350-286

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XR 3,571,602

[11] 3,571,602

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[21] Appl. No. 787,953
[22] Filed Dec. 30, 1968
[45] Patented Mar. 23, 1971
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[32] Priority Jan. 10, 1968
[33] Sweden
[31] 321/68

[54] **OPTICAL SYSTEM TO REDUCE REFLECTION LOSSES IN A PHOTOCELL**
7 Claims, 3 Drawing Figs.

[52] U.S. Cl. 250/216, 250/213, 350/286
[51] Int. Cl. H01j 43/28
[50] Field of Search 250/216, 277, 213; 350/286, 96, 171, 203; 313/65, 94

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ABSTRACT: A photodetector system including a photocell of the type having a photosensitive coating on the internal surface of a plane transparent wall forming part of the envelope of the cell. At least one prism whose principal section has the form of a trapezoid is attached to the wall so that the shorter one of the two parallel sides of the prism is in contact with the exterior surface of the wall in front of a central portion of the coating. The lengths of the sides and the angles of the principal section of the prism are so chosen that a bundle of light entering the longer one of the parallel sides at right angles to that side, is in part reflected by a first one of the nonparallel sides towards the other one of the nonparallel sides and reflected towards the wall by the last-mentioned side, while another part of the light bundle is reflected by the first one of the nonparallel sides directly towards the wall, both parts entering the wall under an angle of about 45°.

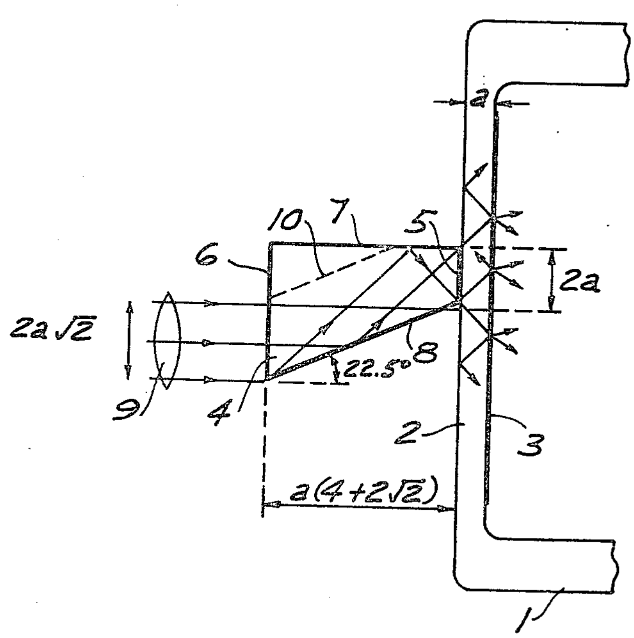


FIG. 1

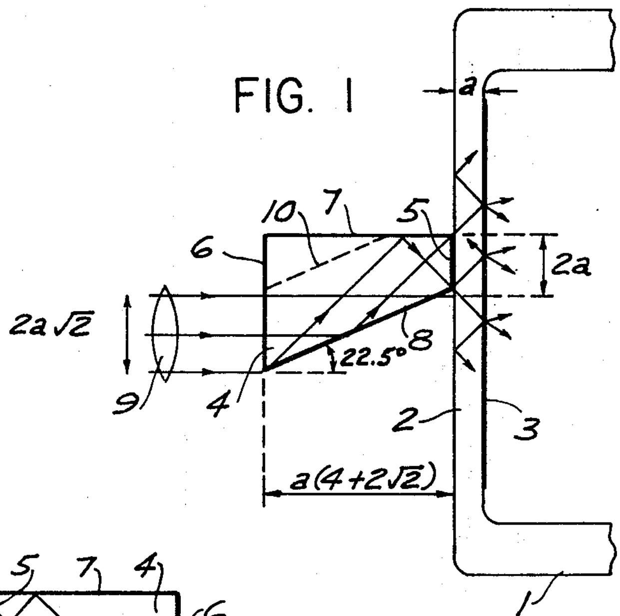
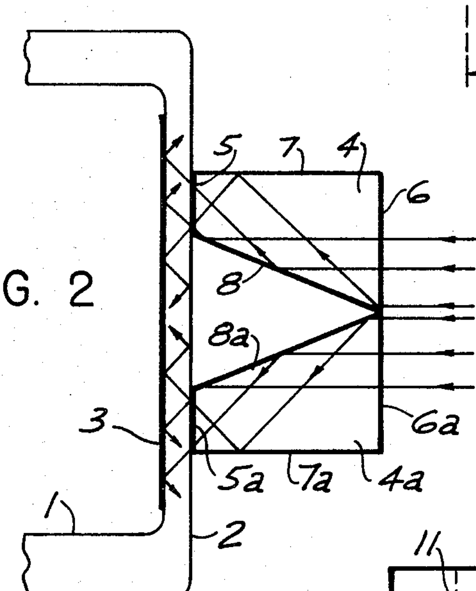


