

[54] **IMAGE INTENSIFIER WITH IMPROVED  
INPUT SCREEN**

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[21] Appl. No.: **280,614**

**Related U.S. Application Data**

- [63] Continuation-in-part of Ser. No. 76,851, Sept. 30,  
1970, abandoned.

- [52] U.S. Cl. .... 313/102, 313/65 R, 313/474  
[51] Int. Cl. .... H01j 29/18  
[58] Field of Search ..... 313/65 LF, 92 LF, 102,  
313/108 R; 250/213 VT, 71.5 R, 80

**References Cited**

**UNITED STATES PATENTS**

- 3,267,283 8/1966 Kapany ..... 250/227 X

**OTHER PUBLICATIONS**

Leverenz, *An Introduction to Luminescence of Solids*  
John Wiley & Sons, Inc., New York pp. 76,77.

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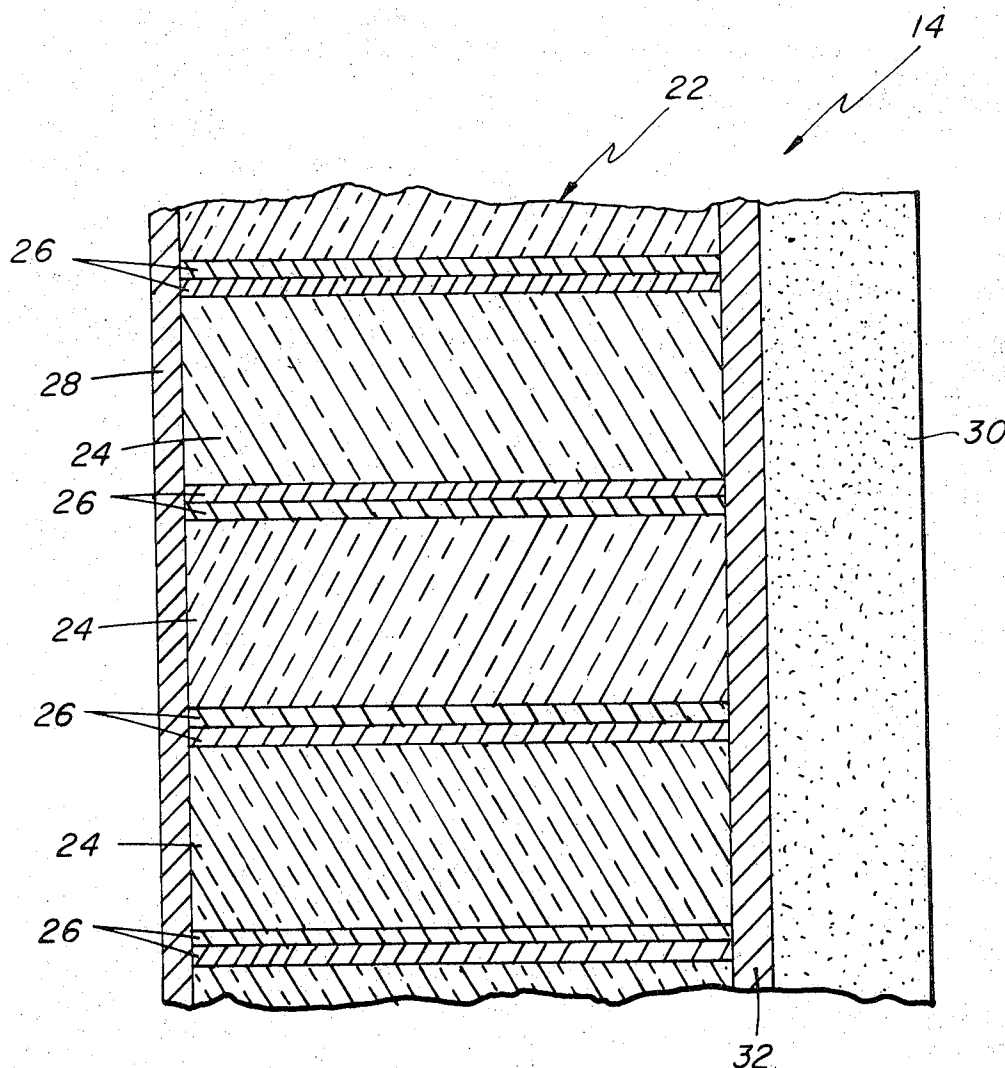
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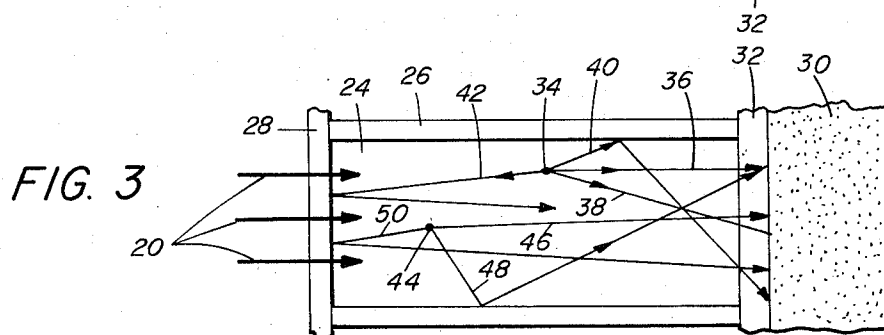
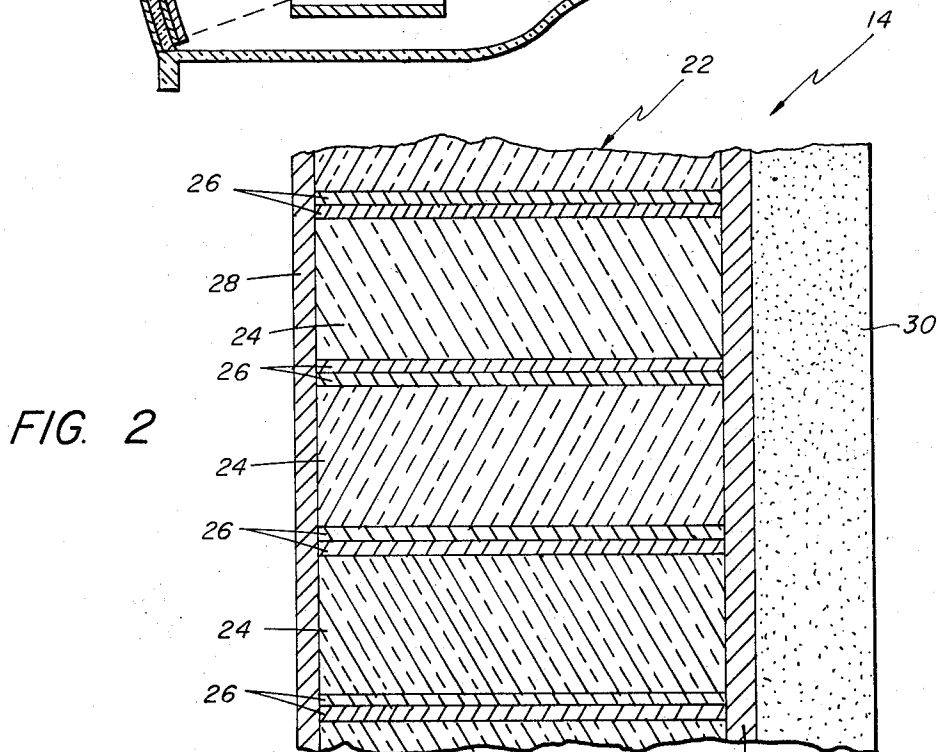
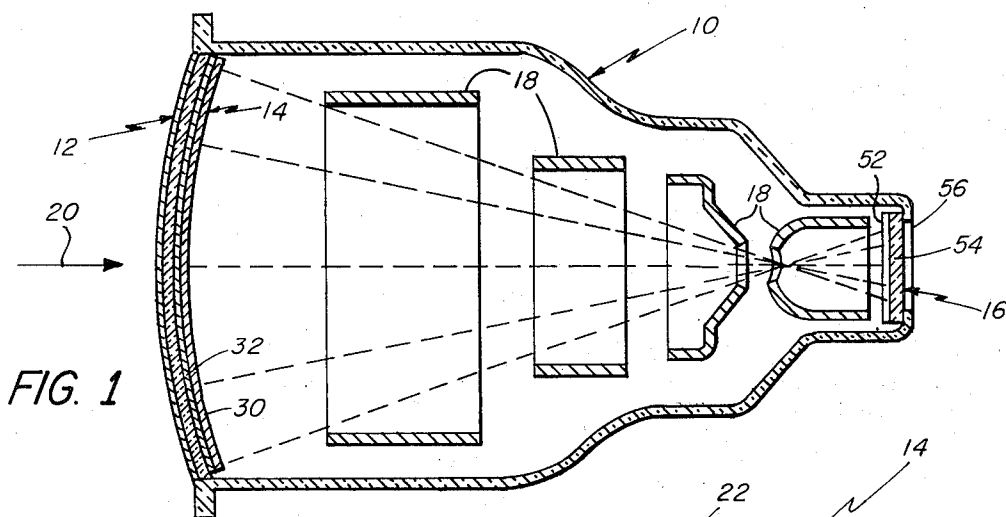
[57]

**ABSTRACT**

An image intensifier tube having a novel input screen  
structure comprising a photocathode used in conjunc-  
tion with a novel radiation-sensitive structure for in-  
creasing efficiency in the conversion of X-rays,  
gamma rays or neutrons to light and subsequently to  
electrons.

