

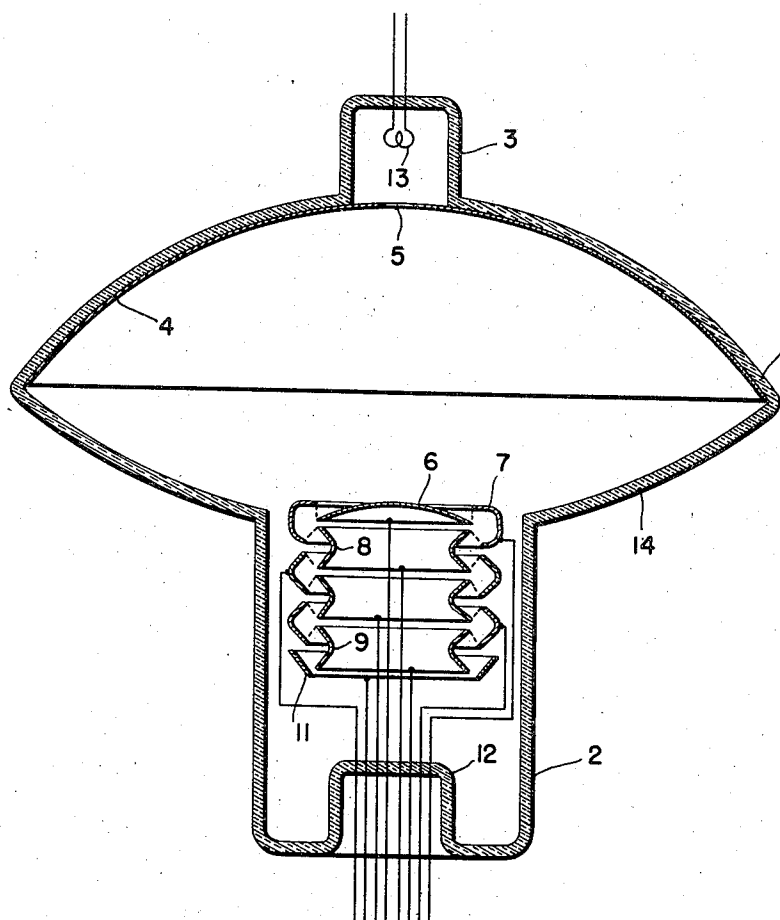
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PHOTOELECTRON MULTIPLIER

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PHOTOELECTRON MULTIPLIER

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This invention relates to phototube apparatus and particularly to phototubes having large light gathering properties suitable for use in conjunction with electron multipliers.

It is customary to employ phototubes for the conversion of light energy into electrical energy in numerous cases. The electrical energy developed by the photosensitive cathode of a phototube ordinarily is of insufficient magnitude for most uses. In order that such energy be utilized, it is necessary to amplify it by some means. Inasmuch as thermionic amplifiers, by reason of some of their inherent characteristics, develop spurious electrical effects commonly called "noise," they are not particularly well suited for amplifying phototube-developed electrical energy, since this energy is of an order of magnitude comparable to that of the thermionic amplifier-developed noise effects. Consequently, amplifiers of the electron multiplier type are preferred for magnifying the relatively small electrical effects developed by phototubes in response to light incident upon the cathodes thereof.

Electron multipliers characteristically are devices in which any spurious electrical effects developed are of relatively low magnitudes. There are numerous uses of phototubes combined with electron multipliers, where it is undesirable to position the multiplier so that it will obstruct any substantial portion of the light which it is desired to project onto the phototube cathode. Consequently, there have been developed numerous structural arrangements in which the electron multiplier is located effectively on the side of the cathode remote from the photosensitive surface thereof. These arrangements, in most instances at least, have not included cooperating optical systems.

The photosensitive cathode surfaces which have been found particularly effective for translating light into electron energy are formed first by depositing upon a preferably metallic surface an oxide of an alkali or earth metal such as caesium. Such surfaces have been found to be materially improved, however, by the subsequent deposition upon the caesiated surface of the cathode of a metal, such as silver, which may be vaporized readily. One means for effecting this evaporation is to introduce into the evacuated vessel, in which is mounted the caesium sensitized cathode, a small filamentary wire such as tungsten, coated with a small amount of silver. In order that the deposit of the additional sensitizing material such as silver be uniformly distributed over the entire cathode surface, it is nec-

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essary that the sensitizing apparatus be located symmetrically with respect to all points of the cathode surface and somewhat removed therefrom.

Obviously, in apparatus of this character known to the prior art, it is not possible to locate the silver sensitizing apparatus in a position to effect the desired uniform sensitization of the cathode without obstructing a substantial portion of the light which it is desired to project onto the cathode. Inasmuch as the silver sensitizing of the cathode is done after the vessel has been evacuated, usually this apparatus is left in place after it has been utilized for the remainder of the life of the phototube device in order not to additionally complicate the tube structure necessary to remove it from the light path. It also is necessary to so locate the silver sensitizing device that, upon evaporation, the silver is deposited only on the phototube cathode and not upon any of the transparent walls of the envelope of the device. Consequently, it is necessary to provide a means for suitably shielding the envelope walls from the silver sensitizing apparatus.

