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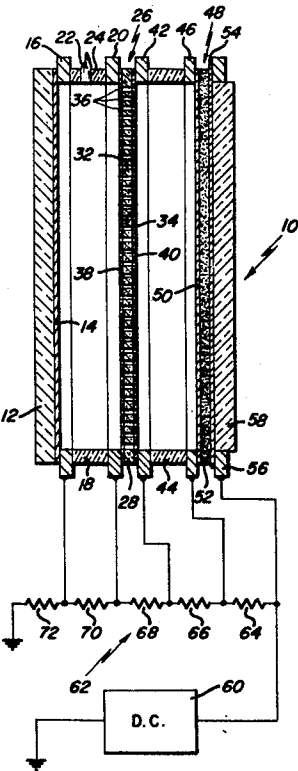
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[54] IMAGING SCREEN ASSEMBLY FOR IMAGE
INTENSIFIER TUBE
9 Claims, 2 Drawing Figs.

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315/10
[51] Int. Cl..... H01j 31/50
[50] Field of Search..... 250/213;
315/10, 11

ABSTRACT: An image intensifier tube having an imaging screen assembly provided with means for preventing particles of imaging screen material and flakes of reflective coating material from being drawn electrostatically away from the imaging screen assembly, which means include an electrode comprising a layer of light-transmissive material disposed between the imaging screen and the output face plate of the tube.