**27 Claims, 8 Drawing Figures**





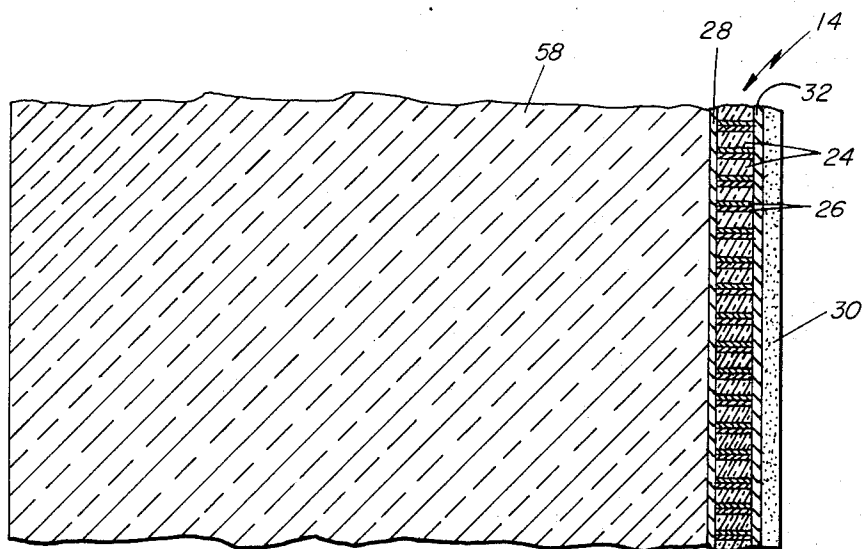


FIG. 4

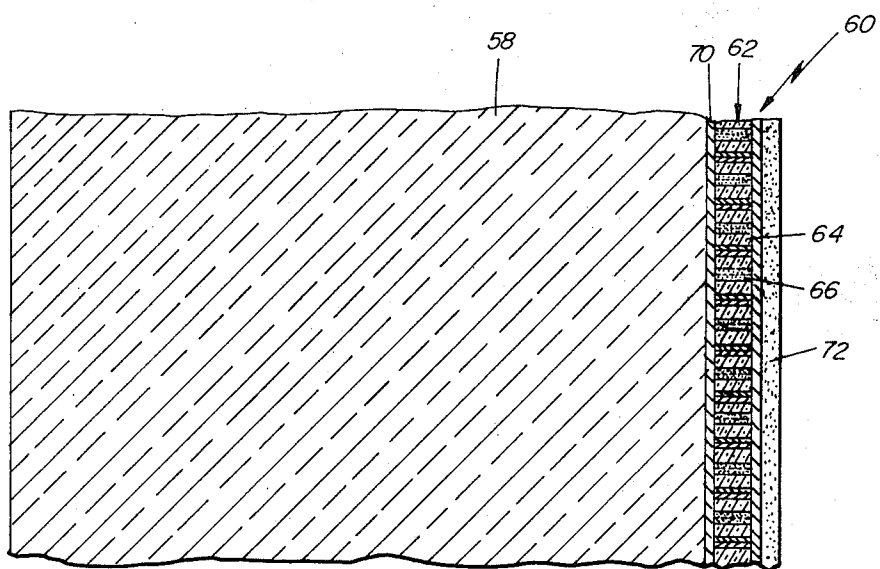


FIG. 5

FIG. 6

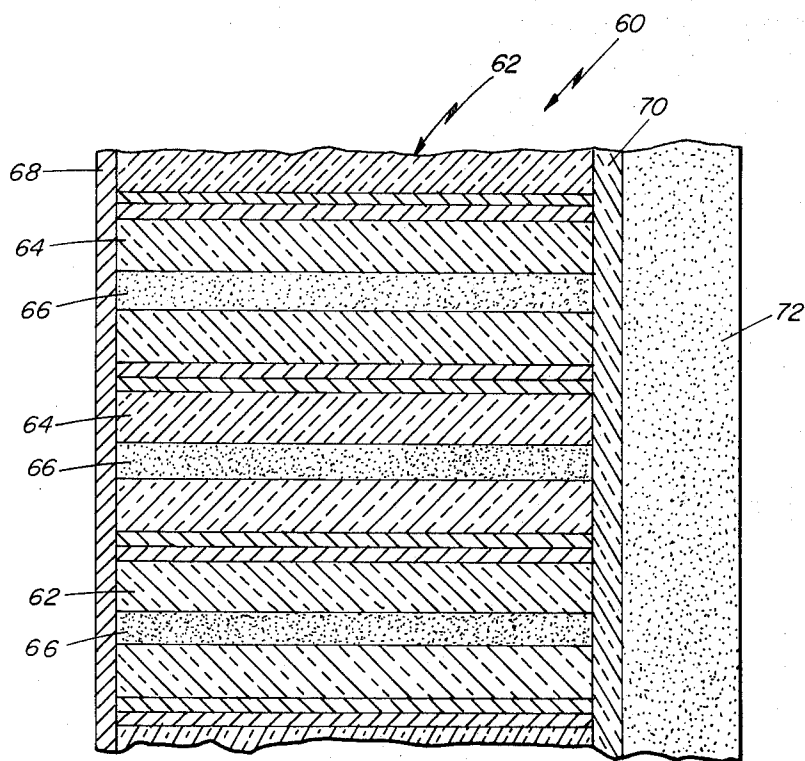


FIG. 7

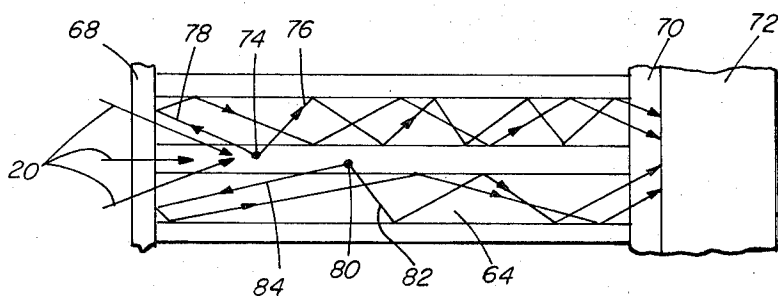
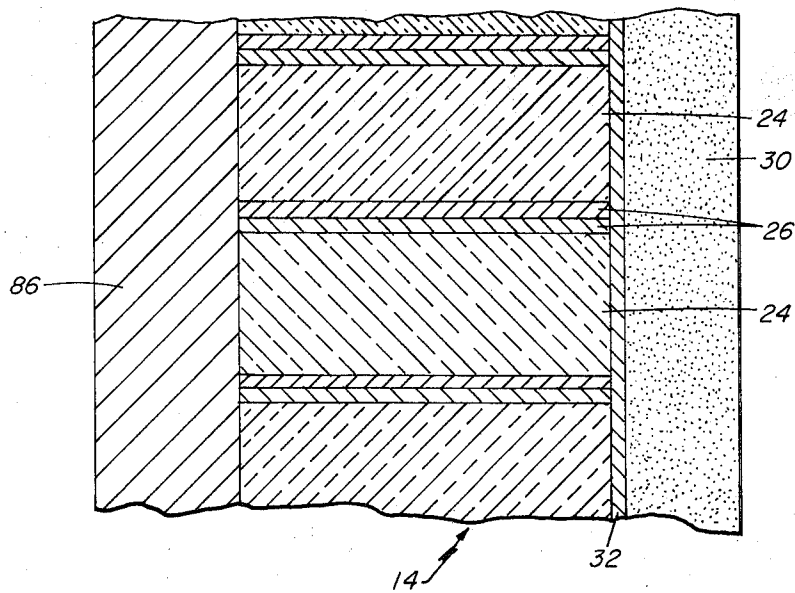


FIG. 8



# IMAGE INTENSIFIER WITH IMPROVED INPUT SCREEN

## CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U. S. Pat. application Ser. No. 76,851, filed Sept. 30, 1970, and now abandoned.

## BACKGROUND OF THE INVENTION

Image intensifier tubes of conventional type employ a photocathode which is usually mounted adjacent an input faceplate which is transparent to incident radiation. The photocathode is used together with a layer of radiation-sensitive phosphor material which becomes optically fluorescent when subjected to the impinging X-rays, gamma rays or neutrons to which it is sensitive. The resultant fluorescent radiation has a pattern corresponding to the pattern of the incident radiation, and passes through a transparent substrate to the superimposed photosensitive layer which converts the fluorescent light into a corresponding electron image. The electrons then are made to flow through the tube to a phosphor output screen which converts the electron image into a corresponding visible light image.

Such tubes, however, have certain recognized limitations which prevent the tubes from operating at maximum efficiency. For example, although an incoming radiation image may be intensified or amplified as much as several thousand times, the light which is actually available from the conversion of incoming radiation photons to light photons by the fluorescent phosphor screen is limited by the quantity of light photons which can penetrate through or otherwise be emanated from the phosphor layer. Furthermore, high resolution requires that the phosphor layer be relatively thin, although the total light possible from an invisible radiation-to-light conversion requires absorption of the greatest amount of the incoming radiation as is possible.

