

[54] **IMAGE INTENSIFIER USING
RADIATION SENSITIVE METALLIC
SCREEN AND ELECTRON
MULTIPLIER TUBES**
[72] Inventor: **Joseph Tinney**, Livermore, Calif.
[73] Assignee: **The Bendix Corporation**
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313/65-67, 95, 104, 105

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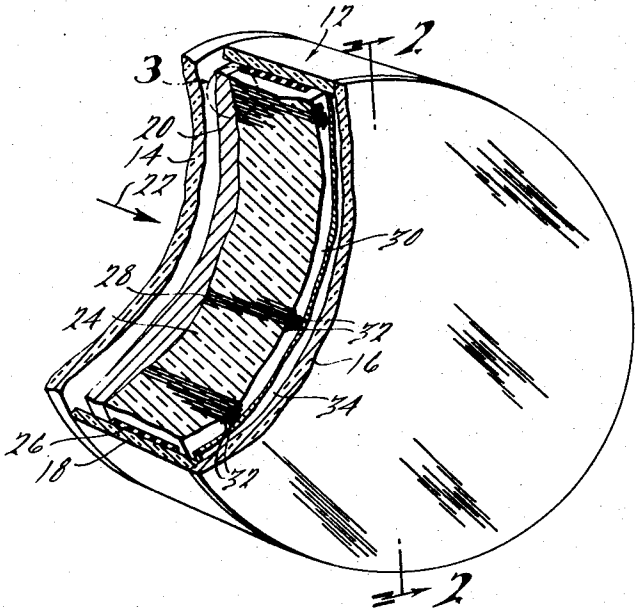
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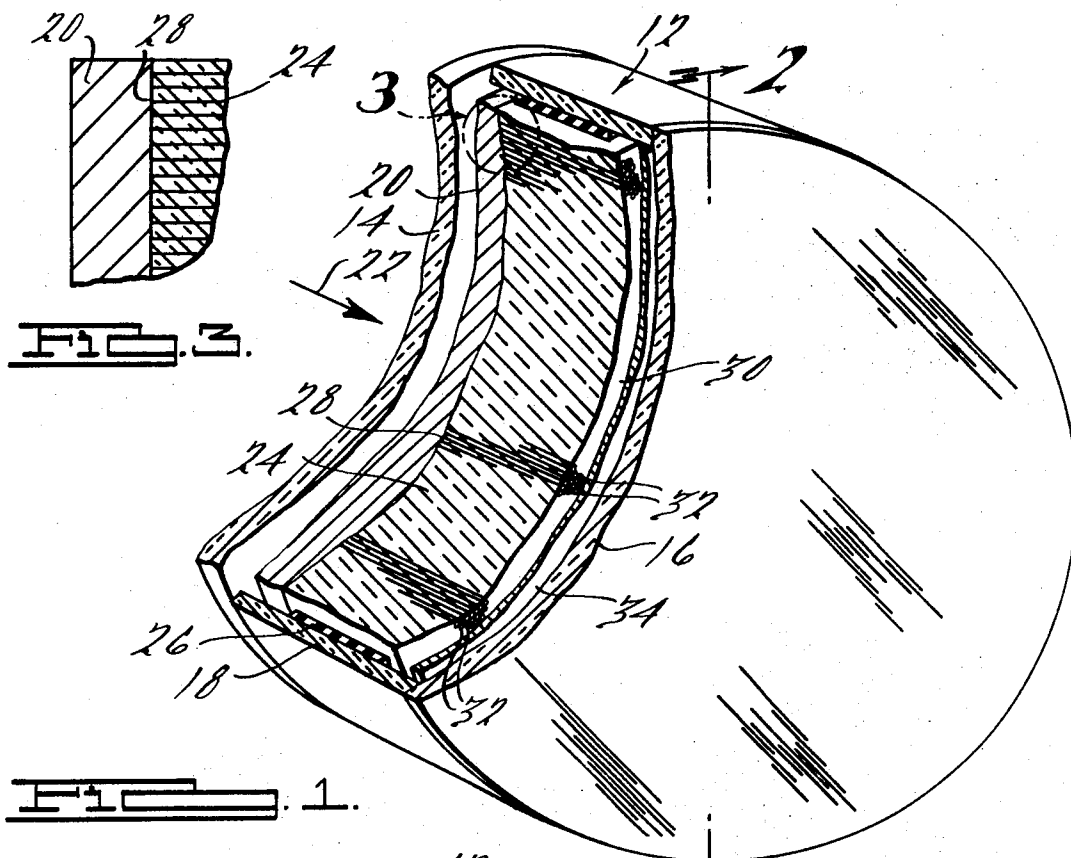