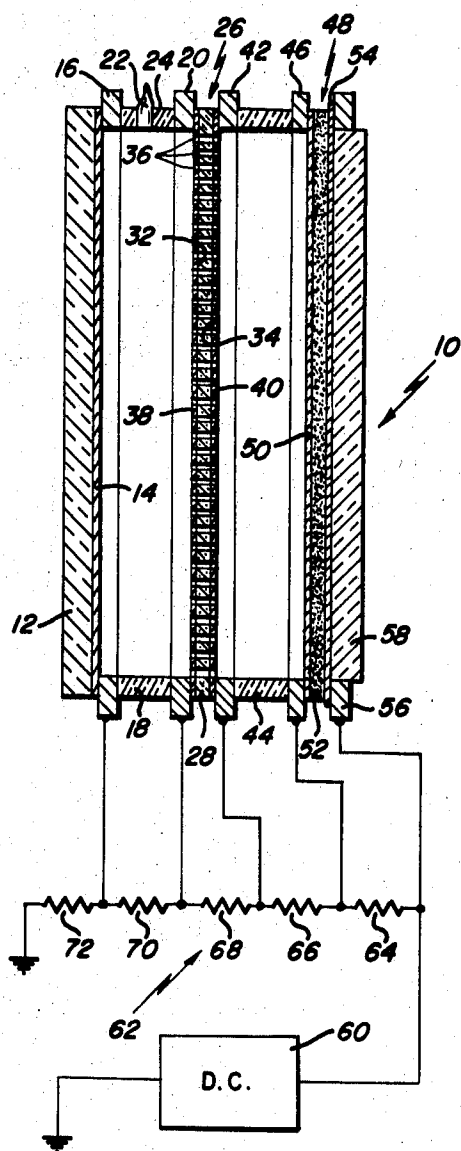


FIG. 1

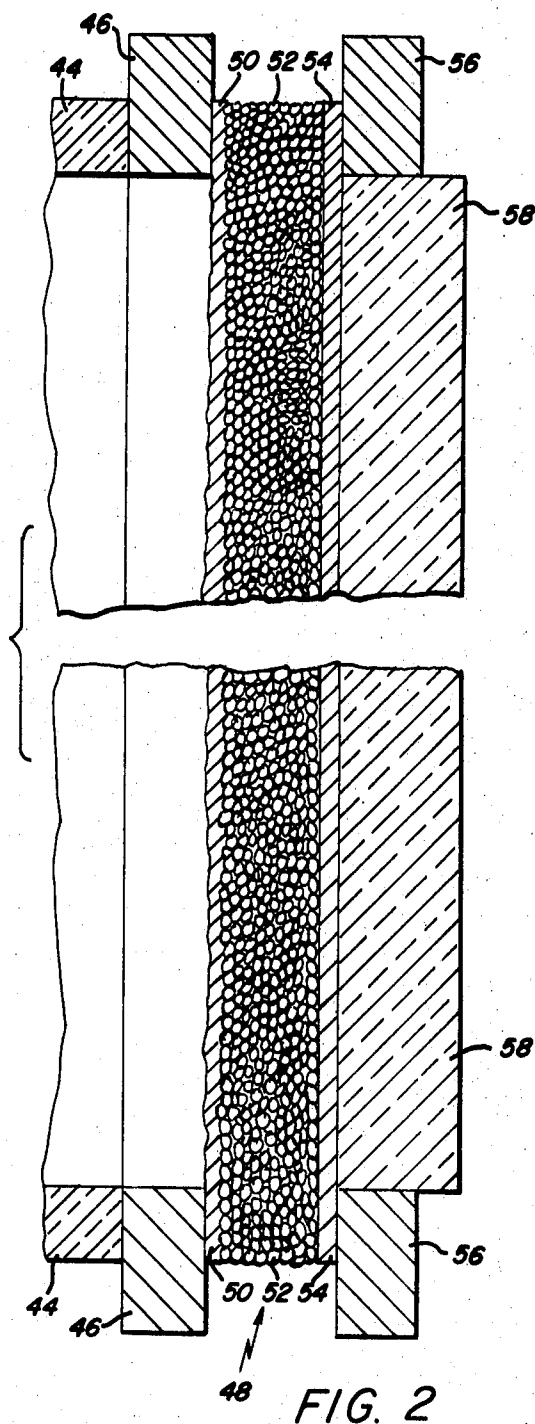


FIG. 2

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IMAGING SCREEN ASSEMBLY FOR IMAGE INTENSIFIER TUBE

BACKGROUND OF THE INVENTION

This invention is related generally to electron tubes and is concerned more particularly with an imaging screen assembly for light amplifying tubes.

Generally, an image intensifier tube comprises a tubular envelope having a photocathode adjacent one end thereof and an imaging screen adjacent the other end. The photocathode often is disposed as a coating of photoemissive material on the inner surface of a face plate at the input end of the tube. In operation, photons emanating from localized areas of an external object pass through the input face plate and impinge on corresponding localized areas of the adjacent photocathode. Since photoemissive material emits electrons from each discrete region thereof struck by photons, the photoemissive coating will convert the incident optical image into an electron image of the external object. This electron image is amplified within the tube and focused on the imaging screen at the opposite end of the tubular envelope. Usually the imaging screen comprises a layer of phosphor material which is disposed on the inner surface of an output face plate. When the electron image strikes the inner surface of the phosphor layer, photons of visible light will be emitted from localized regions of the phosphor material in proportion to the energy and density of the penetrating electrons. Thus, the imaging screen converts the amplified electron image into an intensified optical image of the external object. For viewing purposes, the output face plate usually is made of a material that is transparent to visible light, such as glass, for example. Also, the inner surface of the imaging screen generally is coated with a metal, such as aluminum, for example, which reflects visible light but is transparent to the amplified electron image. Thus, the reflective coating enhances the final optical image and shields the photocathode from the visible light produced by the phosphor layer.

Recently developed image intensifier tubes achieve a bright optical image in a single stage of amplification by disposing a microchannel plate between the photocathode and the imaging screen. A microchannel plate comprises a glass disc having a plurality of closely spaced holes with respective opposing apertures disposed in the planar surfaces of the disc. Electrons in the image emitted by the photocathode enter respective holes in the disc and collide with the respective walls thereof. Each collision produces a multiplicity of secondary electrons which, in turn, also collide with the walls of the associated holes. This process is repeated until each electron emitted by the photocathode is multiplied many thousands of times. Thus, the microchannel plate amplifies the electron image emitted by the photocathode by increasing the electron density of the image.