It has been found that as the energy of X-rays or gamma rays, for example, is increased, the useful conversion of these rays to light photons decreases.

Therefore, the desired objective of a thick fluorescent layer for production of ample quantities of fluorescent light photons coupled with means for collecting and utilizing the resultant increase in light photons has been found to be inefficient in conventional tube photocathode structures.

## SUMMARY OF THE INVENTION

The above and other disadvantages are overcome in accordance with this invention by the provision of a novel input screen structure for an image intensifier tube which screen structure may be separate from or may form in itself the input faceplate of the tube, and which comprises a supporting structure embodying scintillation crystal material which becomes fluorescent when impinged by the incoming radiation which is to be intensified or amplified. Such crystal material may be in the form of small diameter parallel rods of scintillation material such as cesium iodide, sodium iodide, lithium iodide or potassium iodide for example, which may be suitably activated with tellurium, sodium, thallium or europium as the case may be and which becomes fluorescent when illuminated by gamma radiation or X-rays.

These rods, in accordance with this invention, will be of a predetermined length so as to provide the layer of crystal material with a predetermined thickness consistent with the incident radiation's penetration characteristics and the absorption characteristics of the crystal material. Therefore, the thickness of the layer will be computed in accordance with the reasoning that when a layer is subjected to radiation such as X-rays, for example, the decrease in radiation intensity caused by absorption of the radiation as it passes through the layer may be determined and used in the computation of the thickness of the layer in accordance with Lambert's Law  $I = I_0 e^{-\alpha t}$  where  $I_0$  is the incident flux of photons,  $I$  is the emerging flux of photons,  $e$  is the exponential function,  $\alpha$  is the attenuation coefficient per cm of the crystal material, and  $t$  is the thickness in cm.

