

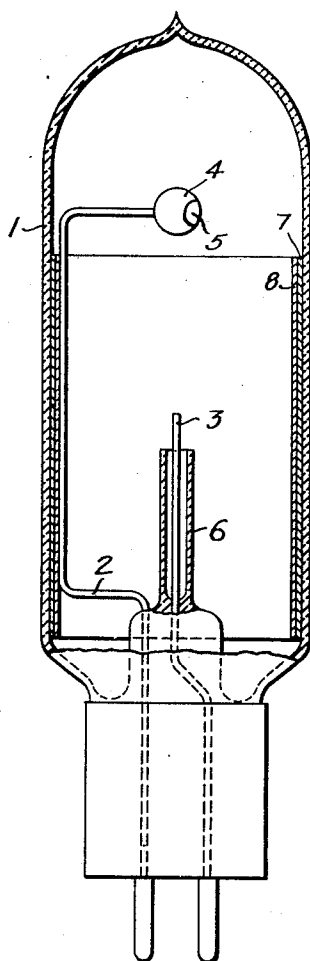
April 17, 1934.

D. D. KNOWLES

1,955,335

PHOTOGLOW TUBE

Filed Jan. 18, 1929



INVENTOR

Dewey D. Knowles.

BY

Shelley L. Carr

ATTORNEY

UNITED STATES PATENT OFFICE

1,955,335

PHOTOGLOW TUBE

Dewey D. Knowles, Wilkesburg, Pa., assignor to
Westinghouse Electric & Manufacturing Com-
pany, a corporation of Pennsylvania

Application January 18, 1929, Serial No. 333,389

6 Claims. (Cl. 250—27.5)

My invention relates to light-sensitive electric-discharge devices and particularly to light-sensitive discharge devices in which the initiation of an electrical discharge in a gaseous medium is controlled by the intensity of radiation incident to an electrode surface therein.

One object of my invention is to produce a discharge device in which the initiation of gaseous discharge in response to the intensity of incident radiation may be employed in controlling relays and circuits generally requiring a current flow of substantial magnitude.

Another object of my invention is to provide a light-responsive electrical-discharge device which shall maintain its electrical characteristics substantially invariable throughout long periods of operation.

A further object of my invention is to provide an electrical-discharge device of the character described above in which the range of wave length of radiation to which it is responsive may be varied between wide limits.

In connection with many branches of the electrical art, it is desirable to provide a relay device adapted to initiate and cut off the flow of current of considerable magnitude in response to the amount of illumination falling upon a particular point or area. The present invention provides a single electrical-discharge tube having one of its electrodes covered by a photo-electrically-sensitive substance. When a voltage is impressed between the electrodes of such a tube, a critical voltage exists below which substantially negligible current flows through the tube and above which a current of the magnitude of one-tenth of an ampere is conducted in connection with a glow in the tube, and the value of this critical voltage decreases as the intensity of radiation falling upon the photo-electrically-sensitive electrode increases.

It is true that a number of substances are known which are photo-electrically responsive and will, accordingly, vary the electrical-current flow through a gas by which they are surrounded in accordance with the amount of illumination falling upon their surfaces. However, in the case of substances heretofore known, it is found that the sensitivity of the substance to light varies with time, perhaps due to a chemical combination between the photo-electric substance and the gaseous atmosphere. In accordance with one feature of my present invention, I have found that, if the photo-sensitive surface comprises an underlying layer of silver or, alternatively, an alkaline-earth metal, or preferably magnesium,

which has superposed upon it an extremely thin layer of an alkali metal, such as cesium, the electrical characteristics of a gaseous discharge path comprising one of the noble gases, such as helium, remained unaltered through extremely long periods of use. Light-sensitive surfaces of the character above described have the further advantage of being capable of simple and quick manufacture by processes well adapted to large-scale production.

With the foregoing principles and objects in mind, my invention may be better understood by reading the following specification, taken in connection with the drawing in which the single figure is a view, partly in elevation and partly a longitudinal section, of a tube embodying the principles of my invention.

