April 14, 1936. D. G. HAINES 2,037,075

PHOTOTUBE

Filed Oct. 25, 1933

FIG. 1

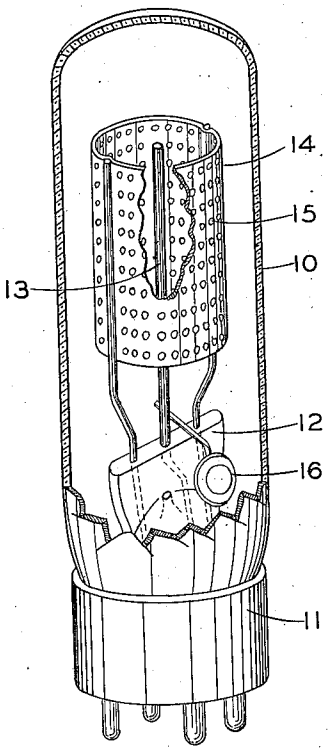


FIG. 2

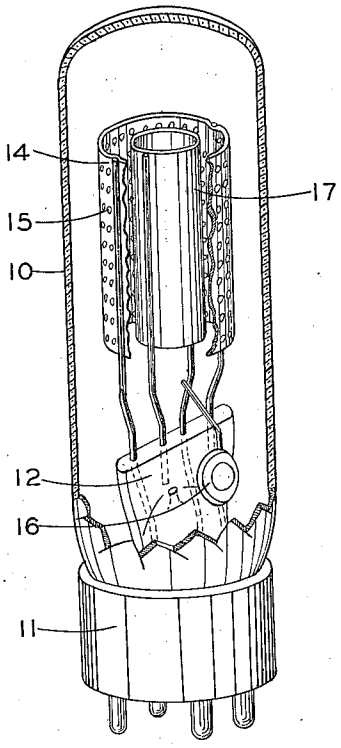
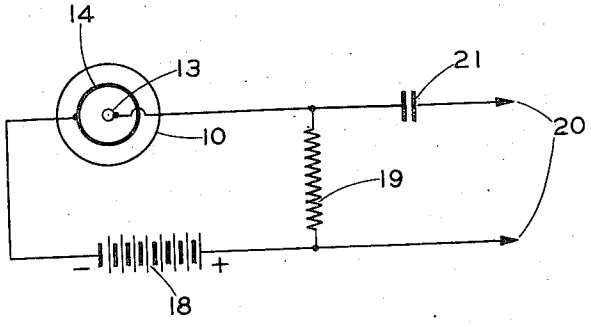


FIG. 3



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PHOTOTUBE

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3 Claims. (Cl. 250—27.5)

This invention relates to phototubes and more particularly to a photocathode or light sensitive element for such tubes.

A well known type of phototube has a concave photocathode, usually semi-cylindrical, and a rod anode positioned approximately at the focus or axis of the cathode. As the effective light sensitive surface of such a cathode is the concave surface, the incident beam of light must be within a comparatively narrow angle and the total useful electron emission is determined by the surface area of the concave side of the photocathode.

One object of my invention is to provide a phototube having a light sensitive element energized by diffused incident light or by light falling upon it from any and all directions.

Another object of my invention is to provide a phototube cathode so constructed that the photo emission from its entire surface is useful in the operation of the tube.

In one embodiment of my invention the light sensitive photocathode is approximately cylindrical, and is made of sheet metal perforated with a large number of holes or openings of any desired shape and of a diameter several times the thickness of the sheet metal. These openings are preferably so distributed that the solid metal of the cathode constitutes about one-half its surface. The entire surface of this photocathode, both inside and outside, is light sensitized by some well known method, such as that used to make thin film caesium oxide photocathodes. The straight or rod anode, mounted within and at the center of the cylindrical photocathode, draws photoelectrons emitted by the outside of the photocathode through the holes in the cathode so that the photo emission from both the inside and the outside surfaces is utilized.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, will be best understood by reference to the following description taken in connection with the accompanying drawing in which:

Figure 1 is a perspective view with parts broken away of a phototube constructed in accordance with my invention;

Figure 2 is a perspective view of a modification of the phototube shown in Figure 1;

Figure 3 is a circuit diagram of a representative type of circuit in which the phototubes of Figures 1 and 2 may be operated.