These parallel rods will generate light photons throughout their selected lengths or selected portions of their lengths when subjected to the incoming invisible radiation and, being light transparent, will transmit such photons axially onto the photosensitive layer. In order to prevent transconductance of light, each rod may be coated with a thin layer of opaque material such as a reflecting metal or a glass having a lower index of refraction than the scintillation crystal material itself, or the rods may be spaced with voids between them for the purpose.

In order to provide high resolution, the rods are made very thin, such as about 0.010 inches in diameter, for example, and will be located closely enough to one another as to produce a resultant light picture of the order of three line pairs per millimeter.

The output surface of the fluorescent scintillation layer is covered by a photoemissive layer of a type which is compatible with the particular fluorescent material used so as to produce an electron image which corresponds to the fluorescent light image. In general the photocathode and/or its transparent substrate should have a higher index of refraction than the fluorescent material to prevent back reflection at the interface.

In a modification of this invention the fluorescent material may be in opaque powder form resembling conventional phosphors, and is located within hollow glass tubes. When contacted by incident radiation, the phosphor material will effectively generate light photons throughout the selected length of the tubes. Although in normal phosphor layers only the light photons at or adjacent the surface of the layer adjacent the photoconductive layer can be effectively utilized, with the present structure the light generated within the phosphor at all the surfaces will readily pass through the walls of the glass tubes toward the photoemissive layer which is superimposed on the inner surface of the phosphor-tube structure. In this way greater quantities of light photons may be generated and utilized.

In a further modification of this invention, phosphor particles such as cesium iodide or zinc cadmium sulphide may be fused with a glass frit and formed into rods.

It has been found that with the above structure the spacings between the centers of the glass rods should be about from 0.010 inches to 0.100 inches depending on the length of the rods required to absorb the major part of the incident radiation. This will provide a picture of the order of three line pairs per millimeter. The cross-sectional area of phosphor to total area should be

optimized to obtain the greatest light output, and for this purpose in the order to 50 percent phosphor area is reasonable.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The above and other advantages are achieved by the structures shown in the drawings, wherein:

FIG. 1 is an axial sectional view of an image intensifier tube embodying the invention;

FIG. 2 is a greatly enlarged fragmentary sectional view of a portion of the input screen structure of the tube shown in FIG. 1;

FIG. 3 is a diagrammatic illustration of photon passage through a scintillation crystal rod in accordance with this invention;

FIG. 4 is a fragmentary sectional view similar to FIG. 2 of a modified faceplate-input screen structure embodying the invention;

FIG. 5 is a view similar to FIG. 4 illustrating a further embodiment of the invention;

FIG. 6 is an enlarged fragmentary sectional view of a portion of the structure of FIG. 5 illustrating a modification thereof;

FIG. 7 is a diagrammatic view of photon passage through the structure illustrated in FIG. 6; and

FIG. 8 is a view similar to FIG. 2 illustrating another embodiment of the invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

An image intensifier tube embodying one form of the invention is shown in FIG. 1 and comprises a vacuumized envelope 10 having a faceplate 12 at one end which may be combined with or may superimpose an input screen structure 14. At the other end of the envelope is an output screen 16, and accelerating and focusing electrodes 18 are located within the envelope for purposes to be described.

In the operation of a conventional image intensifier tube incident radiation in the form of a pattern of varying intensity will be directed, as indicated by arrow 20, onto the input screen 14. The screen functions to convert the radiation image into light photons having a pattern corresponding to the pattern of the input radiation and will further function to convert the photon image into an electron image having a corresponding pattern. The electrons will be accelerated and focused by the electrodes 18 onto the output screen 16 which includes a phosphor which functions to convert the electron image into a visible light image which may be viewed by an observer. In a system of this character the incoming radiation pattern will be amplified and intensified thousands of times so that the resultant image viewed on the output screen 16 will be a clearly focused, sharp, well defined picture.

In accordance with the present invention, and as clearly illustrated in FIG. 2, the input screen structure 14 comprises a fluorescent layer 22 which embodies a plurality of light pipes or conductors 24 in the form of rods of scintillation crystal material. Scintillation material is defined for the purposes of this invention as a clear, transparent crystalline material which fluoresces when impinged by X-rays, gamma rays or neutrons. Such materials which are satisfactory for this purpose include silicon iodide activated with thallium, cesium iodide activated with tellurium or sodium, lithium iodide activated with europium, and potassium iodide ac-

tivated with thallium. It has been found that when subjected to the impinging radiation, cesium iodide activated with tellurium will emit light of about 5,500 Angstroms, and when activated with sodium will emit light at about 4,000 Angstroms. Sodium iodide activated with thallium and potassium iodide activated with thallium will emit at about 4,100 Angstroms, while lithium iodide activated with europium will emit light of about 4,400 Angstroms.