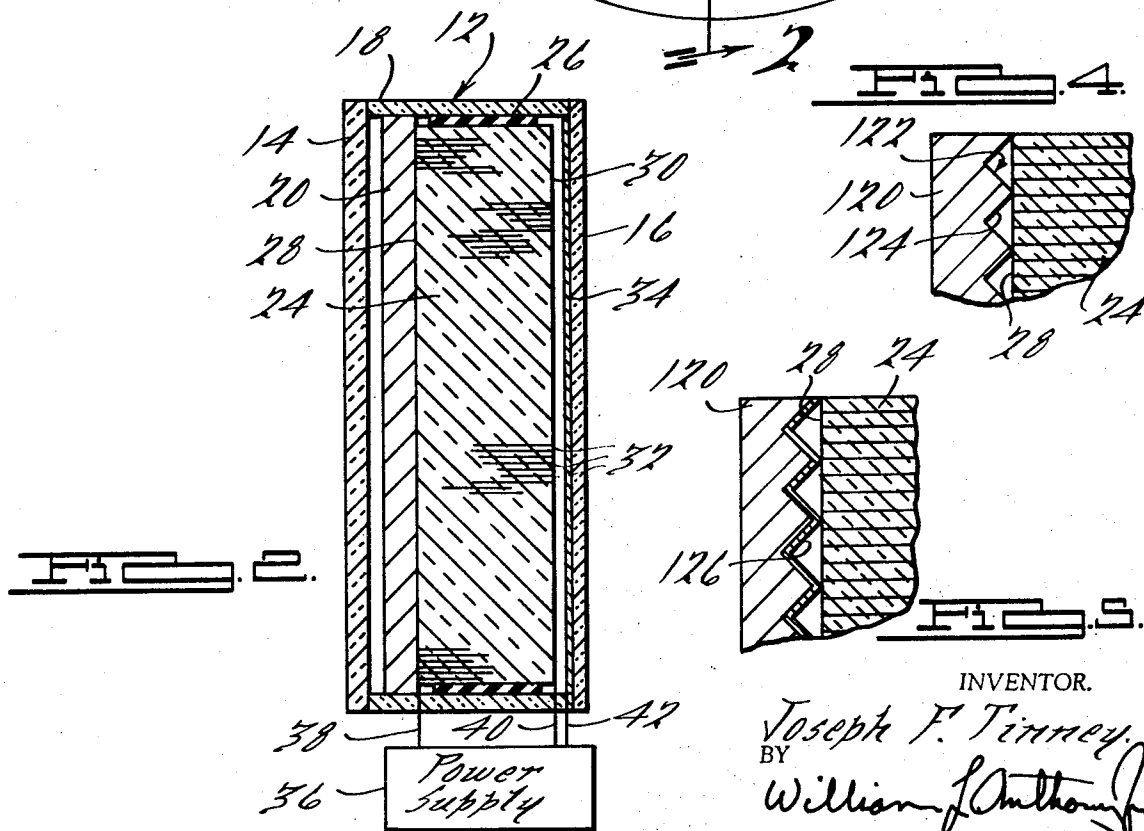
Primary Examiner—Walter Stolwein
Attorney—William L. Anthony, Jr. and Plante, Hartz,
Smith, & Thompson

[57] **ABSTRACT**

A radiation image intensifier having a metallic screen such as a lead screen to convert a radiation image into a corresponding electron image in combination with an electron multiplier array for amplifying the electron image.