The preferred phototube construction illustrated in Figure 1 as one embodiment of my invention comprises a sealed evacuated bulb 10 of transparent glass enclosing the tube electrodes and having the usual base 11 and a reentrant stem 12 which carries an electrode assembly consisting of an anode 13 and a photocathode 14. The anode 13 may be a rod of nickel or similar metal and the photocathode 14 is considerably smaller in diameter than the bulb and preferably made an open ended cylinder of perforated sheet metal having a large number of holes or openings 15 arranged in rows and distributed over all the periphery of the cylinder. I have obtained good results with a cylindrical photocathode three-fourths of an inch long, three-fourths of an inch in diameter, and made of sheet metal 10 mils thick, with holes 15 each about 40 mils in diameter and having a total area of approximately 48% of the total photocathode surface area. The foundation metal of the photocathode is preferably silver although silver surfaced nickel or copper coated nickel with a silver coating on the copper may be used. Preferably both sides of the metal are silver surfaced so that when the photocathode is sensitized both the inside and outside of the photocathode will emit photoelectrons, although a nickel strip with a silver surface on only one side may be used if a photocathode light sensitive on only one side is desired.

The tube may be made by the methods usually employed in making the thin film caesium type of phototube, such as described in U. S. Patent to Bainbridge, #1,901,578, March 14, 1933. After the tube has been exhausted the caesium may be introduced by heating with a high frequency coil the pellet 16 which contains the usual compounds for liberating caesium. The liberated caesium deposits on the previously oxidized silver surface of the cathode and makes the surface light sensitive.

Figure 2 shows a modification of the tube of Figure 1, with a cylindrical highly polished anode 17 of substantially the same length as the cathode 15. The light passing through the holes 15 of the photocathode 14 is reflected by the polished anode 17 and falls on the light sensitive inner walls of the photocathode 14 thus substantially increasing the total useful photoelectron emission from the perforated photocathode.

In operation of the tubes shown in Figures 1 and 2, which may be either vacuum or gas filled, the light incident on the outside solid portions of the photocathode 14 causes an emission of photoelectrons which in general are pulled through the holes 15 to the inside of the photocathode and then to the anode 13, while light passing through the holes 15 and falling on the inner surface of

the photocathode **14** produces photoelectrons which go directly to the anode **13**. The holes **15** are preferably large in comparison with the thickness of the sheet metal of the cathode so that the positive field of the anode can in effect reach through the holes **15** and pull in the photoelectrons emitted from the outside surface of the photocathode **14**. If the holes **15** are too small compared to the thickness of the sheet metal of the photocathode **14**, the pull of the anode is not great enough to draw the electrons from the outside of the photocathode through the holes.

An obvious commercial use of the phototube such as shown in Figures 1 and 2 is to mount the tube on a parabolic reflector, preferably at the focus of the reflector, so that light impinging upon the reflector will be concentrated onto the light sensitive photocathode and cause it to operate a relay connected to produce the desired result.

Figure 3 shows a representative type of circuit in which tubes of Figures 1 and 2 may be operated. The photocathode **14** is connected to the negative pole of the supply battery **18** and the anode **13** is connected to the positive pole of the battery through an impedance **19**. When light falls upon the photocathode **14** photoelectrons are emitted and are drawn to the anode **13**, causing a flow of current in the external circuit of the two electrodes. This current flows through the impedance **19** and produces across this impedance a voltage drop which may be utilized in the output circuit **20**. For example, the circuit **20** may be connected to a relay system or to the input circuit of the first tube of a thermionic amplifier such as that used in a picture transmission or television system. A condenser **21** may be used to block from the phototube any voltage from the output circuit, such as the grid bias voltage commonly used on the first tube of an amplifier, so that such voltage will not interfere with the operation of the phototube.

My invention may be utilized in the type of combination phototube and amplifier disclosed in U. S. patent application of Herbert Nelson #690,045, filed Sept. 19, 1933, and assigned to the same assignee as the present application in which case the anode and other amplifier elements will be placed within the cylindrical photocathode as shown in that application.

The embodiments of the invention hereinabove disclosed are merely illustrative and that many changes may be made without departing from the scope of the invention which is limited only by the appended claims.

What is claimed as new is:—

1. A phototube comprising, a perforated light sensitive photocathode, and a light reflecting anode surrounded by said cathode for causing multiple reflection of light projected through said cathode and for collecting the photoelectrons emitted from said cathode due to the projected and reflected light.

2. A phototube comprising a tubular photoelectric cathode with all of the inner and all of the outer surfaces sensitized to light and having in each quarter of its periphery an aperture through its wall greater in diameter than the thickness of said wall to admit light to the interior of said cathode, and a tubular sheet metal anode mounted inside and coaxial with said cathode and having a light reflecting outer surface to cause multiple reflection of light projected through said cathode.

3. A substantially non-directional phototube comprising an evacuated envelope enclosing a tubular photoelectric cathode spaced from the walls of said envelope with light sensitized surfaces and having in each quarter of its periphery a plurality of apertures through its wall greater in diameter than the thickness of said wall, and a cylindrical electron collecting electrode inside said photocathode to receive electrons and with an exposed light reflecting outer surface to receive and reflect light entering said apertures.

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