The recently developed image intensifier tubes are often called "wafer tubes" because the elements of the tube are disposed extremely close to one another and result in a very compact tube structure. This close spacing of the tube elements permits the use of proximity focusing when the electron image is travelling from the photocathode to the microchannel plate and from the microchannel plate to the imaging screen. Thus, when the electron image is emitted from the internal surface of the photocathode, there is a tendency for the image to spread laterally due to the initial lateral velocity of the electrons in the image. However, the electron image is maintained in focus and accelerated toward the microchannel plate by an electrostatic field which is established between the photocathode and the microchannel plate. Consequently, the electron image arrives at the adjacent planar surface of the microchannel plate before appreciable lateral spreading can take place. The electrons are drawn through the holes of the microchannel plate by a second electrostatic field which is established between the planar surfaces of the plate. When the

electron image emerges from the opposite surface of the microchannel plate, the electron density of the image has been greatly increased by secondary emission from the walls of the holes in the plate. As a result, there is a greater lateral velocity of the electrons in the image and, therefore, a greater tendency for the amplified image to spread laterally. Consequently, a third electrostatic field which is established between the microchannel plate and the imaging screen assembly generally is stronger than the electrostatic field established between the photocathode and the microchannel plate in order to maintain the electron image in focus. As the electrons in the amplified image are drawn toward the imaging screen assembly by this stronger electrostatic field, they are accelerated to progressively higher velocities and, consequently, to higher levels of kinetic energy. However, each electron in the image must attain the minimum energy level required to pass the electron through the reflective coating before it can impinge on the imaging screen. Furthermore, the kinetic energy of each electron must exceed a critical value in order to cause the emission of a photon from the adjacent phosphor layer. Any excess kinetic energy possessed by the respective electrons results in additional photons of visible light being emitted by the phosphor layer due to the excess energy being absorbed by the atoms of the phosphor material. Therefore, the higher the kinetic energy levels of the respective electrons in the amplified image, the brighter the optical image produced by the layer of phosphor material. Thus, the third electrostatic field provides another means of intensifying the final optical image, namely by increasing the kinetic energy of the respective electrons in the amplified image. Ideally, a very high value electrostatic field should be established between the microchannel plate and the imaging screen assembly for maintaining the amplified electron image in focus and for accelerating the respective electrons in the image to very high kinetic energy levels. However, it has been found that even an electrostatic field of the minimum required value is sufficiently strong to draw flakes of the reflective metal coating away from the imaging screen and toward the microchannel plate. Particles of the phosphor material, thus exposed, also are drawn in the same direction. The resulting arcing and flashing that occurs within the tube eventually causes catastrophic failure of the tube. Thus, the recently developed image intensifier tubes require a means for preventing flakes of the reflective metal coating and particles of imaging screen material from being drawn away from the imaging screen assembly when a high value electrostatic field is established between the microchannel plate and the imaging screen assembly.

SUMMARY OF THE INVENTION

Accordingly, this invention comprises an image intensifier tube having an imaging screen assembly provided with means for offsetting the electrostatic pull exerted on the reflective coating thereof when a strong electrostatic field is established between the reflective coating and another closely positioned element of the tube, such as an adjacent metallized surface of a microchannel plate, for example. The aforesaid means includes a conductive film of light transmissive material which is disposed on the inner surface of the output face plate of the tube. A dielectric layer of imaging screen material is superimposed on the inner surface of the light transmissive material and a conductive coating of light reflecting material is disposed on the inner surface of the imaging screen material. The conductive film of light transmissive material and the conductive coating of light reflecting material are connected to respective terminals of the tube for the purpose of applying a voltage potential therebetween which establishes an electrostatic field across the intervening dielectric layer of imaging screen material. Another closely positioned element of the tube such as a microchannel plate, has an adjacent metallized surface which also is connected to a terminal of the tube for the purpose of applying a voltage potential therebetween

which establishes an electrostatic field between the reflective coating of the imaging screen assembly and the adjacent surface of the closely positioned electrode. In the preferred embodiment, a large voltage potential is applied between the reflective coating of the imaging screen assembly and the adjacent surface of the microchannel plate for the purpose of establishing the strong electrostatic field therebetween that maintains an electron image in focus and accelerates it toward the screen. However, since this strong electrostatic field also exerts a pulling force in each incremental area of the reflective coating which force tends to pull flakes of the reflective material away from the adhering surface of the imaging screen, a relatively small voltage potential is applied between the reflective coating and the light transmissive film of the imaging screen assembly to establish an electrostatic field therebetween. This latter field exerts a force on the reflective coating which force is sufficient to counteract the pulling force exerted on the reflective coating by the strong electrostatic field established between the reflective coating and the adjacent surface of the microchannel plate.

