March 30, 1948. A. H. TAYLOR 2,438,587

PHOTOTUBE CONTAINING MEANS TO COUNTERACT NEGATIVE WALL CHARGES

Filed Dec. 24, 1943

Fig. 1.

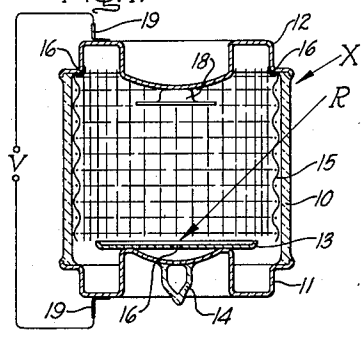


Fig. 2.

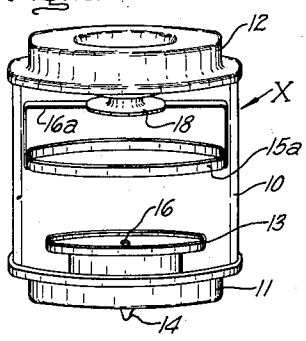


Fig. 3.

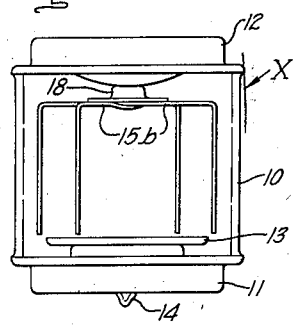
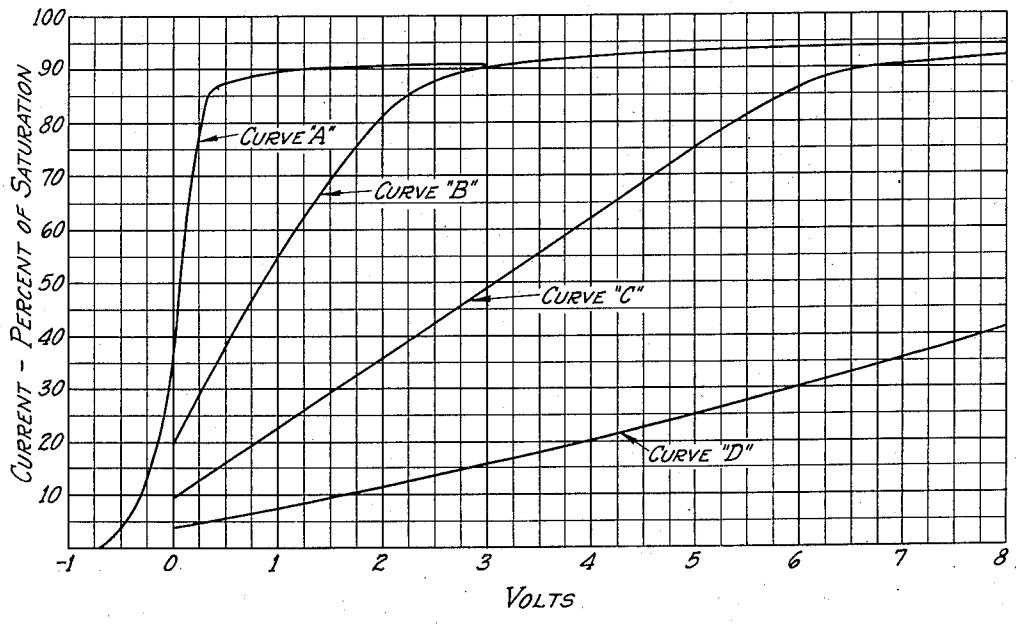


Fig. 4.



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PHOTOTUBE CONTAINING MEANS TO COUNTERACT NEGATIVE WALL CHARGES

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5 Claims. (Cl. 250—165)

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This invention relates to electric discharge devices in which the discharge is a space current consisting of electrons, as distinguished from a current in ionized gas or vapor, and relates particularly to photoelectric cells and the like. The invention aims at minimizing the impedance offered by the cell to the passage of current under any given conditions of applied voltage and incident light, thus allowing the current to reach a desired value under a lower applied voltage on the cell. The invention is here explained with particular reference to a simple type of photocell having an envelope formed of a vitreous tube with sheet metal end walls or headers, and having a cathode surfaced or activated with an antimony and caesium combination; but it will be understood that it is applicable to other types of photocells and to other types of discharge devices, such as electron multipliers, for example. Various features and advantages of the invention will appear from the description of species and forms of embodiment, and from the drawings.

In the drawings, Fig. 1 shows a vertical longitudinal section through a photocell conveniently embodying the invention; Fig. 2 is a tilted side view of a photocell embodying the invention in a different form; Fig. 3 is a side view of a cell embodying the invention in another form; and Fig. 4 is a diagram showing current and voltage curves characteristic of the several cells shown in Figs. 1, 2, and 3.

