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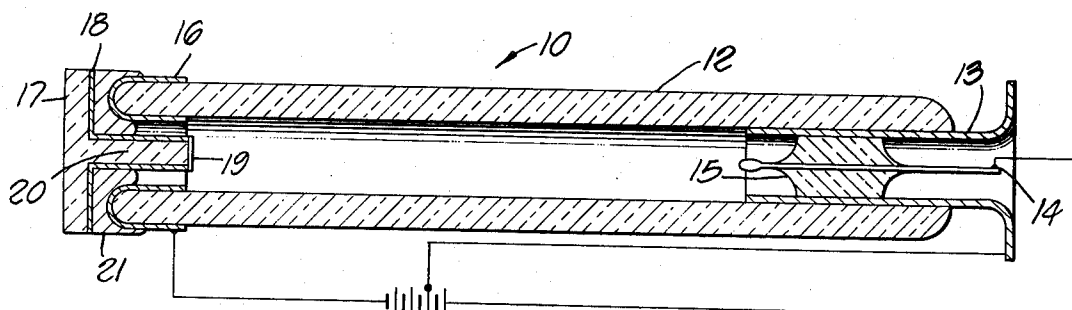
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[54] **TUBULAR PHOTOCELL WITH SECONDARY EMISSION FROM INTERNAL SURFACE**
4 Claims, 4 Drawing Figs.

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 250/211 R, 313/103, 313/95
 [51] Int. Cl. **H01J 39/12**
 [50] Field of Search. 250/207,
 211; 313/103, 94, 95, 102

ABSTRACT: A photocell using channel-type electron multiplier operation. The photocell has a glass body which acts as a structural portion of an evacuated envelope and, at the same time, is provided with one or more holes therethrough which have surfaces that will support secondary emission.

The method of the invention utilizes a molten metal to seal off all the envelopes in a group simultaneously. The method, thus, achieves high-production efficiency.



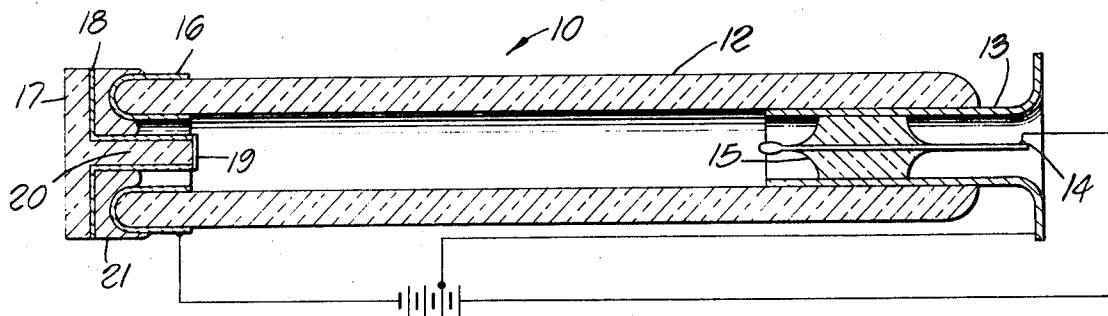


FIG. 1.

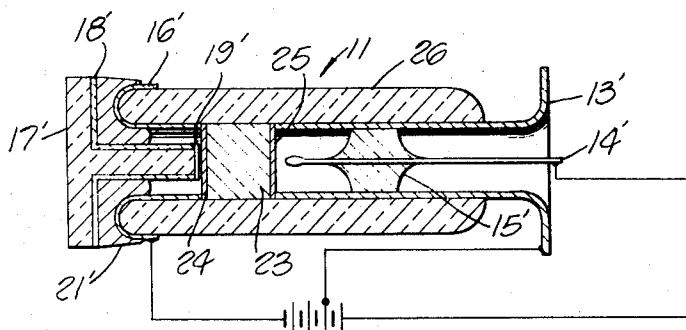


FIG. 2.