Referring in detail to the drawing, the tube comprises a vacuum-type container 1 of ordinary form into which are sealed a cathode lead 2 and an anode wire 3 of the general form shown in the drawing. The lead 2 lies parallel, and closely adjacent, to the wall of the container 1 for a considerable distance, its upper end being bent and provided with a disk 4 of some suitable metal, such as nickel. On the disk 4 is welded a small piece of magnesium or other volatilizable metal 5. The anode wire 3, which may suitably be of nickel and of a diameter of 40 mils, is surrounded, except for one-eighth of an inch or so at its upper end, by a glass sleeve 6 which constitutes a projection integral with the container wall. The tube 6 preferably does not fit tightly over the wire 3 but is spaced away from it by a distance of the order of magnitude of the diameter of wire 3.

A tube, constructed as hereinbefore described, is first exhausted by methods well known in the vacuum-tube art. In accordance with such methods, the tube is heated to a temperature as high as the glass wall thereof will withstand without collapsing, but before sealing off, a noble gas, at less than atmospheric pressure, is introduced into the tube by any method well known in the art. It may then be sealed off from the vacuum pump. Such having been done, a high-frequency magnetic field is produced in the vicinity of the electrode 4, and the latter is heated to such temperature that the magnesium 5 thereon is vaporized and immediately deposited on the walls of the tube, making contact with the wire 2 and forming the base for the photo-sensitive film. At the same time, the magnesium acts as a getter for any gases or vapors remaining or liberated during the sealing-off process. The sleeve

6 prevents the vapor of magnesium from depositing on the glass near the joint with lead 3 and thereby insures the insulation of the latter from the magnesium coating.

5 It will be noted that, while I have described magnesium as the metal to be vaporized, metals of the alkaline-earth group and even aluminum alloys, such as the well known calcium-magnesium alloy "misch metal", may be utilized for
10 this purpose. The metal to be used depends upon convenience of manufacture and the particular characteristics of the photo-electric tube which are desired.

Where it is desired to employ a base layer of
15 silver, the latter may be formed by subliming silver from an electrically heated wire within the container or even by the chemical-reduction methods well known in the mirror-making art.

In order to provide the other element of the
20 pair of metals which are combined in the photo-electric surface which I have invented, several methods and materials are available. In accordance with one method, a small amount of the vapor of a metal or metals may be introduced, after
25 a high vacuum has been produced in the tube, by heating a small tube containing the desired metal. The metals chosen should be such as have a maximum on their emissivity versus wavelength curve in the region of the wave length of
30 the radiation to which response is desired. Usually response is desired to radiation in the visible spectrum; hence, lithium, sodium, potassium, rubidium and cesium, which have maxima of emissivity in the visible region, are ordinarily preferable for use.

A way which I prefer, however, consists in painting a weak solution of an alkali-metal trinitride, such as cesium trinitride, on the portion
40 of the electrode 4 considerably removed from the magnesium 5.

Still another method of setting free the required alkali metal is to place a small amount of some salt thereof, which will not yield a deposit when heated in vacuum to about 500 degrees C.,
45 on an electrode within the tube and produce a discharge which shall bombard the salt with ions and, consequently, decompose it.

After the vaporization of the magnesium, it may, in general, be necessary to heat a small portion of the tube wall to clear a window so that
50 light may enter and strike upon the photo-sensitive surface.

In the foregoing manner, a layer of magnesium
7 will be deposited on the tube wall and, upon the surface of the latter, will be deposited a thin
55 layer of cesium 8. It will be recognized that the proportions of the layers 7 and 8 shown in the drawing are diagrammatical only and do not represent the true magnitude or relative proportion of the materials probably actually employed in practicing my invention. The lead 2 serves to make contact between an external circuit and the photo-sensitive layer 7, 8. If a voltage of a magnitude less than a certain critical value is impressed between the anode 2 and the lead 3, substantially negligible current flow will occur
65 through the interior of tube 1. If now, the photo-sensitive surface 7, 8 be illuminated, the radiation of a suitable wave-length photo-electrons will be projected from it into the gaseous atmosphere of the tube and will so increase the electrical conductivity thereof that ionization by collision will increase to an enormous degree, and a very considerable current will flow between the electrodes
70 of tube 1 accompanied by a glow in the tube.

This current may be employed to control relays or any other electrical devices which it is desired to actuate in response to the amount of illumination falling upon the sensitive surface 7, 8.

