Aug. 29, 1939. R. J. ERICHSEN 2,171,233

PHOTOTUBE

Filed Aug. 13, 1937

Fig. 1

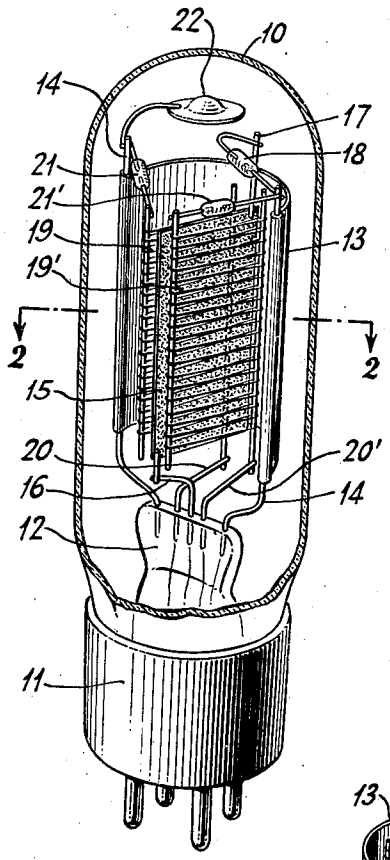


Fig. 2

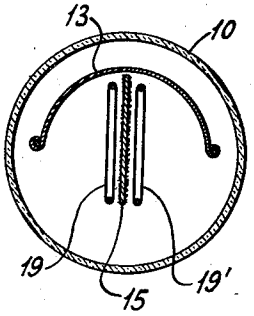
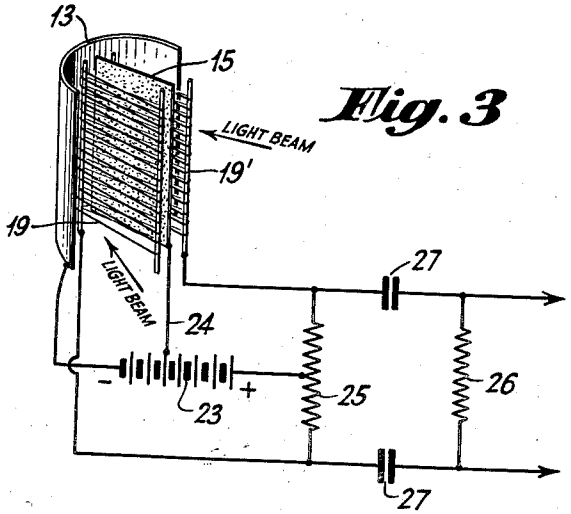


Fig. 3



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PHOTOTUBE

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2 Claims. (Cl. 250—166)

This invention relates to phototubes and more particularly to phototubes in which secondary emission is used to amplify the cathode current.

Vacuum type phototubes have been made in which amplification of the primary emission current is effected by utilizing the secondary emission from a large surface electrode called the secondary emitter cathode. These phototubes have an electrode, called the collector or accelerator, adjacent the secondary emitter cathode for collecting the secondary electrons emitted from the secondary emitter cathode and also to accelerate the primary electrons emitted from the photocathode. Such tubes can be used only with a single light source and because they have only a single output electrode are not capable of use in circuits such as push-pull circuits.

An object of this invention is to provide an improved vacuum type phototube in which secondary emission from a secondary emitter cathode is utilized to effect amplification of the primary emission from the photocathode and which is responsive to a plurality of light sources and capable of being used in circuits of the push-pull type.

A more complete understanding of the invention may be had by reference to the following description taken in conjunction with the accompanying drawing in which:

Figure 1 is a perspective view, with parts broken away, of a phototube made in accordance with the invention;

Figure 2 is a transverse section taken along line 2—2 of Figure 1, and

Figure 3 is a diagrammatic representation of the phototube and associated circuit.

The preferred form of phototube illustrated in Figure 1 as embodying one form of my invention is of the vacuum type and comprises a sealed evacuated bulb 10 enclosing the tube electrodes and having the usual base 11 and a reentrant stem 12 which carries an electrode assembly consisting of a photocathode and three cooperating electrodes, one of which is a secondary emitter cathode. The photocathode 13 shown in Figure 1 is a sheet of metal, preferably curved or semi-cylindrical, although it could be flat, and mounted on the stem on lead wires 14 in the usual way. The photocathode has on its concave side a light sensitive surface, such as the usual caesium oxide light sensitive surface. One way of preparing such a surface on silver is described in United States patent to Bainbridge No. 1,901,577, March 14, 1933.

The first cooperating electrode or secondary emitter cathode 15 is preferably a flat rectangular sheet of metal, such as silvered copper or polished nickel, set edgewise to the photocathode 13, and preferably lying in the diametrical plane with respect to which the semi-cylindrical cathode 13 is symmetrically disposed with the edge set close to the cathode so that the maximum amount of light may fall on the photocathode 13 and so that the two halves of the photocathode are shielded from each other. The secondary emitter cathode 15 is supported at one edge by a stem lead 16 and is steadied at the other edge by a brace comprising an extension 17 tied through an insulating bead spacer 18 to one of the leads 14 of the photocathode. The secondary emitter cathode may to advantage and for reasons which will be explained have a light sensitive surface.