It is an object of the present invention, therefore, to provide a phototube of such construction that the cathode thereof may be additionally sensitized, after evacuation of the vessel in which it is mounted, without obstructing any substantial portion of the light which it is desired to project upon the cathode.

In accordance with this invention, there is provided a phototube having a photosensitive cathode. If electron multiplying apparatus also is to be used it is effectively disposed with respect to the cathode to receive photoelectrons from the photosensitive surface thereof. There also is provided a reflecting member facing the photosensitive surface of the cathode. Light is redirected from the reflecting member onto the cathode. Also, opposite the cathode there is located sensitizing apparatus. For this purpose the reflecting member may be provided with an aperture opposite to the cathode, behind which there is located the sensitizing apparatus which, upon energization, effects the evaporation of the sensitizing material. The reflecting member aperture, if desired, may be so dimensioned that, with respect to its location relative to the sensitizing apparatus and the cathode surface, the vaporized sensitizing substance is directed only onto the cathode surface.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description,

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taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

The single figure of the drawing is a longitudinal cross sectional view of a phototube multiplier embodying the present invention.

Having reference now to the drawing, there is shown an evacuated envelope 1, having a stem 2 projecting from one end thereof and a small projection 3 extending from the opposite end thereof. In this embodiment of the invention there is provided a concave light reflecting member 4 formed on the inside of a similarly shaped end wall of the tube envelope. Such a reflector may consist of a metallic wall coating such as aluminum, which may be deposited on the interior surface of the tube wall in any well known manner. Alternatively, the reflector may be an independent member mounted either inside or outside of the tube envelope. The reflector is provided with a centrally disposed aperture 5 providing communication between the main body of the tube 1 and the space enveloped by the projection 3.

A substantially circular cathode 6, having a convex photosensitive surface facing the concave reflector 4 and substantially concentric therewith is disposed in the mouth of the tube stem 2 substantially as shown. Adjacent the peripheral edge of the cathode there is mounted a first stage annular multiplier electrode 7. This electrode is provided with a substantially concave interior secondary electron emissive surface. On the side of the cathode remote from the photosensitive surface thereof, there is mounted a second stage multiplier electrode 8. This electrode also has an annular configuration and is provided with a substantially concave exterior surface which is capable of secondary electron emission. The second stage electrode 8 is so arranged with respect to the first stage electrode 7 that it is capable of receiving electrons emitted from the first stage electrode. Additional annular secondary electron emissive multiplier electrodes are provided in any desired number. These electrodes are serially arranged in a manner well known in the art so that they each may receive electrons from the immediately preceding stage and also may provide access for the secondary electrons emitted thereby to the immediately succeeding electrode. Adjacent to the final secondary emissive multiplier electrode 9 there is provided an annular electron collecting electrode 11.

The cathode 6, the multiplier electrodes such as 7, 8 and 9, and the collector electrode 11 are connected by suitable conductors sealed through the press portion 12 of the tube to an external source of energy whereby the desired electron accelerating potentials may be impressed upon the electrodes. In accordance with well known practice, the potential impressed upon each electrode is more positive than that impressed upon the immediately preceding electrode.

In the tube projection 3 there is disposed a loop 13 of filamentary material upon which there may be provided a coating of silver or other suitable sensitizing metal. Alternatively, a globule of silver may be located in the tube projection in proximity to the filamentary loop or other suitable source of heat, which latter apparatus may, if desired, be located externally of the tube. Electrical conducting leads connected to the terminals of the filament 13 are sealed through the wall of the tube projection 3 for connection to an external source of energy suitable for heating the

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filament sufficiently to vaporize the material with which it is coated. The filament is located in alignment with the reflector aperture 5.

In fabricating the tube, the convex surface of the cathode 6 initially is sensitized in a well known manner, such as by the evaporation of caesium from some salt thereof, whereby the caesium is deposited and combined with a layer of silver oxide which previously has been deposited on the cathode. Finally, in order to additionally sensitize the cathode surface, the filament 13 is heated as described. The silver thereby is vaporized and passes in vapor form through the reflector aperture 5 to be deposited on the caesium sensitized surface of the cathode. The size of the aperture 5 is made only sufficient to permit the vaporized silver to reach the cathode surface in a substantially uniform density distribution over the area of the cathode. By this means the silver is prevented from being deposited on the wall of the tube opposite to the reflector 4. Thus, this tube wall is maintained in a transparent condition.