BRIEF DESCRIPTION OF THE DRAWING

For a better understanding of this invention, reference is made to the drawing wherein:

FIG. 1 is an exaggerated, side elevational view, in axial section, of a tube embodying the invention; and

FIG. 2 is an enlarged sectional view of the imaging screen assembly portion of the tube shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to the drawing wherein like characters of reference designate like parts, there is shown, greatly exaggerated, in FIG. 1 an electron tube of the image intensifier type comprising a tubular envelope 10 closed at one end by a disc 12, which is commonly referred to as the input face plate of the tube. The input face plate 12 is made of a material that is transparent to the radiational wavelengths of interest, which may or may not be in the visible region of the spectrum. Disposed on the inner surface of face plate 12 is a photocathode 14 which comprises a thin film of photoemissive material, such as sodium potassium cesium antimonide, for example. The photoemissive material is coated on the inner surface of face plate 12 by conventional means, as by evaporation, for example. The photoemissive coating extends radially to the circular edge of face plate 12 and is hermetically attached, adjacent the periphery thereof, to one side of a ring 16 of metallic material, such as Kovar, for example. The ring 16 serves as an electrical terminal for the photocathode 14. A hollow cylinder 18 of dielectric material, such as ceramic, for example, is peripherally sealed at one end to the other side of ring 16 and is similarly sealed at the opposite end to one side of a ring 20 of metallic material, such as Kovar, for example. One end of an exhaust tubulation 22 is circumferentially sealed to the periphery of an aperture 24 in the wall of cylinder 18 and is sealed off at the other end when processing of the tube is completed.

Disposed between the opposing ends of tubular envelope 10 and in longitudinal alignment with photocathode 14 is a microchannel plate 26 which comprises a glass disc 28 having opposing planar surfaces 32 and 34 respectively. Plate 26 is provided with a plurality of closely spaced holes 36 which have opposing apertures disposed in the respective planar surfaces 32 and 34 of the disc 28. Planar surface 32 supports a metallized coating 38 which extends radially to the circular edge of disc 28 and is hermetically attached, adjacent the periphery thereof, to the side of ring 20 opposite the attached end of cylinder 18. The planar surface 34 supports a similar metallized coating 40 which extends radially to the circular edge of the microchannel plate 26 and is hermetically sealed, adjacent the periphery thereof, to one side of a ring 42 of metallic material such as Kovar, for example. Each of the respective metallized coatings 38 and 40 comprises a conduc-

tive film of a noble metal, such as gold, for example, which is disposed on the associated surface of disc 28 by a conventional process, as by deposition, for example. The ring 42 serves as an electrical terminal for the planar surface 34 of microchannel plate 26. A cylinder 44 of dielectric material, such as ceramic, for example, is peripherally sealed at one end to the side of ring 42 opposite the attached microchannel plate 24 and is similarly sealed at the other end to one side of a ring of metallic material, such as Kovar, for example.

As shown more clearly in FIG. 2, the opposite end of tubular envelope 10 is closed by a disc 58 which is commonly referred to as the output face plate of the tube. The face plate 58 usually is made of a material that is transparent to visible light, such as glass, for example. Circumferentially sealed to the outer perimeter of face plate 58 is a ring 56 of metallic material, such as Kovar, for example. A conductive coating 54 of light-transmissive material, such as tin oxide, for example, is disposed on the inner surface of face plate 58 by conventional means, as by evaporation, for example. The conductive coating 54 extends radially to electrically contact the adjacent annular surface of ring 56. Thus, ring 56 serves as an electrical terminal for the conductive coating 54. A luminescent layer 52 of phosphor material, such as zinc cadmium sulfide, for example, is disposed on the inner surface of conductive coating 54 by a conventional process, such as deposition, for example. The phosphor layer 52 forms the imaging screen of the tube and displays the final optical image which can be seen by an observer through the light-transmissive coating 54 and the light-transmissive material of face plate 58. The inner surface of image screen 52 supports a coating 50 of reflective metal, such as aluminum, for example, which coating is transparent to high velocity electrons. Reflective coating 50 extends radially to the annular surface of ring 46 and is hermetically sealed thereto. Thus, ring 46 serves as an electrical terminal for the reflective coating 50. The superimposed layers of reflective material 50, phosphor material 52 and conductive, light-transmissive material 54, form the imaging screen assembly 48 of the tube.