In accordance with my invention the second and third cooperating electrodes or anodes are grid-like electrodes 19 and 19' interposed between the photocathode 13 and positioned on opposite sides of the secondary emitter cathode 15. These anodes may be similar to the regular flat grids used in radio receiving tubes. These grid shaped anodes or collector electrodes 19 and 19' are supported at the bottom by press leads 20 and 20' and are steadied by being tied at the top to leads 14 of the photocathode by insulating bead spacers 21 and 21'.

Thus, in the arrangement shown a separate beam of light can be directed on each half of the photocathode and the beam varied in any desired manner to produce varying currents in the collector electrode adjacent to the half of the cathode which is exposed to the light beam. This makes the tube particularly suitable for a push-pull circuit. Because the secondary emitter electrode is set edgewise it not only acts as a secondary emitter but forms an optical and electrostatic shield between the two halves of the photocathode so that there is no interference between the two. This tube not only has a better sensitivity than a gas filled tube but has better fidelity, stability and higher signal to noise ratio. While the tube is particularly suitable for use in push-pull circuits, it is also suitable for other circuit arrangements capable of using a pair of phototubes. It is much more simple than the use of two tubes or the usual multiple unit tubes and is also much more sensitive than conventional high vacuum phototubes due to the secondary emission amplification.

The caesium may be introduced into the tube during manufacture in various well known ways, one convenient way being to evolve caesium vapor

by heating a getter cup or holder **22** containing a reducible salt of caesium mixed with a reducing agent such as magnesium or silicon.

The photocathode structure as well as the exhaust and sensitizing processes employed in the manufacture of the phototube of the present invention are similar to those used in the manufacture of the well known thin film caesium oxide types of phototube. In the present tube the secondary emitter cathode surface may be prepared in the same manner as the photocathode surface, the object being to reduce the work function of the surface and thereby permit a copious secondary electron emission from the secondary emitter cathode to the collector electrode.

In ordinary operation the secondary emitter cathode is connected to a positive terminal of a source of direct potential and the collector electrodes connected to a higher positive potential, the photocathode being connected to the negative side of the voltage source or sources. During operation of the phototube connected as described above, the electrons which are emitted from the photocathode due to the action of the incident light are drawn towards the positively charged accelerator and secondary emitter electrodes. Some of these electrons are intercepted by the accelerator electrodes but the majority continue on through the interstices of this electrode to the secondary emitter cathode. The magnitude of the photo-electron current intercepted by the accelerator electrodes as well as the efficiency of these electrodes as collectors depends upon their configuration and disposition with respect to the other electrodes. The impact of these primary electrons upon the secondary emitter cathode causes an emission of secondary electrons from its surface. Such secondary electrons are collected by the more highly positive collector electrodes. The amount of amplification effected by this secondary or auxiliary electron emission depends upon the ratio of the secondary electrons, thus emitted, to the primary electrons. If the number of secondary electrons per primary electron is greater than unity, an amplification has taken place.

Figure 3 illustrates diagrammatically a phototube of the type shown in Figure 1 connected in a suitable push-pull circuit. A supply battery **23** has its negative pole connected to the photocathode **13**, its intermediate terminal **24** connected to the secondary emitter cathode **15**, and its positive pole connected to the resistor **25** intermediate its ends, the grid shaped anodes or collector electrodes **19** and **19'** being connected to opposite ends of the resistor. Both the secondary emitter cathode and the anodes are positive with reference to the photocathode **13**, the anodes being at a higher positive potential with respect to the cathode **13** than the secondary emitter cathode **15**. The output or work circuit **26** is connected through condensers **27** across resistor **25** and to the collector electrodes **19** and **19'**. When the photocathode **13** is illuminated it emits electrons which in turn cause an emission of secondary electrons from the secondary emitter cathode **15** in the manner explained above. These secondary electrons being collected by the collector electrodes **19** or **19'** depending upon which half of the photocathode is illuminated to cause a flow of current in the circuit between the electrodes **19** and **19'** and the photocathode **13**. This current flowing through the resistance **25** builds up across this resistance a voltage which may be utilized in the output circuit **26** in any desirable manner.

In the constructions described above secondary emission may be obtained from either the collector or the secondary emitter cathode by suitable adjustment of the voltages applied to these elements. The electrode which is to serve as the collector should be always maintained at a higher potential than the secondary emitter cathode.

While a general description and a few specific examples of my invention have been described and illustrated it is to be understood that many other modifications are contemplated, all of which come within the scope of the appended claims.

What I claim as new is:

1. A phototube comprising a semi-cylindrical shaped light sensitive photocathode, a thin flat light sensitive secondary emitter cathode set edgewise to said photocathode and sufficiently close to prevent reflected light and electrons from either side of the secondary emitter going to the other side of said secondary emitter, and a flat grid-like collector electrode positioned on each side of said secondary emitter cathode, each of said collector electrodes being separate and distinct and electrically insulated from the other.

2. A phototube having a semi-cylindrical light sensitive photocathode the concave surface of which is coated with light sensitive material, a solid flat secondary emitter cathode diametrically positioned with respect to the concave coated surface of said photocathode and with its edge closely adjacent to but not contacting said photocathode, and a grid-like collector electrode on each side of and parallel to said secondary emitter cathode, each of said collector electrodes being separate and distinct and electrically insulated from said other collector electrodes.

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