12 Claims, 5 Drawing Figures





INVENTOR.

Joseph F. Timney
BY
William J. Anthony
ATTORNEY.

IMAGE INTENSIFIER USING RADIATION SENSITIVE METALLIC SCREEN AND ELECTRON MULTIPLIER TUBES

CROSS REFERENCE TO RELATED APPLICATIONS

Application of Joseph F. Tinney for "Radiographic Intensifying Screen", Ser. No. 759,361, assigned to the assignee of the present application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Radiation image intensifiers, and more particularly, x-ray intensifiers utilizing electron multiplier arrays.

2. Description of the Prior Art

It is known in the art to utilize the combination of a fluorescent screen for converting a radiation image into a corresponding light image, a photocathode for converting the light image into a corresponding electron image, an accelerating potential for increasing the energy level of the electron image to a predetermined value, and an electron multiplier array which is responsive to electron images at the above predetermined level for amplifying the electron image. For example, the Canadian Pat. to Dunn No. 600,151 discloses such a system. Although the prior art devices are satisfactory for most applications, they have been found to be unsuitable for use with low-contrast radiation images due to inherent effects of photocathodes, explained below, which tend to obscure low-contrast electron images.

It will be appreciated by those skilled in the art that photocathodes are necessarily operated at elevated temperatures. By virtue of the temperature of a photocathode, electrons are thermionically emitted which provide a base level of electron output from the photocathode even at zero input to the photocathode. It will be appreciated that this base level of electron emission will obscure electron images having a contrast level which is not significantly greater than the base level of the thermionically emitted electrons.

Photocathodes require an accelerating potential between the photocathode and an electron multiplier array input to bring the electrons emitted from the photocathode to the operating level of the electron multiplier array. It will be appreciated that even though photocathodes and electron multiplier arrays are operated in a high vacuum chamber, it is not possible to fully evacuate the chamber containing the photocathode and the electron multiplier array due to physical limitations of available vacuum producing equipment and materials. Accordingly, a small amount of residual gas will remain in the chamber containing the photocathode and the electron multiplier array. This residual gas is ionized by the accelerating potential between the photocathode and the electron multiplier array thereby producing ions which are drawn to the photocathode by the accelerating potential. The ions strike the photocathode with sufficient energy to secondarily emit electrons. The secondarily emitted electrons also tend to obscure low-contrast images. In this regard, it will be appreciated that the electron images provided by photocathodes in radiation image intensifiers have not as yet been amplified and consequently are quite often at low-contrast levels, and hence, most susceptible to the combined obscuring effects of thermionically and secondarily emitted electrons.

SUMMARY OF THE INVENTION

The present invention provides a radiation image intensifier wherein a photocathode is not utilized and accordingly the obscuring effects of thermionically and secondarily emitted electrons is not encountered. Particularly, the radiation image intensifier of this invention utilizes a metallic screen disposed adjacent to and in close proximity with an electron multiplier array to convert a radiation image into a corresponding electron image having a sufficient energy level to operate the electron multiplier array; a function accomplished in prior art image intensifiers by the combination of a fluorescent screen, a photocathode and an accelerating potential between the photocathode and an electron multiplier array. The metallic screen may comprise any metal having at least 13 electrons per atom, for example, lead, uranium, tantalum, tungsten, gold, silver, osmium or iridium. It has been found that the thickness and density of a metallic screen of this invention may be adjusted to provide electron images having energy levels within the operating range of an electron multiplier array, for example, electrons having 5 to 10 ev energy levels.

Accordingly, to this invention, there is a single step conversion from a radiation image into an electron image. It is important to note that prior art devices require a two step conversion, i.e. from a radiation image into light image, and in turn, from a light image to an electron image.

The metallic screen of this invention offers several important advantages, for example, it is not operated at elevated temperatures and hence does not yield thermionically emitted electrons. Furthermore, an accelerating potential is not required between the metallic screen of this invention and the input of an electron multiplier array. Accordingly ionization of the residual gas in the vacuum chamber does not occur between the metallic screen of this invention and an electron multiplier array, and consequently, ions are not formed which, in the prior art devices, caused obscuring secondary emission of electrons from the photocathode.