In operation, a high voltage, direct current source 60 is connected across a voltage divider 62 which is attached at the high voltage end to ring 56, thereby applying the maximum voltage, 10.05 KV for example, to the conductive coating 54 of light-transparent material. A comparatively slight voltage drop occurs across the resistor 64, 50 volts, for example, thereby applying approximately 10 KV to the reflective coating 50. A large voltage drop occurs across the resistor 66, 8,000 volts for example, thereby applying approximately 2000 volts to the planar surface 34 of microchannel plate 26. A smaller voltage drop occurs across resistor 68, 1000 volts for example, thereby applying 1000 volts to the planar surface 32 of microchannel plate 26. A still smaller voltage drop, 500 volts for example, occurs across the resistor 70 thereby applying 500 volts to the photocathode 14. The remaining 500 volts is dropped across the resistor 72.

When photons from localized areas of an external object pass through the input face plate 12 and impinge on the adjacent surface of photocathode 14, an electron image of the external object is emitted from the internal surface of photocathode 14. The 500 volts applied between photocathode 14 and the planar surface 32 of microchannel plate 26 establishes an electrostatic field therebetween which focuses the electron image and accelerates it toward the planar surface 32. The electron image enters the aligned holes 36 in microchannel plate 26 and increases in electron density due to the electrons colliding with the walls of the respective holes. The 1000 volts applied between the respective metallized coatings 38 and 40 on the opposing planar surfaces 32 and 34 of the microchannel plate 26 establishes an electrostatic field therebetween which draws the electrons of the image through the holes 36 of microchannel plate 26.

When the amplified electron image emerges from the apertures of holes 36 in planar surface 34, it is maintained in focus and accelerated toward the imaging screen assembly 48. The

8000 volts applied between the planar surface 34 of microchannel plate 26 and the reflective coating 50 of imaging screen assembly 48 establishes a strong electrostatic field therebetween. This strong electrostatic field is required because of the higher lateral velocity of the electrons in the amplified image and the necessity of accelerating the image toward the imaging screen before lateral spreading can occur. Also, the electron image must be accelerated to a sufficiently high kinetic energy level to pass through the reflective coating 50 and impinge on the adjacent phosphor layer 52. Furthermore, the kinetic energy levels of the impinging electrons must be above a critical value or the phosphor material will not emit photons of visible light. Any excess energy possessed by the respective electrons of the amplified image results in additional photons of visible light being emitted due to the atoms of phosphor material absorbing this excess energy.

It has been found that the electrostatic field established by the 8000 volts applied between the planar surface 34 of microchannel plate 26 and the reflective coating 50 of imaging screen assembly 48 is sufficiently strong to pull flakes of the reflective material away from the inner surface of the phosphor layer 52. Particles of the phosphor layer 52, thus, exposed, are also drawn away from the imaging screen assembly 48 and toward the microchannel plate 26. The resulting arcing and flashing that occurs within the tube eventually damages the tube permanently. However, in the imaging screen assembly of this invention, an electrode is provided on the side of the phosphor layer opposite the reflective coating 50. The 50 volts applied between the conductive coating or electrode 54 and the reflective coating 50 of imaging screen assembly 48 is sufficient to electrostatically balance the electrostatic force exerted on the reflective coating 50 by the 8000 volts applied between the reflective coating 50 and the adjacent surface of microchannel plate 26. The 50 volts applied between the reflective coating 50 and the light-transmissive electrode 54 can counteract the electrostatic force exerted by the strong field established between the microchannel plate and the reflective coating because of the close spacing between the reflective coating 50 and the conductive coating 54 and the adherent bond between the reflective coating 50 and the adjacent surface of phosphor layer 52.

Thus, there has been disclosed herein a novel image intensifier tube having an imaging screen assembly provided with means for counteracting the electrostatic pull exerted on the reflective coating of the imaging screen assembly when a strong electrostatic field is established between the reflective coating and the adjacent surface of the microchannel plate or other adjacent electrode. It should be noted that the electrostatic field established between the reflective coating 50 and the conductive coating 54 need not electrostatically balance the force exerted on the reflective coating by the electrostatic field established between the reflective coating and the adjacent surface of the microchannel plate. It is only necessary that the resultant force per unit area which tends to pull flakes of the reflective coating away from the adjacent phosphor layer be less than the adherent bond between the reflective coating and the adjacent phosphor material. Furthermore, it should be pointed out the polarity of the electrostatic field established between the conductive coating 54 and the reflective coating 50 may be in the same direction or in the opposite direction as compared to the electrostatic field established between the reflective coating 50 and the planar surface 34 of microchannel plate 26. The latter field must be an accelerating field but the former field can be either an accelerating or a decelerating field. In some cases, a decelerating field between the reflective coating 50 and the conductive coating 54 may be preferable.