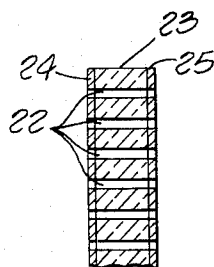
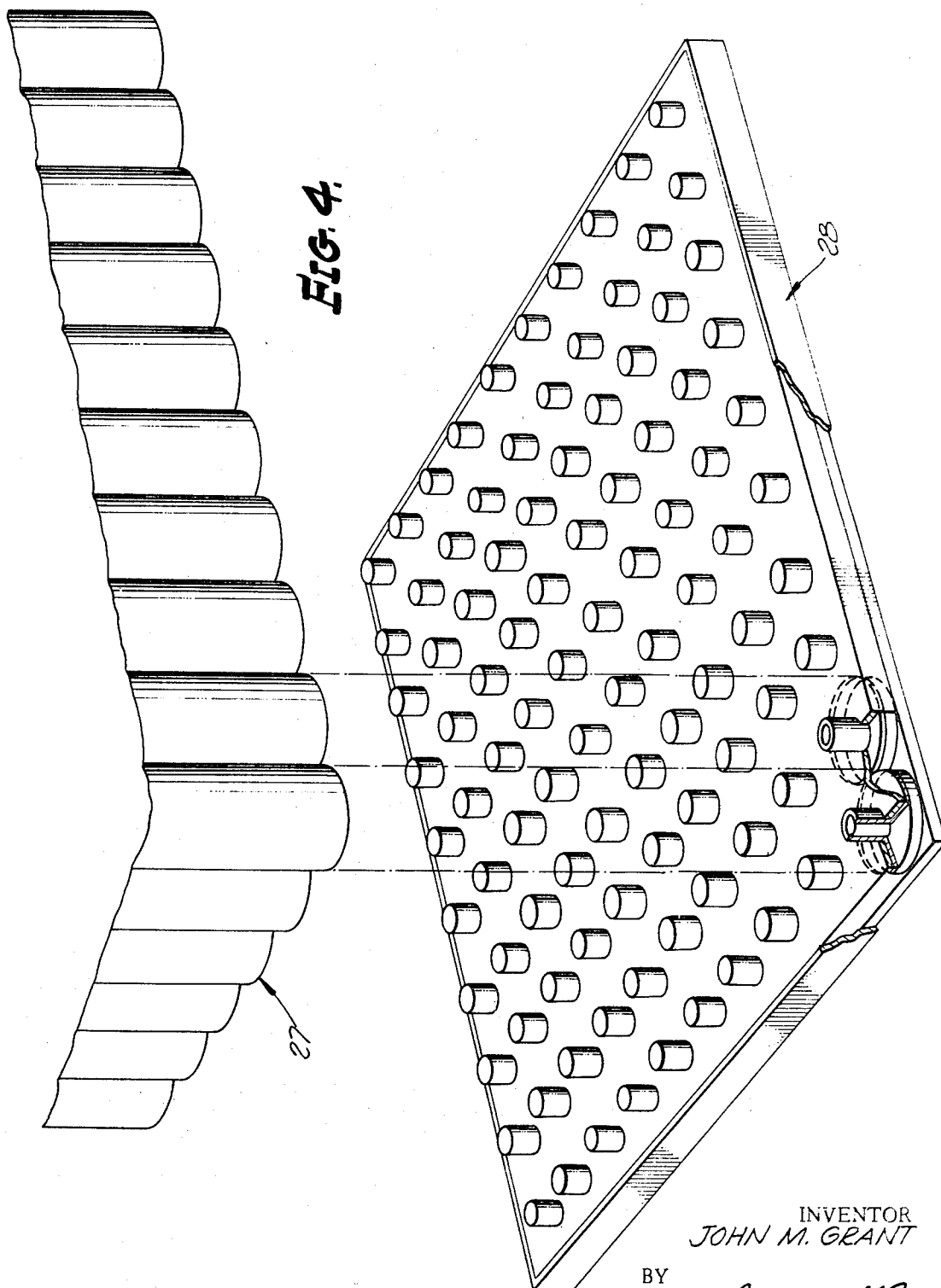


FIG. 3.

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TUBULAR PHOTOCELL WITH SECONDARY EMISSION FROM INTERNAL SURFACE

BACKGROUND OF THE INVENTION

This invention relates to photoelectric devices and, more particularly, to photocells and a method of making a large group of them at one time.

In the past, photocells have been made with the use of dynode electron multipliers. These prior art photocells have been relatively large in size due to the use of the dynode multipliers. Further, prior art photocells have not been adapted to mass production techniques.

