flow to the photocathode through the anode, whereby bright spots are eliminated in the output image of the intensifier tube.

In another feature of the present invention, the potential supplied to the photocathode and anode are referenced to the potential applied to the microchannel

electron multiplier plate and voltage divider resistors are provided between the photocathode and the microchannel multiplier and between the anode and the microchannel multiplier. These resistors are proportioned such that as the anode intercepts substantial electron current drawn from the photocathode at high input light levels, the potentials are dropped across said voltage dividing resistors in such a manner that as the negative photocathode bias potential is reduced, the positive potential applied to the anode is reduced to a negative value relative to the microchannel plate multiplier such that the electron image current to the microchannel multiplier is not cut off at high input light levels.

Other features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic longitudinal sectional view, partly in block diagram form, of an image intensifier tube incorporating features of the present invention,

FIG. 2 is a plot of voltage V vs. longitudinal distance along the axis of the tube of FIG. 1 depicting the potential profile of the tube and how it varies with changing input light intensity, and

FIG. 3 is a simplified schematic circuit diagram for the anode and the cathode bias circuits of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there is shown an image intensifier tube 1 incorporating features of the present invention. The tube 1 includes an evacuated tubular envelope 2, as of glass or ceramic, closed at its input end via an optically transparent electrode, not shown, deposited upon the curved face 4. A photocathode 5 is deposited over the transparent electrode. An anode electrode 6 is disposed adjacent the photocathode 5 and includes a spherically convex face 7 facing the photocathode 5 with a small central aperture 8 disposed on the axial center line of the tube 2.

The photon image to be intensified passes through the transparent input plate 3 and transparent electrode to the photocathode 5 wherein the photons are absorbed and converted into an electron image emitted from the photocathode 5 into the evacuated tube 2. The emitted electron image is accelerated and focused through the central aperture 8 of the anode 6 onto the input face 9 of a microchannel electron multiplier plate 11 for multiplying the electron current of the electron image. The electron output image of the microchannel electron multiplier 11 is accelerated and directed through an electron permeable metallic film, not shown, deposited overlaying an output fluorescent screen 12 of a cathode luminescent material which in turn is deposited upon the internal face of an optically transparent end plate 13, as of glass, sealed in a gas tight manner across the output end of the envelope 2.

A hollow cylindrical distortion corrector electrode 14 is interposed, along the beam path, between the anode 6 and the input face 9 to the microchannel electron multiplier plate 11 for correcting the electron image to remove undesired "pin cushion" type distortion.

The multiplier plate 11 includes a pair of electrodes disposed on opposite faces 9 and 15 of the multiplier

plate 11. A source of potential V_m , as of 700 to 1,000 volts, is applied across the electrodes 9 and 15 of the multiplier 11 for variably adjusting the gain of the multiplier plate 11. The output electrode of the multiplier 15 is grounded and the potentials applied to the distortion corrector electrode 14, anode 6, and photocathode 5 are all referenced to the potential applied to the input face 9 of the multichannel electron multiplier 11. More particularly, a source of cathode potential V_c , as of -4,000 volts, is applied between input face 9 and the photocathode 5 via the intermediary of a cathode bias resistor R_c , as of $7 \times 10^9 \Omega$.

A negative potential is applied to the distortion correction electrode 14 as derived from the cathode potential at point C via the intermediary of a pair of voltage divider resistors R_{d1} and R_{d2} to provide approximately 0.9 of the cathode potential to the distortion corrector electrode 14.

The anode 6 is supplied with bias potential relative to the input electrode 9 of the microchannel plate 11 via the intermediary of a low reverse leakage, as of $0.1 \mu A$, Zener diode 19 and Zener biasing resistor 21, as of $10^9 \Omega$, connected across the microchannel plate 11 between electrodes 9 and 15. The Zener diode 19 is selected to provide a regulated voltage thereacross, as of 800 volts, which is derived from node 22 and fed via anode bias resistor R_a , as of $2 \times 10^9 \Omega$, to the anode 6. A final accelerating potential V_0 , as of 4,000 volts, is applied to the output screen 12 relative to the output face 15 of the microchannel plate 11.

Referring now to FIG. 2 there is shown, by solid line 25, the low input light level potential profile for the image intensifier tube 1. From profile curve 25 it is seen that the anode 6 is biased approximately 800 volts positive with respect to the input face 9 of the microchannel plate 11. This positive potential applied to the anode 6 relative to the microchannel plate input face 9 prevents positive ions, as indicated by 26, which are generated near the output of the microchannel plate at potential energies of approximately one-half to two-thirds of the microchannel plate voltage V_m (800 volts), from flowing back along the path of the electron images through the anode opening 8 to the photocathode 5. The positive ions are thus trapped between the anode opening 8 and the input face 9 of the microchannel plate 11. Thus, in this manner, bright spots are eliminated in the output light image obtained from the fluorescent screen 12. The positive anode bias V_a applied to the anode 6 and as derived across Zener diode 19 should preferably have a potential greater than one-half the potential applied across the microchannel electron multiplier plate 11. By use of a regulated anode bias voltage V_a referenced to the input voltage of the microchannel plate 11, changes in the microchannel plate voltage V_m above that of its regulated voltage V_a do not produce variation in the magnification of its tube.

