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CYLINDER WITH INTERNAL PHOTSENSITIVE COATING AND PRISM ON
OUTER SURFACE FOR ADMITTING LIGHT AT AN ANGLE TO BE
TOTALLY INTERNALLY REFLECTED

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Fig. 1

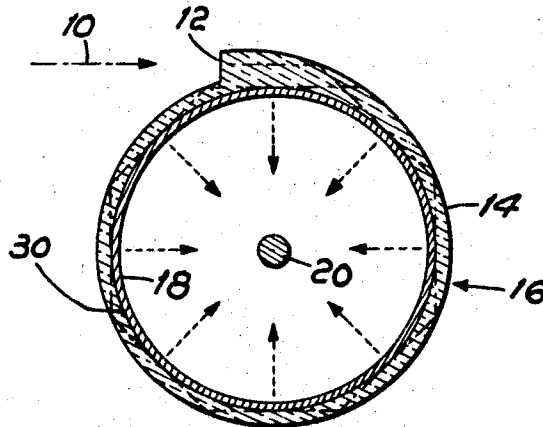


Fig. 2

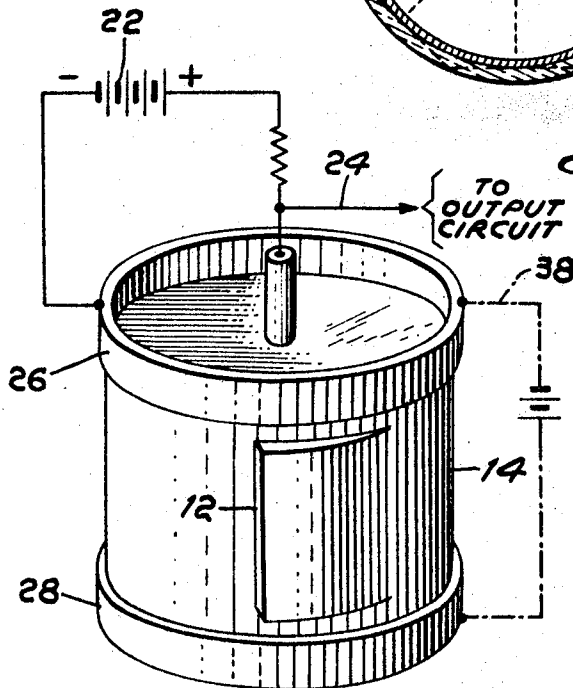
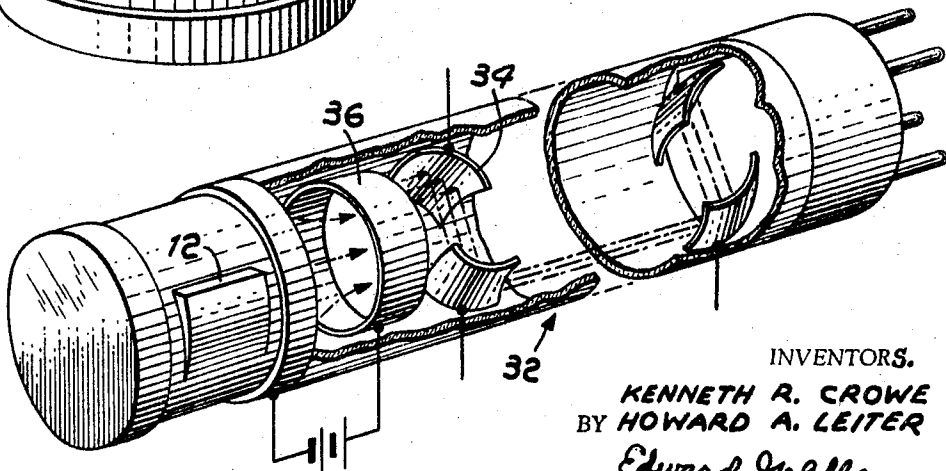


Fig. 3



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CYLINDER WITH INTERNAL PHOTOSENSITIVE COATING AND PRISM ON OUTER SURFACE FOR ADMITTING LIGHT AT AN ANGLE TO BE TOTALLY INTERNALLY REFLECTED

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7 Claims

ABSTRACT OF THE DISCLOSURE

A cylindrical phototube has a photosensitive layer on the inner surface of a glass envelope. Light is injected into a prism on the outer surface at an angle to cause total reflection along multiple paths within the glass between the photosensitive layer and outer surface around the tube. The photosensitive layer is responsive to changes in light intensity and provides an electrical output signal which varies accordingly.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to photosensitive tubes and particularly to an improved structure utilizing multi-reflected light.

Description of the prior art

Prior art phototubes have utilized reflected light to provide greater sensitivity and electron emission from photocathodes. These have generally employed a flat glass faceplate into one end of which light was injected at an angle to cause total internal reflection. A flat photoemissive layer on a surface of the glass provided increased electron emission due to the multiple reflections of the light beam. One such device is illustrated in U.S. Patent No. 3, 040,976, issued July 10, 1962. There is need, however, for tubes having even greater sensitivities and for a configuration that is capable of adaption to a variety of systems utilizing light detection devices.

SUMMARY OF THE INVENTION

It is therefore the primary object of the invention to provide a simplified more efficient phototube structure which utilizes multireflected light for improved sensitivity.