In conventional image intensifier tubes, it has been found that layers of phosphor have serious limitations which prevent operations of the tubes at maximum efficiency. For example, although the impinging incident radiation may penetrate throughout the thickness of the continuous phosphor layer, all the light photons generated within the layer cannot pass to the photoemissive layer adjacent thereto. Therefore, optimum efficiency of the phosphor layer is considerably reduced because of the opacity of the particles of phosphor which prevent a considerable portion of the light from passing to the photoemitter. In other cases, the incident radiation may possibly enervate only the surface area of the layer of phosphor. When high resolution is required, as is usually the case, the phosphor layer must be relatively thin, thus resulting in a layer thickness which is too thin to absorb the greatest amount of incoming radiation as is possible.

In accordance with the present invention, the fluorescent layer 22 comprises the aforementioned small rods 24 of scintillation crystal material which are arranged in parallel relation throughout the extent of the photocathode and extend substantially longitudinally of the axis of the tube. The rods 24 are very thin, such as about 0.010 inches - 0.100 inches in diameter, for example, and are located closely enough to one another as to produce a resultant fluorescent light picture of the order of three line pairs per millimeter or per centimeter respectively. The rods may be formed in any suitable manner, as is well known in the art, such as by being drawn down to the fine dimensions required from relatively large diameter rod material. The art as developed in connection with the production of fiber optics is particularly suitable for the production of the rods 24, although other means and methods of producing the rods may be employed.

The rods 24 may be any selected length which will provide substantially complete absorption of the radiation incident upon one end thereof. It will be understood, of course, that the layer 22 of rods may be made to the desired thickness which will most efficiently handle the absorption of the particular wavelength of incident radiation which is being utilized.

While it is generally desired that the length of the rods, and consequently the thickness of the fluorescent layer 22, will be selected to absorb substantially all of the incident radiation without containing any crystal material which will not be contacted by the radiation, it will generally be suitable to absorb 90 percent or more of the impinging radiation. In some cases, however, it may be desirable to select a layer thickness which will absorb only about 50-75 percent of the incident radiation.

Therefore, in accordance with this invention, the layer will be of a thickness which will absorb the selected quantity of the incident radiation as will give the desired output fluorescence. For example, Lambert's Law is employed as follows:  $I = I_0 e^{-\alpha t}$  where  $I$  is the

emerging flux,  $I_0$  is the input flux,  $e$  is the exponential function,  $\alpha$  is the attenuation coefficient of the fluorescent material, and  $t$  is the layer thickness.

Using CsI(Na) as an example of fluorescent material and selecting 200 KV photons as the incident flux, it can be easily determined that a layer 1 cm thick will absorb about 63 percent of the incident radiation, 2 cm thick will absorb about 86.5 percent, and 3 cm thick will absorb about 95 percent.

Therefore, in accordance with this invention, an image intensifier tube may be made with a fluorescent layer 22 of a selected thickness which will efficiently produce desired quantities of light photons. However, in further accordance with this invention the light photons must be permitted to pass to the adjacent photocathode 30. The rods 24 will each preferably be coated with a thin layer 26 of reflecting material, and such coatings 26 may be easily formulated during the production of the rods in the manner well known in the art. Furthermore, the end surfaces of the rods 24 directed toward the source of radiation will be covered with a thin layer 28 of aluminum or the like, which layer 28 is thin enough to readily pass the incident radiation 20 without substantial attenuation, but will reflect internally generated light photons back into the material of the rods, as will the reflecting coatings 26.

The photocathode comprises a layer 30 of photoemissive material such as antimony and cesium or antimony, potassium, sodium and cesium and any combinations thereof, for example, which is disposed upon the opposite end surfaces of the rods 24, by suitable well-known deposition methods. Therefore, light photons generated within the rods 24 by the input radiation 20 will pass longitudinally through the rods and out the ends thereof onto the photoemissive layer 30. The photoemissive layer 30, upon thus becoming energized by the light photons, will emit electrons in response thereto. In many cases the photoemissive material 30 is incompatible with the material of the rods 24 and, therefore, a thin barrier layer 32 may be required. Such barrier layers are commonly formed in the art by disposing a thin layer of glass of the thickness of a few microns directly upon the inner ends of the rods, and then depositing the photoemitter 30 upon the opposite side of layer 32. In other cases such a barrier layer 32 may be formed of a thin layer of aluminum oxide. In either case, the layer 32 will be transparent to the photons from the rods 24 and will be thin enough so that the layer 32 will not impair the quality of the light image passing to the photoemitter, as would be the case when thick layers are utilized.

In FIG. 3, there is shown a rod 24 having illustratively one point 34 which generates light when impinged by the incident radiation 20. This point source 34 will produce rays which extend radially therefrom in all directions. Four such rays are illustrated in FIG. 3. Ray 36, for example, will pass directly from the point source 34 longitudinally of the rod 24 directly through layer 32 to the photoemitter 30. Ray 38 will pass from point source 34 obliquely through rod 24 to the photoemitter 30, as shown. Ray 40 will pass at an angle from point source 34 so as to impinge upon the inner surface of the reflecting coating 26 and will be deflected obliquely through rod 24 to the photoemitter 30. Ray 42, however, will pass through the rod toward the reflective coat 28 at the input end of the rod, which coating 28 will reflect it back through the entire length of the rod

to the potentiometer 30. Another point source 44 will likewise generate exemplar rays 46, 48 and 50 which will pass through the material of the rod as indicated.