In the low input light intensity operating regime of the image intensifier tube 1, a negligible amount of the electron image current is intercepted by the anode 6 and, thus, the effective photocathode to anode resistance R_{ca} is very high, i.e., much higher than the sum of the resistance of the cathode bias resistor R_c and the anode bias resistor R_a such that the entire anode bias potential V_a is applied to the anode 6.

However, in the high input light intensity regime, a substantial amount of electron image current emitted

from the photocathode 5 is intercepted on the anode 6 such that the effective resistance R_{ca} of the beam between the photocathode 5 and the anode 6 is small compared to the resistance of the bias resistors R_c and R_a . In this regime, bias resistors R_a and R_c form a voltage divider network, as shown in FIG. 3, for dividing the potentials V_a and V_c such that the negative cathode potential is decreased from -4,000 volts to approximately -200 volts with respect to the input of the microchannel plate, and the anode potential is decreased from +800 volts to approximately -200 volts with respect to the input of the microchannel plate. The small but finite resistance R_{ca} between the cathode 5 and the anode 6 causes the anode always to be slightly more positive than the cathode potential. By reducing the anode potential to a potential slightly negative with respect to the microchannel input potential the electron image will not be cut off because the cathode potential will thus always be negative with respect to the microchannel input face 9.

The resistors R_a and R_c are proportioned such that the ratio R_a to R_c is equal to or preferably within 50% greater than the ratio of the source potentials V_a to V_c . In other words, $R_a/R_c \geq V_a/V_c$. Thus, in the high input light intensity regime, the ion trapping potential V_a applied to the anode is overcome by negative potential derived via the voltage divider network of resistors R_a and R_c and source V_c , thereby eliminating the ion trapping effect in the high current regime. However, in the high current regime, the electron image signal current is so high that the amount of noise current contributed by ions is negligible and therefore not troublesome.

The advantage to the image intensifier tube of FIG. 1 is that the magnification does not change for variations in the potential across the microchannel plate. Ion produced bright spots in the output photon image are automatically eliminated over the operating range of the tube from low input light intensity to high input light intensity. Also, the image is not cut off at high input light intensities and a separate power supply for deriving the ion trapping potential V_a is not required as this potential is derived from the microchannel voltage V_m via the Zener diode 19.

What is claimed is:

1. In an image intensifier tube, a photocathode means disposed to receive a photon image for emitting into the tube an electron image corresponding to the received photon image, microchannel electron multiplier means having an input face disposed to receive the emitted electron image for multiplying the electron current of said image, an anode electrode means disposed intermediate said photocathode means and said microchannel multiplier means along the path of flow of the electron image for accelerating the electron image and for focusing same upon said electron receiving the face of said microchannel electron multiplier means, and power supply means for biasing said anode electrode means at a potential positive with respect to the operating potential of said input face of said microchannel electron multiplier means to inhibit the flow of positive ions from said microchannel multiplier means to said photocathode means, said biasing means for biasing said anode means relative to said microchannel electron multiplier means include, a series connection of a voltage regulating means and a resistor to form a source of regulated anode bias potential connected in

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parallel with the potential applied across said micro-channel electron multiplier means, and means for applying the regulated anode bias potential derived across said voltage regulator means to said anode means.

2. The apparatus of claim 1 wherein said voltage reg- 5
ulating means includes a Zener diode.

3. The apparatus of claim 1 wherein said means for applying the voltage derived across said voltage regula-
tor means to said anode means includes, anode resistive means connected in series beteen said anode means 10
and said source of regulated anode bias potential.

4. The apparatus of claim 3 including, cathode bias means for biasing said photocathode means at a poten-
tial negative with respect to the potential of the input face of said microchannel electron multiplier means, 15
and cathode resistive means connected in series with said cathode bias means between said photocathode

means and said microchannel electron multiplier means.

5. The apparatus of claim 4 wherein said anode resis-
tive means and said cathode resistive means form a voltage divider when said anode intercepts substantial
electron image current emitted from said photocathode means, and said cathode resistive means being substan-
tially more resistive than said anopde resistive means.

6. The apparatus of claim 5 wherein the resistances
of said cathode resistive means and said anode resistive means are proportioned such that the ratio of the
anode resistance R_a to the cathode resistance R_c is ap-
proximately equal to or within 50% greater than the
ratio of the anode source potential V_a to the cathode
source potential V_c .

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