A photocell device X is shown in the figure as comprising a short vitreous or glass envelope tube 10 having its ends sealed by fusion to the margins of abutting annularly embossed discs or electrode headers 11, 12 of sheet metal (such as chrome iron or "Allegheny 55," as it is commercially known), generally similar to those used for the ends of the tubular incandescent lamps commercially known as "Lumiline" lamps. The cathode header 11 which appears at the bottom in Fig. 1 carries a coaxial sheet metal cathode disc 13 (as of Nichrome or nickel) welded thereto and shown with its outer edge turned up toward the anode header 12. In practice, the tube 10 may be of about ⅞ inch cylindrical bore and about ¾ inch long in the axial direction. The sealed-off remainder of a glass appendix or exhaust tube 14 is shown attached or sealed by fusion to the outer side of the centrally apertured header 11, substantially coaxial with its aperture and with a corresponding central opening 18 in the disc 13. The anode header 12 which appears at the top of the figure is not apertured, but carries a metal part 18 (as of nickel foil) that presents a substantially

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flat surface toward the cathode 13. Current connections 19, 19 are shown welded to the headers 11, 12. The cathode 13 may have a light-sensitive photoelectric emitting surface of any suitable character, such, for example, as an antimony-caesium combination formed by thermal deposition on the cathode first of antimony and then of caesium. The cell X is evacuated so thoroughly that current through it due to voltage across the electrodes is essentially a space current carried by electrons emitted from the cathode 13, as distinguished from a current in ionized gas or vapor.

As thus far described, the cell X and its mode of operation correspond essentially to those already known.

In the use of such a cell X, the current leads 19, 19 of the anode and cathode electrodes at opposite sides or ends of the cell (it is convenient to refer to the parts 11, 12 as "ends," without regard to the relative dimensions of the cell vertically and horizontally in Fig. 1) are connected across a suitable constant voltage source V as shown in Fig. 1, and a variable ray of light or other radiation R falls diagonally or slopingly on the cathode 13, after passing through the vitreous wall 10. The current through the cell under a voltage V of any given value varies according to or in proportion to the strength of the ray R. While the saturation current of the cell X is only reached under a relatively high voltage V, of the order of some 135 volts when the cell is constructed and proportioned as above described, 90 per cent of this current is reached under a very much lower voltage, of the order of only a few volts. It is desirable that some 90 per cent of the saturation should be reached under a relatively low voltage, lower, indeed, than is generally the case with the cells X heretofore known.

In accordance with this invention, the cell X is provided with a conductor or conductors extending to point(s) more or less adjacent the cathode 13, as compared with the anode 12, and also adjacent the tube wall 10, such conductor(s) being electrically connected to a source of potential less negative or more positive than the cathode. As shown in Fig. 1, the conductor means in question comprises a foraminous metal cylinder 15 of woven wire (e. g., 20 meshes per inch) that is substantially conformable to the interior of the envelope tube 10 and extends from adjacent the anode header 12 down to about the level of the cathode 13, but is separated from the periphery of the cathode; and this wire mesh lining 15 is connected directly to the anode header 12, as by one or more welds 16 within the cell. The effect

of this conductor means 15 thus connected is to reduce very much the voltage V on the cell X required to produce any desired current value: e. g., while an ordinary cell without my invention may generally require a voltage of 7 volts to give only some 35 to 90 per cent of the saturation current, a cell with the wire mesh 15 may be expected to give 90 per cent of the saturation current on no more than 1.2 volts.

Fig. 2 shows a cell X equipped with an annular band or hoop 15*a* of thin sheet metal or foil extending around in the envelope 10 adjacent the vitreous wall, preferably in contact therewith, with a sheet metal strip 16*a* welded across the anode part 18 diametrally of the vitreous tube 10 and having its ends bent down adjacent the vitreous wall and connected directly to the hoop 15*a*. As shown, the band 15*a* is at a level in the envelope 10 intermediate the end electrodes and sufficiently close to the cathode 13 to exert an effect very similar to that of the wire mesh 15: e. g., a tube so equipped may be expected to give 90 per cent of saturation current for a voltage of about 3 volts.

Fig. 3 shows a cell X equipped with wires 15*b* welded across the anode part 18 diametrally of the vitreous tube 10 and bent to extend down along the wall 10 parallel to its axis to points about level with the periphery of the cathode 13. As here shown, the wires 15*b* are arranged at right angles so that four equally spaced straight wires extend along the wall 10. This arrangement gives about the same results as that shown in Fig. 2.

In Figs. 2 and 3 various parts and features are marked with the same reference characters as their homologues in Fig. 1, as a means of dispensing with repetitive description.

Fig. 4 shows comparative voltage-current curves A, B for photocells equipped as illustrated in Figs. 1 and 2 or 3, respectively, and curves C, D for photocells having about maximum and minimum amounts of caesium (invisible in both cases) coating the wall 10, but without features 15, 15*a*, 15*b*.