These results are achieved by a novel cylindrical phototube structure wherein light is injected into the glass envelope for total internal reflection around the cylinder. The characteristics of a photosensitive layer on the inner surface of the glass change in accordance with the intensity of light projected thereon to provide an output signal. A photocathode layer emitting electrons in response to the light intensity, may be utilized in conjunction with a centrally positioned anode or an electron multiplier to provide a varying output current, or a photoconductive layer having a resistance which changes with light intensity may similarly be employed. The details of the invention may be more fully understood and other objects and advantages become apparent by reference to the following description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top cross-sectional view of one form of the novel cylindrical phototube structure.

FIG. 2 shows a side view of the structure, and

FIG. 3 shows an electron multiplier used in conjunction with the phototube.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, a source of light 10 is directed at a prism or stepped window 12 on the outer surface of a cylindrical glass envelope 14 of a photosensitive tube 16. The light or radiation enters the envelope at normal incidence to the prism faceplate. The prism is designed so that the angle of incidence of the beam entering the prism at the glass-air interface on the outer surface and at the glass-vacuum interface on the inner surface, is greater than the critical angle. This is a known relationship which causes the light to be trapped within the glass envelope so that the light is reflected in multiple bounces, shown by dashed lines, between the inner and outer surfaces as it continues around the cylindrical envelope. The critical angle is a function of the index of refraction of the particular transparent material and is usually about 42-45°.

In the preferred embodiment, a relatively thin photoemissive layer or coating 18 is deposited around the inner surface of the glass so that electrons, shown by dotted lines and arrows, are emitted at each point as the light strikes the inner surface and photons penetrate the emissive layer. The multiple passes permit increased absorption of energy for any particular desired wavelength region and are particularly useful with long infrared wavelengths which require absorption by the photosensitive material.

A longitudinal anode or collector electrode 20 is centrally positioned within the tube to collect the electrons. A suitable source of potential 22 is connected between the anode and photoemissive cathode to cause electrons to be attracted to the anode which is also connected to an output circuit or utilization device 24, as shown in FIG. 2. The cathode may typically be at ground potential while the anode may be at +100 volts.

FIG. 2 shows a side view of the prism 12 which is positioned longitudinally on the outer surface of the envelope. The prism may be cemented on the envelope or step ground and polished into the glass. Annular areas of metallic film or rings 26, 28 of a relatively soft metal such as Kovar are connected to the upper and lower ends of the photocathode to apply the potential source thereto.

Suitable photoemissive materials such as a standard S11 type coating which includes cesium and antimony, or an S20 coating including antimony, potassium, sodium and cesium may be used. If a poor conductor is employed as the cathode material, it is necessary to apply a non-absorptive transparent conductive coating 30 such as NESA or tin oxide material to the glass before applying the photoemissive layer. The potential source will then be connected between the conductive coating and the anode.

A photomultiplier 32 having a plurality of successive longitudinally positioned dynodes 34 such as shown in FIG. 3, may be utilized in place of the anode to amplify the current and provide still greater sensitivity. A coaxial accelerating ring 36 adjacent the photocathode is provided with a suitable positive potential which may be about 300 volts, to shape the electrons into a beam which is attracted into the multiplier section.

In some applications, it may be desirable to utilize a layer of photoconductive material, such as an antimony trisulphide or cadmium sulphide, having a resistance which varies with light intensity, in place of a photoemissive material. In this case the central anode is eliminated and the potential source is applied between the two metallic rings across the ends of the photoconductive layer, as shown by dashed lines 38 in FIG. 2. Current through the layer and the output circuit will then vary in accordance with the changes in light intensity.

Relative dimensions of a particular tube may include

an outer diameter of about 1 inch with the glass being about 1.0 mm. in thickness. The stepped edge of the prism may also extend outwardly about 1 mm. from the glass and may be about 1.0 cm. in length.

The present invention thus provides an improved phototube of greater sensitivity having a novel multireflecting cylindrical structure which is useful in a variety of applications. While several embodiments have been illustrated, it is apparent that the invention is not limited to the exact forms or uses shown and that many other variations may be made in the particular design and configuration without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. A photosensitive tube comprising:
 - an evacuated envelope having a relatively thin transparent cylindrical wall, said wall having inner and outer surfaces;
 - a photosensitive coating disposed completely around the circumference of the inner surface of said wall; said outer surface having a wedge-shaped prism portion including a flat face extending from said outer surface whereby a beam of light directly transversely through said flat face is totally internally reflected in multiple passes between said outer surface and photosensitive coating on said inner surface in a circular path around said envelope;
 - said coating being responsive to changes in the intensity of light impinging thereon from within said wall;
 - means applying potential between two portions of said tube, one portion including said coating; and
 - output means providing an electrical signal varying in accordance with said light changes.
2. The device of claim 1 wherein said photosensitive coating includes a photoemissive layer emitting electrons in response to said light impinging thereon and a centrally positioned anode arranged to collect said electrons, said potential being applied between said layer and said anode.
3. The device of claim 1 wherein said photosensitive coating includes a photoconductive layer having a resist-

ance which changes in accordance with said light intensity, said potential being applied between opposite ends of said layer.

4. The device of claim 2 including a transparent conductive coating on said inner surface between said photoemissive layer and said wall, said potential being applied between said transparent coating and said anode.

5. The device of claim 1 wherein said photosensitive coating includes a photoemissive layer emitting electrons in response to said light impinging thereon and an electron multiplier arranged to collect said electrons, said potential being applied between said layer and said electron multiplier.

6. The device of claim 5 wherein said electron multiplier includes an accelerating electrode arranged to attract said electrons into said multiplier.

7. The device of claim 6 wherein said accelerating electrode is a coaxial ring positioned adjacent said layer and including a plurality of successive longitudinally positioned dynodes, said potential being applied between said layer and said accelerating electrode.

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