SUMMARY OF THE INVENTION

In accordance with the present invention, the above-described and other disadvantages of the prior art are overcome by providing a photocell with a channel-type electron multiplier. Due to the fact that such multipliers are generally made of glass, the glass can be used as part of a photocell evacuated envelope as well as part of a multiplier. The size of such a photocell may, thus, be reduced to an extraordinary degree. Further, by use of the method of the invention, the envelopes of a large number of photocells may be sealed simultaneously to a corresponding number of light inlet windows for high production efficiency.

The above-described and other advantages of the invention will be better understood from the following description when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a longitudinal sectional view of a photocell constructed in accordance with the present invention;

FIG. 2 is a longitudinal sectional view of an alternative embodiment of the invention;

FIG. 3 is a longitudinal sectional view of a channel-type electron multiplier; and

FIG. 4 is a perspective view of photocell assemblies illustrating the method of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The photocell structures of the present invention are shown at 10 and 11 in FIGS. 1 and 2, respectively. In FIG. 1, an outer cylinder 12 forms the tube envelope and, at the same time, serves as the channel multiplier. The cylinder 12 can be made from various types of ceramics or glasses, but the most successful material to date has been lead-doped glass. An electrical feedthrough is sealed to one end of the cylinder 12. This feedthrough consists of an outer metal cylinder 13 which makes electrical contact to the channel walls and a second metal conductor 14 insulated from cylinder 13 by a suitable ceramic or glass dielectric 15. The subassembly of cylinder 13, conductor 14, and dielectric 15 is sealed to cylinder 12 with a conventional glass seal or other suitable material.

If cylinder 12 is made of lead glass, the subassembly of cylinder 12, cylinder 13, conductor 14, and dielectric 15 is hydrogen-fired to develop the proper surface conductivity on the channel wall, i.e., the internal cylindrical surface of cylinder 12. If the conductivity of the cylinder 12 is determined when the cylinder is formed, as in the case of several semiconducting glasses and ceramics, this additional step is not necessary.

The open end of cylinder 12 is then evaporated with copper layer 16 or other suitable metal. The purpose of layer 16 is twofold: It insures a good electrical contact to the secondary emissive surface, particularly when the channel fields are determined by the surface conductivity; and it also provides a surface to which indium and/or indium alloys wet readily. The internal surface of cylinder 12 supports secondary mission.

A tube window 17 is provided which can be constructed from any one of a variety of common glasses by any conven-

tional extruding, grinding, photoetching, or a number of other glass-forming techniques. Window 17 is evaporated with a copper layer 18 of other metal. A photocathode is fixed to an end projection 20 of window 17. Layer 18 makes contact to photocathode 19 and also serves as a wettable surface for indium and its alloys.

The copper-coated window 17 is heated and a layer 21 of indium or indium alloy is applied to the copper layer 18. The subassembly of cylinder 12 with layer 16 and all the structure at the right end of cylinder 12 is mounted with layers 18, 21, and window 17 in a conventional bakeable vacuum chamber equipped with evaporation sources and materials for forming the desired photocathode 19. The photocathode 19 is formed, and then the two subassemblies are brought together. The temperature of the subassemblies is raised to the melting point of the indium, and the two subassemblies are sealed together.

The operation of the photocell 10 is straightforward. A potential difference is applied between layer 16 and cylinder 13, the latter being positive with respect to the former. This establishes the appropriate fields along the internal surface of cylinder 12. Electrons emitted from photocathode 19 are multiplied by repeated impacts with the secondary emissive internal surface of cylinder 12. The multiplied current is then collected at conductor electrode 14 which is maintained at a positive potential relative to cylinder 13.

A second version of a miniature photocell 11 is shown in FIG. 2. This tube 11 differs from that in FIG. 1 in that it contains a mosaic array or plate 23 of channels 22. This is shown in FIG. 3. Also, see *Electro-Optical Systems Design*, Nov./Dec., 1969, page 50.

Plate 23 is made of glass and has holes or channels 22 which have surfaces that will support secondary emission. Plate 23 has evaporated, conductive electrodes 24 and 25 fixed thereto which have holes the same size as and which lie in registry with channels 22. The electrodes 24 and 25 lie in electrical contact with the secondary emissive surfaces of channels 22 at corresponding ends thereof. Plate 23 may be sealed to the internal wall of cylinder 26.