From the foregoing, it will be apparent that a major portion of the photons generated within the respective rods 24 will be made to pass to the photoemitter without substantial loss, as is the case of prior art fluorescent layers. Since the scintillation material of the rods is clear and transparent, the material of the rods will not substantially contribute to reduce the quantity of light photons which reach the photoemitter. Furthermore, the layer 22 can be made with rods of considerable length, in contrast to the required thinness of prior art fluorescent layers, so that the greatest amount of incoming radiation as possible is absorbed within the rods. Therefore, optimum quantity of light photons is produced and is directed onto the photoemitter 30.

Although the reflective coatings 26 on the circumferential surfaces of the rods are preferably any suitable reflective metal, such as aluminum, silver or gold, they may comprise a glass having a refractive index which is lower than the refraction of the scintillation crystal material itself, or voids, as desired.

The photons generated within the rods 24 as described, upon passage to the photoemissive layer 30, will be converted into electrons which are accelerated and focused by electrodes 18, when suitable potentials are applied thereto in the usual manner of operation of a tube of this character, onto the output phosphor screen indicated by numeral 52 in FIG. 1. Phosphor layer 52 is any of the well-known phosphor materials which may be disposed upon the inner surfaces of a glass support 54 and which will convert the electron image into the intensified visible light image which may be viewed from externally of the tube through the port 56.

In one form of the invention as illustrated in FIGS. 1 and 2, the photocathode-phosphor input screen assembly 14 is sufficiently rigid and strong enough to be self supporting and to comprise in itself the faceplate 12. However, where greater rigidity and strength is required, the input screen assembly 14 may be mounted upon the inner surface of a glass faceplate 58 as shown in FIG. 4. Such a structure will impart considerable rigidity and strength to the device such as will enable the tube to withstand rough handling as well as the forces resulting from creating a vacuum within the interior of the tube.

In a modification of this invention, a different form of input screen assembly 60 may be provided as illustrated in FIGS. 5 and 6. In this modified form of the invention, the glass faceplate 58 may or may not be provided. However, the fluorescent layer 62 comprises a plurality of light pipes 64 in the form of small glass tubes of selected length. The glass tubes 64 contain within their central axially disposed cavities a respective supply 66 of phosphor material which may be a conventional phosphor normally used in image intensifier tubes or ground scintillation material of the character set forth above. The end surfaces of the rods and supplies of fluorescent material which are directed toward the source of incident radiation are covered with a thin layer 68 of light-reflecting radiation-transparent material such as aluminum, for example, and the opposite ends of the tubes and supplies of fluorescent material are preferably covered with a layer 70

of light-transparent material upon which is superimposed a deposited layer 72 of photoemitter material. Incident X-rays, gamma rays or neutrons will pass through the reflecting layer 68 and will enter the fluorescent layer 62. Such radiation will impinge upon the supplies 66 of fluorescent material, causing it to fluoresce. In order to provide means for a large quantity of the resultant photons to pass to the photoemitter 72, the glass fibers or tubes 64 will function to collect and pass such photons longitudinally thereof.

For example, a light photon 74, illustrated in FIG. 7, will generate rays 76 and 78, for example, which will be reflected to the photoemitter through the transparent layer 70 as shown. Another point source 80 of light photons will produce rays such as 82 and 84, for example, which will also pass through the glass tubes 64 to the photoemitter 72.

It will be apparent that this modified structure also provides a considerable increase in the quantity of light photons which may be generated within the fluorescent layer, and a greater quantity of these photons are enabled to pass to the photoemitter than is possible with structures of the prior art. Therefore, this being the case, a greatly intensified photoelectron image may be produced by the photosensitive material 72.

Referring to FIG. 8, another modification in the invention is shown which utilizes a faceplate 86 of aluminum which may be made of a thickness which will impart sufficient rigidity and upon which either of the input screens 14 or 60 may be provided as described above. Such an aluminum faceplate may be particularly desirable in tubes designed for use with gamma rays. The faceplate 86 may comprise beryllium, if desired, which also is relatively easily penetrated by X-rays and gamma rays.

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 apparent, however, that various modifications may be made by those skilled in the art without departing from the spirit of the invention as expressed in the accompanying claims. Therefore, all matter shown and described is to be considered as illustrative and not in a limiting sense.

I claim:

1. A fluorescent screen for use with and sensitive to a selected exciting radiation incident thereon, which radiation has known penetration depth values with respect to known fluorescent materials, comprising a layer embodying a multiplicity of rods of selected fluorescent material extending in parallel relation through the thickness of the layer, the layer being of a thickness which will absorb at least 50% of the selected exciting radiation impinging thereon, and means for preventing transconductance of fluorescence between rods.

2. A fluorescent screen as set forth in claim 1 wherein said means comprises a reflective coating on said rods and each of said rods is covered by a light-transparent sheath within said reflective coating.