In view of the above summary, it will be appreciated that Applicant's invention not only provides a significant improvement in performance over prior art devices, particularly in the case of low-contrast radiation images, but also provides a greatly simplified and correspondingly less expensive apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectioned-perspective view of the radiation image intensifier embodying the present invention.

FIG. 2 is a longitudinal cross section, taken along the plane A—A, of FIG. 1.

FIG. 3 is an enlarged view of a portion of FIG. 2 showing a metallic screen according to this invention in combination with an electron multiplier array.

FIG. 4 is a view similar to FIG. 3 showing a modified metallic screen of this invention, characterized by having a grooved surface, in combination with an electron multiplier array.

FIG. 5 is a view similar to FIG. 3 showing still another modified metallic screen according to this invention, characterized by having a secondary emissive subcoating on a grooved surface, in combination with an electron multiplier array.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGS. 1 and 2, a radiation image intensifier 10 incorporating the present invention is shown. A housing 12 forming an evacuated chamber is provided which comprises front end plate 14, rear end plate 16 and cylindrical side section 18. A metallic screen 20 is positioned inside of the housing 12 and is adapted to receive a radiation image from a direction indicated generally by arrow 22. The metallic screen 20 may comprise any metal having at least 13 electrons per atom, for example, lead, uranium, tantalum, tungsten, gold, silver, osmium or iridium. The metallic screen 20 is placed adjacent to, and in close proximity with, an electron multiplier array 24 as shown in detail in FIG. 3. The electron multiplier array 24 is suitably positioned in the housing 12 by cylindrical mount 26. The electron multiplier array 24 amplifies electron images received at its input end 28 to provide an amplified corresponding image at its output end 30. For example, the electron multiplier array 24 may comprise a great number of channels or tubes 32, each of which acts as an individual electron multiplier. Accordingly, electrons forming an image or pattern which are received by the electron multiplier 24 at the input end 28 will be multiplied by respectively positioned channels 32 to provide a preserved and amplified electron image at the output end 30. Electron multiplier arrays of this nature are well known in the art, for example, see the U.S. Pat. to Goodrich et al No. 3,313,940, assigned to the assignee of this invention. Channel electron multiplier arrays as disclosed therein are marketed by the Electro-Optics Division of the assignee of this invention under the trademark "Channeltron".

A utilization means 34, in this case a photoanode, is positioned in the housing 12 adjacent to, and in close proximity with, the output end 30 of the electron multiplier array to receive electrons emerging therefrom.

A power supply 36 is provided having conductors 38, 40 and 42 for applying appropriate operating potentials to the input end 28, the output end 30 of the electron multiplier array 24 and the photoanode 34, respectively. Since the operation of electron multiplier arrays and photoanodes are well known in the art, a detailed discussion of their operation will not be given.

In operation, a radiation image is received by the radiation image intensifier 10, generally from the direction indicated by arrow 22. The interaction of the radiation image with the metallic screen 20 causes the emission of electrons, for example, by virtue of the photoelectric effect or Compton interactions. The electrons will be emitted from the metallic screen 20 in a pattern corresponding to the pattern of the received radiation image, i.e., an electron image is formed which corresponds to the received radiation image. The thickness, density and configuration of the metallic screen 20 is selected according to the energy level of the expected received radiation image so that electrons are emitted which have energy levels within the operation range of the electron multiplier array 24, for example, energy levels of 5 to 10 eV are satisfactory. Particularly, reducing the density of a material will increase the energy level at which electrons are emitted. Density can be controlled through the use of lightweight filler materials which are highly permeable to radiation and

electrons or the configuration of the material can provide air spaces or the like to reduce the density. Also, reducing the thickness of a material will increase the energy level of the emitted electrons. The electron multiplier array 24 amplifies the electron image emitted from the metallic screen 20 thereby providing an amplified preserved electron image at its output end 30. The photoanode 34 receives the amplified electron image from the electron multiplier array 24 and provides a visual representation of the electron image, i.e. a viewable light image corresponding to the radiation image received by the radiation image intensifier 10.