Since the channel diameter in a mosaic array can be quite small, the length of the channels can also be reduced. This permits a significant shortening of the tube compared to a single channel version. However, identical parts are indicated by prime reference numerals. Glass cylinder 26 is identical to cylinder 12 except that the former is shorter than the latter.

Plate 23 with electrodes 24 and 25 may be made by a conventional process. When cylinder 13' and window 17' are sealed as before, both are made to physically contact the respective faces of the electrodes 25 and 24. In the case of the contact between window 17' and electrode 24, a concave or recesses area may be preformed therein, if desired, to prevent field emission and damage to the photocathode 19' when the contact is made.

Both of the photocells 10 and 11 are readily adaptable to multiple cathode processing and sealing techniques. Subassemblies of 12, 13, 14 15, and 16 or 26, 13', 14', 15', 16', 23, 24, and 25 are first formed and arranged in a mosaic array 27 as shown in FIG. 4. Windows 17 or 17' can be made from a single piece of glass which has been extruded, ground, or photoetched.

Since the shape of the photocathode substrate is not important, projections 20 can have any cross section which is convenient. It is, however, necessary for sealing and optical transmission that the windows be polished to at least a window glass finish.

Windows 17 or 17' are then assembled in a tray 28 as shown in FIG. 4. This tray should be semitransparent to permit optical monitoring of the photo surface while it is being formed. The tray should be capable of providing good thermal contact to windows during the sealing process. One method of accomplishing this is to make the bottom of the tray out of glass and recess a nichrome heater wire. Windows 17 and 17' are then evaporated with copper or other suitable metal. The copper is wiped from the cathode area, and the plate is covered with in-

dium or an indium alloy. It is recommended that indium be applied in a vacuum to limit the amount of surface oxide formed, but this is not absolutely necessary.

Mosaic array 27 and windows 17 and 17' are mounted in bakeable vacuum chamber equipped with evaporation sources and material for cathode processing. The cathode is formed on the cylindrical projections 20 of windows 17 and 17'. Mosaic array 27 is then moved into position over the ends of windows 17 and 17'. The indium or indium alloy is then heated to its melting point, and the final seal is made by pushing the mosaic array 27 of tube envelopes into the molten indium and letting the indium cool. The tubes are then removed from the vacuum chamber and separated by cutting the indium layer between tubes.

What is claimed is:

1. A photocell comprising:

a hollow, evacuated generally tubular dielectric body having a partially conductive internal surface adapted to support secondary emission;

first means for enclosing a first end of said body, said first means including a copper layer fixed around said first end of said body, said layer extending over a portion of the exterior surface of said body and to a predetermined distance within, and in electrical contact with, said internal surface;

window means including a substantially translucent circular disc having an integral, substantially concentric, solid, cylindrical projection from one face thereof, said window means also having a copper layer substantially covering the cylindrical periphery of said projection and the portion of said disc radially outward from said projection;

a photocathode affixed to the free end of said projection; means comprising an indium seal holding said window in place with said photocathode projecting within said first

end of said body, said indium providing a vacuum seal between said first means and said window means copper layer;

third means at the second end of said body, said third means including a cylindrical layer of copper sealed within a portion of said second end and in electrical contact with said internal surface, an electrode inserted substantially coaxially within said cylindrical layer into said second end of said body, and dielectric sealing means holding and vacuum sealing said electrode in place;

first potential means operative between the copper layer of said first means and said cylindrical copper layer of said third means for energizing said internal surface, said third means connection being the more positive in polarity;

and second potential means for energizing said electrode of said third means at a more positive potential than the maximum positive potential of said internal surface.

2. The invention as defined in claim 1, wherein said body is a channel-type electron multiplier.

3. Apparatus according to claim 1 in which said body includes a channel-type electron multiplier, said internal surface includes the internal surfaces of the plural channels of said multiplier and said copper layer of said first means and said cylindrical copper layer of said third means are extended within said body to cover the channel input and output faces of said multiplier, respectively.

4. Apparatus according to claim 1 further defined in that said internal surface exhibits a potential gradient as a result of said first potential means, thereby to effect secondary electron emissions from said internal surface in response to primary electrons emitted by said photocathode, and said electrode of said third means acts as an anode for collecting said secondary emission electrons.

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