FIG. 2



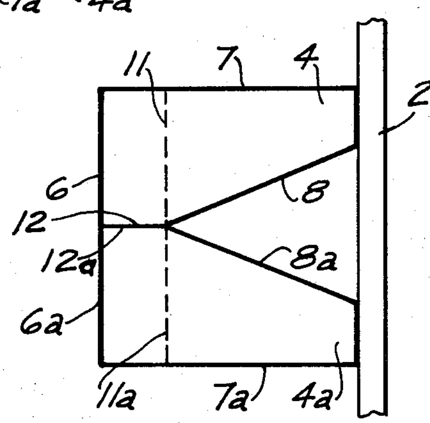


FIG. 3

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OPTICAL SYSTEM TO REDUCE REFLECTION LOSSES IN A PHOTOCELL

BACKGROUND OF THE INVENTION

The invention relates to a photodetector system, which comprises a substantially plane wall of transparent material, for instance glass, the inside of which is coated with a material emitting electrons when exposed to light. The wall may form part of a closed envelope, for instance a glass bulb. A photodetector of this kind, which may be in the form of an electron-multiplier photo tube, can be considered as an electron tube, in which the cathode is constituted by the light-sensitive coating.

A light beam directed from the outside towards the photodetector must first pass through the transparent wall, before the light strikes the photocathode. When the light falls at right angles to the wall, a great part thereof will be reflected against the outer side of the wall and against the inner side of the wall. Thus, only a relatively small portion of the incident light is utilized for releasing electrons from the photosensitive layer, that is the efficiency becomes low.

If the light falls at an angle of about 45° to the cathode, a portion of the light will be reflected to and fro between the inner and outer sides of the wall, and each time the light strikes the inside, a part of the light causes the cathode to emit electrons. Although the efficiency is improved in this way, it is still rather low, since part of the light incident from the outside is reflected away from the photodetector by the outside of the wall due to the large angle of incidence. However, it has been proposed to reduce these reflection losses by attaching to the outer surface of the wall a prism, whose cross section has the form of a right-angled isosceles triangle, the hypotenuse surface of the prism being attached to the wall at a place situated in front of a border area of the photosensitive coating and one of the side faces of the prism facing in a direction from the center axis of the photodetector. A light beam can now be passed through the prism at an angle of 45° to the glass wall without being reflected by the outer surface of the wall. However, this arrangement suffers from the drawback that the direction of incidence of the light beam is neither parallel to or coinciding with the optical axis of the photodetector. Also, that face of the prism that is in contact with the wall must not be too large in relation to the thickness of the wall, because in such case part of the light would be reflected back into the prism and be lost. Thus, if the prism is made so small that no part of the light entering the wall can be reflected back into the prism, the prism will have such small dimensions that the maximum allowable diameter of the incident light beam becomes too small to make the arrangement practically useful.