3. A fluorescent screen as set forth in claim 1 wherein said parallel rods are of a thickness ranging about from 0.010 inch to 0.100 inch and are spaced sufficiently close enough to produce a resultant light picture of the order of from 0.3 to three line pairs per millimeter.

4. A fluorescent screen as set forth in claim 1 wherein the rods are cesium iodide activated with tellurium.

5. A fluorescent screen as set forth in claim 1 wherein the rods are cesium iodide activated with sodium.

6. A fluorescent screen as set forth in claim 1 wherein the rods are silicon iodide activated with thallium.

7. A fluorescent screen as set forth in claim 1 wherein the rods are lithium iodide activated with europium.

8. A fluorescent screen as set forth in claim 1 wherein the rods are potassium iodide activated with thallium.

9. A fluorescent screen as set forth in claim 1 wherein said layer is of a thickness which will absorb at least 90 percent of the selected exciting radiation impinging thereon.

10. A screen assembly for an electron tube, comprising a fluorescent layer embodying photon-emitting material sensitive to a selected exciting radiation incident thereon which radiation has known penetration depth values with respect to known fluorescent materials, and a photoemissive layer adjacent the fluorescent layer capable of electron emission in response to impingement of photons from the fluorescent layer, said fluorescent layer comprising a multiplicity of rods of selected fluorescent material extending in parallel relation through the thickness of the layer, the thickness of the fluorescent layer being substantially equal to the maximum penetration depth of the selected exciting radiation in said selected fluorescent material, and reflective means surrounding each rod for preventing transconductance of fluorescence between rods.

11. A screen assembly as set forth in claim 10 wherein each of said rods is covered by a light-transparent sheath with said reflective means.

12. A screen assembly as set forth in claim 10 wherein said parallel rods are of a thickness ranging about from 0.010 inch to 0.100 inch and are spaced sufficiently close enough to produce a resultant light picture of the order of three line pairs per millimeter.

13. A screen assembly as set forth in claim 10 wherein the photon-emitting material is cesium iodide activated with tellurium.

14. A screen assembly as set forth in claim 10 wherein the photon-emitting material is cesium iodide activated with sodium.

15. A screen assembly as set forth in claim 10 wherein the photon-emitting material is silicon iodide activated with thallium.

16. A screen assembly as set forth in claim 10 wherein the photon-emitting material is lithium iodide activated with europium.

17. A screen assembly as set forth in claim 10 wherein the photon-emitting material is potassium iodide activated with thallium.

18. A screen assembly as set forth in claim 10 wherein a light-reflecting layer transparent to said incident radiation is disposed adjacent the surface of the fluorescent layer which is directed toward the incident radiation.

19. A screen assembly as set forth in claim 10 wherein a thin light-transparent barrier layer is disposed between the photoemissive layer and the adjacent ends of the rods.

20. An image intensifier tube comprising an envelope having an input screen at one end and an output screen at the opposite end, said input screen comprising a fluorescent layer embodying scintillation material sensitive to a selected exciting radiation incident thereon,

which radiation has known penetration depth values with respect to known fluorescent materials, and a photoemissive layer adjacent the fluorescent layer capable of electron emission in response to impingement of photons from the fluorescent layer, said fluorescent layer comprising a multiplicity of rods of selected fluorescent material extending in parallel relation through the thickness of the layer, the thickness of the fluorescent layer being substantially equal to the maximum penetration depth of the exciting radiation in said selected fluorescent material, reflective means surrounding each rod for preventing transconductance of fluorescence between rods, electrodes in the envelope between said screens, and means for applying potentials to said electrodes for accelerating and focusing electrons from said photoemissive layer onto said output screen.

21. An image intensifier tube as set forth in claim 20 wherein each of said rods is covered by a light-transparent sheath within said reflective means.

22. An image intensifier tube as set forth in claim 20

wherein said parallel rods are of a thickness ranging about from 0.010 inch to 0.100 inch and are spaced sufficiently close enough to produce a resultant light picture of the order of three line pairs per millimeter.

23. An image intensifier tube as set forth in claim 20 wherein the scintillation material is cesium iodide activated with tellurium.

24. An image intensifier tube as set forth in claim 20 wherein the scintillation material is cesium iodide activated with sodium.

25. An image intensifier tube as set forth in claim 20 wherein the scintillation material is silicon iodide activated with thallium.

26. An image intensifier tube as set forth in claim 20 wherein the scintillation material is lithium iodide activated with europium.

27. An image intensifier tube as set forth in claim 20 wherein the scintillation material is potassium iodide activated with thallium.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,825,787 Dated July 23, 1974

Inventor(s) Howard D. Doolittle

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Claims

Column 8, line 4, change "silicon" to --sodium--;

Column 8, line 46, change "silicon" to --sodium--;

Column 10, line 13, change "silicon" to --sodium--.

Signed and sealed this 19th day of November 1974.

(SEAL)  
Attest:

McCOY M. GIBSON JR.  
Attesting Officer

C. MARSHALL DANN  
Commissioner of Patents