There is thus produced a supersensitive cathode surface. The disposition of the cathode in relation to the reflector 4 and the transparent tube wall 14 is such that substantially all of the light transmitted through the transparent wall ultimately is directed onto the photosensitive surface of the cathode 6. In response to the light incident upon the cathode, there is developed electron energy. The electrons are drawn away from the cathode surface into the first stage multiplier electrode 7. By reason of the electron accelerating potential impressed between the cathode 6 and the electrode 7, these electrons strike the interior surface of the multiplier electrode with sufficient velocity to effect the emission of a multiplied number of secondary electrons. The electron multiplication process is continued in a well known manner through the succeeding multiplier stages and the greatly multiplied number of electrons finally is collected by the collector 11. This electrode is connected to an output circuit of well known form wherein the collected electrons are suitably employed to develop electrical voltages in correspondence with the number of collected electrons.

The invention is contemplated to include numerous electrode configurations and arrangements other than those specifically shown and described herein. In accordance with the basic concept of the invention, the reflecting optical system may be mounted either inside of the tube, as illustrated, or in any other manner, or outside of the tube, so long as it faces the cathode. Also, the surface configurations of the reflector and the cathode need not be as illustrated. Additionally, other types of electron multipliers having electrodes shaped differently from those shown and described may be used with substantially equal facility. In accordance with present knowledge the electron multiplier may be located in other positions, whereby it may be rendered capable of receiving photoelectrons emitted by the cathode without departing from the scope of the invention. For example, it may be disposed opposite to the cathode as in numerous well known devices such as a television dissector tube. Furthermore, it is considered to be within the scope of the present invention that the sensitizing apparatus may be located in front of the reflecting member in which case a suitably shaped directing means may be provided for confining the sensitizing material in such a manner that it is deposited only on the cathode surface. It is obvious that,

whether the sensitizing apparatus be located in front of or behind the reflector, only a relatively small portion of the incident light is rendered ineffective for producing a corresponding response by the cathode.

It, thus, is seen that, by reason of the arrangement of the cathode, the reflecting optical system and the silver sensitizing apparatus, there is produced a phototube having a supersensitized cathode surface, and, at the same time one in which the maximum incident light may be used.

While there has been described what, at present, is considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications such as those indicated hereinbefore may be made therein without departing from the invention, and therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a phototube, a cathode having a photosensitive surface, an apertured light reflector disposed opposite to said cathode, and sensitizing apparatus disposed behind said reflector aperture for depositing photosensitizing material on the surface of said cathode.

2. A phototube multiplier comprising, a cathode having a photosensitive surface, an apertured light reflector disposed opposite to said cathode, an electron multiplier disposed adjacent said cathode, and sensitizing apparatus disposed behind said reflector aperture for depositing photosensitizing material on the surface of said cathode.

3. A phototube multiplier comprising, a cathode having a photosensitive surface, an electron multiplier disposed on the side of said cathode remote from the photosensitive surface thereof, an apertured light reflector disposed opposite to said cathode, and sensitizing apparatus disposed behind said reflector aperture for depositing photosensitizing material on the surface of said cathode.

4. A phototube multiplier comprising, a cathode having a photosensitive surface, a plurality of electron multiplier electrodes disposed on the side of said cathode remote from the photosensitive surface thereof, one of said multiplier electrodes having the electron entrance opening thereof adjacent to said cathode, an electron collector electrode disposed adjacent to another one of said multiplier electrodes, a light reflector disposed opposite to the photosensitive surface of said cathode, said reflector being provided with an aperture, and sensitizing apparatus disposed behind said reflector aperture for depositing a uniformly distributed layer of photosensitizing material on the surface of said cathode.

5. A phototube multiplier comprising, a cathode having a photosensitive surface, a plurality of serially mounted electron multiplier electrodes disposed on the side of said cathode remote from the photosensitive surface thereof, an end one of said multiplier electrodes having the electron entrance opening thereof adjacent to said cathode, an electron collector electrode disposed adjacent to the other end one of said multiplier electrodes, a light reflector disposed in spaced relation to and facing the photosensitive surface of said cathode, said reflector being provided with an aperture opposite to said cathode, and an evaporator of sensitizing material disposed behind said reflector aperture in alignment with said cathode, whereby when operative to effect the deposit of a uniformly distributed layer of photosensitizing material on the surface of said cathode.

6. A phototube multiplier comprising, a substantially circular cathode having a convex photosensitive surface, a plurality of serially mounted annular electron multiplier electrodes disposed on the side of said cathode remote from the photosensitive surface thereof, an end one of said multiplier electrodes having the electron entrance opening thereof adjacent to the peripheral edge of said cathode, an electron collector electrode disposed adjacent to the other end one of said multiplier electrodes, a concave light reflector disposed in spaced relation to and facing the photosensitive surface of said cathode, said reflector being provided with an aperture opposite to said cathode, and a silver evaporator disposed behind said reflector aperture in alignment with said cathode, whereby when operative to effect the deposit of a uniformly distributed layer of silver on the photosensitive surface of said cathode.

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