In FIG. 4 another embodiment of the present invention is shown. Particularly, a metallic screen 120 is shown having a plurality of grooves 122 which provide a large number of closely spaced surfaces 124 which are oblique to the nominal plane of the screen. As disclosed in my co-pending application for "Radiographic Intensifying Screen", Ser. No. 759,361, the yield of electrons emitted from the screen 120 is enhanced. Accordingly, electron images are emitted from the screen 120 which are of higher intensity than that obtainable with smooth-sided screens.

In FIG. 5, yet another embodiment of the present invention is shown. In the embodiment of FIG. 5, the grooved screen 120 of FIG. 4 is further provided with a coating 126 which secondarily emits additional electrons when struck by electrons from the lead screen 120. In this manner, electron yield from the screen 120 is further enhanced, and accordingly, even higher intensity electron images are provided.

It will now be appreciated that the radiation image intensifier of this invention is a significant advancement over the prior art devices in that it is capable of satisfactory operation with low-contrast images and is simpler in construction and correspondingly less expensive to manufacture.

Although this invention has been disclosed and illustrated with reference to a number of embodiments, it will be obvious that other changes, adaptations and modifications may be made therein without departing from the spirit and scope of the appended claims.

Having thus described my invention, I claim:

1. A proximity focused radiation image intensifier including an evacuated chamber comprising:

an array of electron multiplier tubes for receiving electron images and for providing corresponding amplified electron images, said multiplier array having an input end and an output end, and said multiplier being responsive to electrons having energies within a predetermined range, said energy range having an order of magnitude of approximately five to 10 electron volts;

a screen composed substantially of a metal having at least 13 electrons per atom, said a metal having sufficient thickness and density to receive a radiation image and to emit a corresponding electron image having an energy level within said predetermined range, said screen being positioned proximate said multiplier array input end; and utilization means positioned proximate said array for receiving said amplified electron image.

2. A radiation image intensifier of claim 1 wherein said screen consists only of a metal having at least 13 electrons per atom.

3. A radiation image intensifier of claim 1 wherein said screen is composed of a metal selected from the group consisting of lead, uranium, tantalum, tungsten, gold, silver, osmium and iridium.

4. A radiation image intensifier of claim 1 wherein said utilization means is a photoanode for converting said electron image into a corresponding light image.

5. A radiation image intensifier of claim 1 wherein said screen is characterized by having a plurality of closely spaced surfaces which are oblique to the nominal plane of said screen.

6. A radiation image intensifier of claim 1 including a coating of a secondarily emissive material on said screen.

7. A radiation image intensifier of claim 6 further including a coating of a secondarily emissive material on said oblique surfaces.

8. A proximity focused radiation image intensifier including an evacuated chamber comprising:

a screen comprising a metal having at least 13 electrons per atom adapted to receive a radiation image and to emit an electron image corresponding to said radiation image into said chamber at a predetermined energy level having an order of magnitude of approximately five to ten electron volts, said metal screen having a plane defining surface for receiving a radiation image and an

electron emitting surface having a plurality of closely spaced surface portions that are oblique to said plane to maximize the electron emitting surface area of said screen;

an array of a plurality of individual electron multiplier tubes being operative in response to electron images at said predetermined energy level positioned in said chamber proximate said screen to receive said electron image and provide an amplified electron image corresponding to said electron image emitted from said screen means; and utilization means positioned proximate said array for receiving said amplified electron image.

9. A radiation image intensifier of claim 8 wherein said screen means consists only of a metal having at least 13 electrons per atom.

10. A radiation image intensifier of claim 8 wherein said screen means consists only of a metal selected from the group consisting of lead, uranium, tantalum, tungsten, gold, silver, osmium and iridium.

11. A radiation image intensifier of claim 8 wherein said utilization means is a photoanode for converting said electron image into a corresponding light image.

12. A radiation image intensifier of claim 8 further including a coating of a secondarily emissive material on said oblique surfaces.

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