April 15, 1941. R. SCHADE 2,238,605

GAS-FILLED PHOTOTUBE

Filed Sept. 10, 1938

Fig. 1.

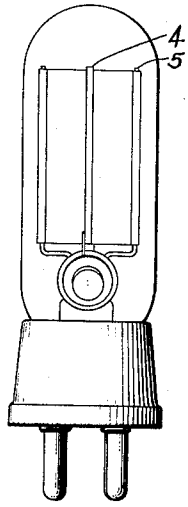



Fig. 2.

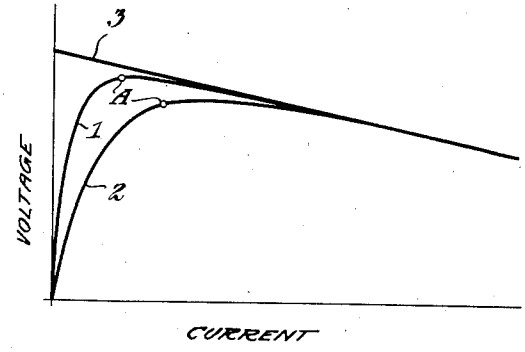
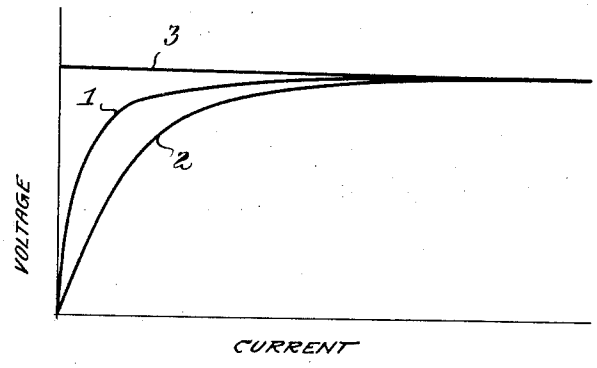



Fig. 3.




INVENTOR
RUDOLF SCHADE
BY J. W. Greenhouse
ATTORNEY

Patented Apr. 15, 1941 2,238,605

# UNITED STATES PATENT OFFICE

2,238,605

## GAS-FILLED PHOTOTUBE

Rudolf Schade, Berlin-Charlottenburg, Germany, assignor to "Fides" Gesellschaft für die Verwaltung und Verwertung von gewerblichen Schutzrechten mit beschrankter Haftung, Berlin, Germany, a corporation of Germany

Application September 10, 1938, Serial No. 229,261
In Germany September 13, 1937

1 Claim. (Cl. 250—165)

My invention relates to phototubes, and especially to the type of phototube having a gaseous medium therein.

An object of the invention is to provide a gas-filled phototube having a substantially constant voltage with high values of current therethrough. Other objects and advantages of the invention will be apparent from the following description and drawing in which Fig. 1 is an illustration of a typical phototube which, in its commonest commercial form, has an anode **4** in the shape of a rod partly surrounded by a semi cylindrical cathode **5**. Fig. 2 is a graph illustrating the characteristic between voltage and current of tubes of the prior art. Fig. 3 is a graph illustrating the characteristic between the voltage and the current of the phototubes embodying the invention.

Phototubes, such as illustrated in Figure 1, are used to convert light fluctuations into electrical current fluctuations or to release any kind of a switching process by means of light. Among these tubes, the gas-filled phototubes are superior to the high-vacuum tubes to the extent that with their aid, it is possible, as a result of the ionization of the gas, to produce greater currents. With the gas-filled phototubes, as with the high-vacuum phototubes, I may attain a continuous current control in dependence upon intensity fluctuations of the impinging light. The relationship between the current and potential for a given light intensity in a gas phototube is shown in Fig. 2. The potential values are plotted as ordinate; the values of the current as abscissa. The characteristic line **1** applies for a weaker and the characteristic line **2** for a stronger illumination. The characteristic of the independent discharge is designated **3**. It is easily recognized from the characteristic graph that, by variation of the lighting intensity, a variation of the current for a given potential takes place.

The extent of possible control of a gas-filled phototube capable of being put to use is, however, limited by the fact that a point A is reached for increasing light intensity and for a given potential at which the discharge goes over into an independent glow discharge. If, after this, the light intensity is weakened, no decrease in the current sets in; on the contrary the process is irreversible and a definite current strength is set in.

To extend the range of control and thereby to increase the usability of phototubes with gas amplification, the tube is, in accordance with the invention, filled not with a unitary pure noble gas, but with a small amount of another gas added to the main filling gas. By such a gas addition, the characteristic of the photo-electric discharge does not, as is illustrated in Fig. 2, fall but extends flat or even rises. For the present purposes, the foreign gas addition may, at best, be so selected that the characteristic with increasing current falls only slightly or extends flat. In this manner, the above-mentioned unstable point A is thrust in the direction of higher current strength and thus there is a large gain in the capacity of control.

Fig. 3 shows such a flat extending characteristic. The unstable point A lies so far to the right that it is no longer visible in the figure. It is easily recognized that in the case of Fig. 2, the same variation of intensity of the impinging light produces a larger variation of the current than the case of Fig. 3, and that still greater currents may be released.

The invention depends on the following: The dropping of the characteristic in a discharge vessel filled with pure noble gases is to be attributed to the fact that in them, ionization processes arise which depend on the square of the current strength and the cause of which is probably to be sought in the ionization effect of meta-stable atoms. By suitable mixing of other gases in small amounts, the ionization effect of the meta-stable atoms may, however, be considerably decreased and in this manner the condition may be attained that the beginning of the downward bend of the characteristic completely flattens out and may, with increasing current strength, further rise upward. As additional gases which decrease the life of the meta-stable atoms, those of which the ionization potential is smaller than the excitation potential of the main gas, are, for example, suitable because in that case, the meta-stable atoms ionize the additional gases. This ionization is proportional to the current strength, and therefore, requires no fall of the characteristic. The ionization potential of the additional gas may, however, be higher than the exciting potential of the main gas, then the additional gas is excited by the meta-stable atoms and they give up their energy in causing the excitation. As additional gases, noble gases are, for example, suitable; however, with the same success, non-noble gases may also be added. Usable gas mixtures are, for example, neon, with an addition of argon which constitutes $\frac{1}{100}$% to 1% of the main gas. With this mixture, very usable results were attained at a gas pressure of 10 mm. hg. and 1 cm. electrode distance. Further mixtures with

argon as main gas and hydrogen as additional gas, helium as main gas and neon as additional gas, are also suitable for the purpose of the invention as well as mixtures of argon with an addition of mercury vapor hydrogen or krypton.

In accordance with whether the ionization potential of the additional gas is smaller or larger than the main excitation of the main gas, the foreign gas condition causes a decrease or an increase in the ignition potential; however, this is not of essential significance for the present case. In many cases, it may be desirable that the ignition potential should decrease by reason of the additional gas and indeed in cases in which there is a thought of operating with lower operating potentials.

What is claimed:

A photosensitive device comprising a container having an anode, a photosensitive cathode and a gaseous atmosphere of the order of 10 millimeters of mercury pressure, said gaseous atmosphere comprising a main noble gas and $\frac{1}{100}\%$ to 1% of another gas, said last mentioned gas having a smaller ionization potential than said first mentioned noble gas.

RUDOLF SCHADE.