By using a prism of a shape other than that described above the light beam can be guided to arrive at the wall in parallel with the axis of the photodetector, but the drawback of the very limited beam diameter remains.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide a photodetector of the kind described above with means which allow a considerably larger diameter of the incident light beam and which makes it possible to direct the light beam at right angles towards the central portion of the wall on which the photosensitive coating is applied.

According to the invention at least one prism is attached to the outer side of the wall. The principle section of the prism has the form of a polygon with at least two parallel sides. A first one of the parallel sides is in contact with the wall at a central portion in front of the coating. Two of the nonparallel sides of the prism form such angles to the parallel sides that light entering the second one of the two parallel sides at right angles is in part reflected by one of said nonparallel sides towards the other one of the nonparallel sides and reflected towards the wall by the last-mentioned side, while another part of the light entering the second one of the parallel sides at right angles is reflected by one of the nonparallel sides directly towards the wall, so that both the light reflected by one of the nonparallel sides and the light reflected by both of the nonparallel sides enters the wall under an angle of about 45°.

DRAWING AND DETAILED DESCRIPTION

The invention will be described more in particular in conjunction with the accompanying drawing in which:

FIG. 1 shows a cross section one embodiment of the invention;

FIG. 2 shows in cross section another embodiment of the invention; and

FIG. 3 shows in cross section a third embodiment of the invention.

FIG. 1 shows in section a part of an envelope **1** of a photodetector. The envelope comprises a plane wall **2** of transparent material, the inside of which is provided with a coating **3** of a material emitting electrons when exposed to light. The photodetector is of a known type, and therefore those parts of it which are not necessary for the understanding of the invention has been omitted from the drawing.

A prism **4** is attached to a central portion of the outer side of the wall **2**. This prism has a trapezoid section. The two parallel sides are designated **5** and **6**. The prism **4** is fixed in some known manner to the outer surface of the wall **2** so that the shorter one of the two parallel sides is in contact with the wall. One of the two nonparallel sides **7** is at right angles to the two parallel sides, while the other one **8** of the nonparallel sides forms an angle of 22.5° to the perpendicular to the wall. A bundle of light **9** which falls at right angles upon the side **6** of the prism and strikes the oblique side **8** within he prism is totally reflected by the last mentioned side and proceeds in a direction forming an angle of 45° to the perpendicular of wall **2**. As will be seen from FIG. **1**, a part of the light thus reflected will enter directly into the wall **2**, while another part strikes the side **7** of the prism and is reflected by this side into the wall **2**. In both cases the light will enter the wall **2** under an angle of 45° to the wall. One part of the light bundle will, however, be reflected upwards while the second part is reflected downwards in the wall **2**. The light strikes the inside of the wall **2**, and a part of its energy is consumed for releasing electrons from the coating **3**. The small arrows extending from the coating **3** towards the right-hand side of FIG. **1** symbolize electrons released in this manner. That part of the light which is not utilized for releasing electrons is reflected by the inner side of wall **2** towards its outer side and is reflected from here back to the inner side where it strikes other points on the inside and causes additional electrons to be emitted from the coating **3**. These repeated reflections proceed towards the border of the wall **2**. Since the prism **4** is located centrally on wall **2**, both the reflections travelling upwards (as seen in FIG. **1**) and those travelling downwards will be utilized for the release of electrons. If the prism **4** is placed adjacent to the border of the wall **2**, only about one-half of the incident light bundle **9** would be utilized for this purpose.

The thickness of the wall **2** is designated by a on the FIG. The side **5** of the prism **4** which is in contact with the wall **2**, has a length of $2a$. It is readily understood that if side **5** had a length larger than $2a$, a part of the light reflected from the inside of wall **2** would again enter the prism and be lost.

If the sides of the prism have the mutual proportions shown in the FIG., the light bundle **9** can be given a diameter of $2a\sqrt{2}$. The thickness of the wall **2**, that is the value of a, is usually about 1.5 mm., and thus the light bundle **9** can be given a diameter of about 4.2 mm. Such a large diameter of the light bundle is advantageous, since it can be easily produced by means of a simple optical system. Also, the mounting of the photodetector in relation to the optical system requires less accuracy than in the case when the light bundle has a smaller diameter.