As to why the conductor arrangements above described improve the degree of current saturation in the cell X in relation to the applied voltage, it appears that when the cathode 13 of a cell X without such a conductor arrangement is illuminated, some of the electrons photoelectrically emitted from the cathode collect on the inner surface of the glass wall 10 as a negative charge, which acts (like the negatively charged grid of a triode) to oppose the passage of electrons from the cathode to the anode. In other words, the voltage required to produce a given space current from the cathode to the anode is materially higher than if this negative charge on the wall 10 were not there. The effect of the conductor arrangements described is to counteract or neutralize the opposition to the space current due to collection of ions on the wall 10, to a greater or less degree, thus lowering the voltage on the cell X that is required to produce a space current of given value. Indeed, the conductor 15, 15*a*, or 15*b* results in actual neutralization of the negative wall charge to a very considerable extent, as will readily be understood by those versed in electrical science.

It is further to be remarked that in the manufacture of photocells X by usual methods involving thermal deposition of caesium on the cathode 13 after completion of the cell structure, some caesium is also naturally and unavoidably deposited on the inner surface of the vitreous

wall 10, although the layer is so thin as to be almost monatomic. It follows that light incident on the wall 10 causes photoelectric emission of negative electrons from the wall, resulting in a reduction or partial neutralization of its negative charge previously mentioned. If the incident light is well diffused over the whole area of the wall 10, the current reaches 90 percent saturation at a lower applied voltage than when only a ray or beam of light shines into the cell X on the cathode 13, as in the ordinary use of the cell.

In Figs. 2 and 3, various parts and features are marked with the same reference characters as those corresponding in Fig. 1, in order to dispense with repetitive description, a distinctive letter being added where such distinction is desirable.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A high vacuum space discharge phototube comprising a light-permeable vitreous tube; anode and cathode electrodes at opposite ends of said tube and adapted to coact with each other, said cathode being activated on its surface toward the anode and being exposed to the tube wall and thus photoelectrically responsive to light incident thereon through the lateral tube wall; and a conductor extending adjacent the lateral tube wall and said cathode and electrically connected directly to said anode, whereby it has substantially the anode potential, and being of small area compared to the tube wall area to leave the light shining through the lateral tube wall on said activated cathode surface substantially unobstructed; said conductor serving to neutralize negative wall charge on the lateral tube wall, without substantial diminution of the illumination of the cathode surface.

2. A high vacuum space discharge phototube comprising a light-permeable vitreous tube; anode and cathode electrodes at opposite ends of said tube and adapted to coact with each other, said cathode being activated on its surface toward the anode and being exposed to the tube wall and thus photoelectrically responsive to light incident thereon through the lateral tube wall; and a conductor extending around inside the tube adjacent the lateral tube wall intermediate said electrodes and electrically connected directly to said anode, whereby it has substantially the anode potential, and being of small area compared to the tube wall area to leave the light shining through the lateral tube wall on said activated cathode surface substantially unobstructed; said conductor serving to neutralize negative wall charge on the lateral tube wall, without substantial diminution of the illumination of the cathode surface.

3. A high vacuum space discharge phototube comprising a light-permeable vitreous tube; anode and cathode electrodes at opposite ends of said tube and adapted to coact with each other, said cathode being activated on its surface toward the anode and being exposed to the tube wall and thus photoelectrically responsive to light incident thereon through the lateral tube wall; and a plurality of conductors attached to said anode extending along the length of the tube wall, at intervals not exceeding substantially 90° therearound, into close proximity to but not touching the cathode, and being of small area compared to the tube wall area to leave the light shining through the lateral tube wall on said activated cathode surface substantially un-

obstructed; said conductors serving to neutralize negative wall charge on the lateral tube wall, without substantial diminution of the illumination of the cathode surface.

4. A high vacuum space discharge phototube comprising a light-permeable vitreous tube; anode and cathode electrodes at opposite ends of said tube and adapted to coact with each other, said cathode being activated on its surface toward the anode and being exposed to the tube wall and thus photoelectrically responsive to light incident thereon through the lateral tube wall; and a lining of wire gauze extending around the tube wall having one edge attached directly to the anode and its other edge adjacent but not touching the cathode and being relatively coarse to leave the light shining through the lateral tube wall on said activated cathode surface substantially unobstructed; said lining serving to neutralize negative wall charge on the lateral tube wall, without substantial diminution of the illumination of the cathode surface.

5. A high vacuum space discharge phototube comprising a light-permeable vitreous tube, metallic headers sealed to and closing the ends of said tube, anode and cathode electrodes at opposite ends of the tube adapted to coact with each other and mounted on and electrically connected to respective ones of said headers, said cathode being activated on its surface toward the

anode and being exposed to the tube wall and thus photoelectrically responsive to light incident thereon through the lateral tube wall, and a lining of wire gauze extending around the tube wall having one edge attached directly to the header carrying the anode and its other edge adjacent but not touching the cathode, said gauze being relatively coarse to leave the light shining through the lateral tube wall on said activated cathode surface substantially unobstructed and said gauze serving to neutralize negative wall charge on the lateral tube wall, without substantial diminution of the illumination of the cathode surface.

A. HADLEY TAYLOR.

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