From the foregoing, it will be apparent that all of the objectives of this invention have been achieved by the structures shown and described. It will be also apparent, however, that various changes may be made by those skilled in the art without departing from the spirit of the invention as expressed in the appended claims. It is to be understood, therefore, that

all matter shown and described is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. An image intensifier tube comprising:

- an evacuated envelope having opposing input and output face plates;
- a photocathode supported adjacent the inner surface of the input face plate;
- a luminescent layer disposed within the envelope adjacent the output face plate;
- a light reflecting layer of conductive material disposed on the inner surface of the luminescent layer;
- an electrode disposed between the photocathode and the light reflecting layer, and in predetermined spaced relationship therewith;

first means for establishing an electrostatic field between the electrode and the light reflecting layer whereby, at said predetermined spaced relationship, an electrostatic force acts on the light reflecting layer; and

second means for offsetting the electrostatic force acting on the light reflecting layer, said second means including a light-transmissive layer of conductive material disposed on the surface of the luminescent layer opposite the light reflecting layer, and third means for establishing an electrostatic field between the light reflecting layer and the light-transmissive layer.

2. An image intensifier tube as set forth in claim 1 wherein said electrostatic field between the light reflecting layer and the light-transmissive layer is in the same direction as the electrostatic field between the electrode and the light reflecting layer.

3. An image intensifier tube as set forth in claim 1 wherein said electrostatic field between the light reflecting layer and the light-transmissive layer is in the opposite direction as compared to the electrostatic field between the electrode and the light reflecting layer.

4. An image intensifier tube comprising:

- an evacuated envelope having opposing input and output face plates;
- a layer of photoemissive material disposed on the inner surface of the input face plate;
- a light-transmissive layer of conductive material disposed on the inner surface of the output face plate;
- a luminescent layer of dielectric material disposed on the inner surface of the light-transmissive layer;
- a light reflecting layer of conductive material adherently bonded to the inner surface of the luminescent layer;
- a microchannel plate disposed between the photoemissive layer and the light reflecting layer and having a conductive surface thereof disposed in opposing spaced relationship with the light reflecting layer;

first means for producing an electrostatic attractive force between the conductive surface of the microchannel plate and the light reflecting layer; and

second means for reducing the electrostatic effects of said attractive force on the light reflecting layer.

5. An image intensifier tube as set forth in claim 4 wherein said second means includes a voltage potential applied between the light reflecting layer and the light-transmissive layer.

6. An image intensifier tube as set forth in claim 5 wherein a higher positive voltage is applied to the light reflecting layer than to the conductive surface of the microchannel plate and a still higher positive voltage is applied to the light-transmissive layer than to the light reflecting layer.

7. An image intensifier tube comprising:

- a tubular envelope having an input face plate at one end and an output face plate at the opposite end;
- a photoemissive layer of conductive material disposed on the inner surface of the input face plate;
- a light-transmissive layer of conductive material disposed on the inner surface of the output face plate;
- a luminescent layer of dielectric material disposed on the inner surface of the light-transmissive layer;

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a light reflecting layer of conductive material disposed on the inner surface of the luminescent layer;

a microchannel plate disposed between the photoemissive layer and the light reflecting layer and having opposing conductive surfaces in predetermined spaced relationship therewith; and

means for applying voltage potentials to the layers of conductive material and to the opposing conductive surfaces of the microchannel plate.

8. An image intensifier tube as set forth in claim 7 wherein said means includes a second means for applying a higher positive voltage potential to the light reflecting layer than to

the conductive surfaces of the microchannel plate and a still higher positive voltage potential to the light-transmissive layer.

9. An image intensifier tube as set forth in claim 7 wherein said means includes a second means for applying a higher positive voltage potential to the light reflecting layer than to the conductive surfaces of the microchannel plate and a lower positive voltage potential to the light-transmissive layer than said higher positive voltage potential applied to the light reflecting layer.

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