The distance between the two parallel sides **5** and **6** should obviously be at least $4a+2a\sqrt{2}$.

As will be seen from FIG. 1, some parts of the sides 6 and 7 of the prism are not utilized for producing the desired effect. Therefore, it is possible to omit that corner of the prism, which is limited by sides 6 and 7 and the dotted line 10, in which case the principal section of the prism will have the form of an irregular pentagon.

FIG. 2 shows an embodiment including two prisms which are arranged symmetrically in relation to the perpendicular of the wall 2. Each of these prisms is of he same shape as prism 4 in FIG. 1. The two prisms 4 and 4*a* in FIG. 2 are so arranged that the edge formed by sides 6 and 8 of prism 4 engages the corresponding edge formed by sides 6*a* and 8*a* of prism 4*a*. The light beam falls centrally upon the photodetector. In the arrangement shown in FIG. 2 the diameter of the light beam can obviously be increased to $4a\sqrt{2}$.

For practical reasons it may be advantageous to extend the prism by a parallelepipedal portion as shown in FIG. 3. This FIG. like FIG. 2 shows two prisms 4 and 4*a* which are extended by parallelepipedal parts bounded by the sides 6, 7, 11, 12 and 6*a*, 7*a*, 11*a*, 12, respectively. The sides 11 and 11*a* have been indicated by dotted lines in the FIG. to indicate that the parallelepipedal parts can be integral with the other parts of the respective prisms. These parallelepipedal extension parts may, however, also be separate plates. If the arrangement comprises two prisms as shown in FIG. 3, these plates may be joined into one plate (the contact surface 12 is omitted).

It is also possible to use a prism of a rotationally symmetrical form, that is a prism whose section in a plane parallel to the wall 2 has the form of an annulus. A longitudinal section of an arrangement with a prism of this form would have the same appearance as the arrangement shown in FIG. 2 or FIG. 3.

The prism is preferably made of the same material as the wall 2 or at least of a material having the same optic properties.

We claim:

1. Photodetector system comprising a plane wall of transparent material, one side of which bears a coating of a material emitting electrons when exposed to light, at least one prism attached to the other side of said wall, the principal section of said prism having the form of a polygon with at least two parallel sides, a first one of said parallel sides being in contact with the wall at a central part thereof and in front of said coating, and two of the nonparallel sides of the prism forming such angles to said parallel sides that light entering the second one of said two parallel sides at right angles thereto is in part reflected by one of said nonparallel sides towards the other one of the nonparallel sides and reflected towards said wall by the last-mentioned side, while another part of the light entering said second one of said parallel sides at right angles thereto is reflected by one of said nonparallel sides directly towards said wall, so that both the light reflected by one of said nonparallel sides and the light reflected by both of said nonparallel sides enters said wall under an angle of about 45°.

2. A system as claimed in claim 1, characterized in that the part of said prism which abuts said wall has a length about twice the thickness of said wall.

3. A system as claimed in claim 1, characterized in that one of said nonparallel sides of said prism forms an angle of 22.5 ° with the perpendicular of said wall, while the other one of said two nonparallel sides forms a right angle with said wall.

4. A system as claimed in claim 3, characterized in that the distance between said two parallel sides of the principal section of said prism is at least equal to $a\ (4+2\sqrt{2})$, wherein a designates the thickness of said wall.

5. A system as claimed in claim 3, characterized in that the distance between said two parallel sides of the principal section of said prism is larger than $a\ (4+2\sqrt{2})$ wherein a designates the thickness of said wall, and that the part of said prism which is situated at a larger distance than $a(4+2\sqrt{2})$ from said wall has a rectangular cross section.

6. A system as claimed in claim 3, and further comprising another prism, said prisms being arranged side by side so that an oblique side of one of the prisms faces the corresponding side of the other of said prisms.

7. A system as claimed in claim 3, characterized in that the prism in a section parallel to the wall has a rotationally symmetrical form.