As indicated on the drawing, the cathode 7, 8
80 preferably has a surface area at least ten times as great as the free surface of the anode 3.

If the voltage impressed between the leads 2 and 3 is a continuous-current potential, current flow, once initiated, will persist even after the
85 illumination of the tube ceases. On the other hand, if the voltage impressed upon the tube is periodic, falling to zero at intervals, current flow once initiated will persist until the voltage falls to zero for the first time after the illumination is cut off. The gas in the tube will then almost instantaneously return to its substantially non-conductive condition, and appreciable current flow will only begin again when radiation is again incident to the light-sensitive surface.
95

In accordance with my invention, I have found that the electrical characteristics of the tube, such as the critical voltage for a given intensity of illumination, remain substantially unaltered throughout an active life of hundreds of hours.
100 Such a permanency of electrical characteristics is obviously of the highest importance from a practical standpoint and is found in the case of no other gas-filled photo-sensitive discharge tubes which carry currents of the magnitude of one-tenth of an ampere, such as the above-described device is capable of carrying. Such a performance is to be distinguished from that of ordinary photo-electric tubes in which the currents actually traversing the device are measured
110 in micro-amperes. That such relatively large current flow should not cause variation in the electrical characteristics of the photo-sensitive device is a very remarkable fact, and by obviating the employment of auxiliary amplifying devices,
115 produces a device of high commercial value.

Another important practical advantage of the device above described lies in the fact that, by properly choosing the base layer 7 and the surface layer 8, the particular wave length of radiation to which the device is most sensitive may be varied over a wide range; thus, by employing barium as the outer layer, in combination with the magnesium base, a device having maximum sensitivity in the visible region of the spectrum
125 is obtainable. By substituting cesium for barium, the maximum sensitivity is displaced toward the blue-green region of the visible spectrum. The substitution of rubidium, potassium and sodium as the surface layer successively decreases
130 the wave length of maximum sensitivity farther and farther into the ultra-violet. On the other hand, by employing two or more of the alkali metals, in combination, in the surface layer, sensitivity corresponding to that of both components
135 is obtained, so that a substantially uniform sensitivity over a very considerable range of wave lengths may be attained. In fact, by properly combining and proportioning the various substances enumerated as suitable for the photo-sensitive layers, a wide range of photo-electric characteristics may be obtained.
140

While I have described the foregoing particular embodiments of my invention, it will be evident to those skilled in the art that many modifications thereof may be employed to meet special problems without departing from the broad principles which I have described. Accordingly, I desire that the claims shall be given the broadest
150

reasonable interpretation to which their terms are susceptible in view of the prior art.

I claim as my invention:

1. A glow tube comprising a photo-sensitive electrode having an outer layer of a metal of the alkali metal group and an underlying layer of a metal of the alkaline-earth group surrounded by an atmosphere adapted to glow in operation comprising a noble gas at less than atmospheric pressure and another electrode cooperating with said first mentioned electrode.

2. A glow tube comprising a photo-sensitive electrode having a layer of a metal of the alkali metal group and an underlying layer of a metal of the alkaline-earth group surrounded by an atmosphere adapted to glow in operation comprising a noble gas at less than atmospheric pressure and another electrode cooperating with said first mentioned electrode.

3. A glow tube comprising an anode having a relatively small exposed surface and a photo-sensitive cathode comprising an outer layer of a metal of the alkali group and an underlying layer of a metal of the alkaline-earth group, said electrodes being surrounded by a noble gas at a sub-

stantial pressure adapted to glow in operation.

4. A glow tube comprising an anode having a relatively small exposed surface and a photo-sensitive cathode comprising a layer of a metal of the alkali group and an underlying layer of a metal of the alkaline-earth group, said electrodes being surrounded by a noble gas at a substantial pressure adapted to glow in operation.

5. A glow tube comprising an anode having a relatively small free surface, a gaseous atmosphere at a substantial pressure adapted to glow in operation and a photo-sensitive cathode having a relatively extensive surface and comprising an underlying layer of a metal of the alkaline-earth group and an outer layer of a metal of the alkali group.

6. A glow tube comprising an anode having a relatively small free surface, an atmosphere of a gas at a substantial pressure adapted to glow in operation and a photo-sensitive cathode having a surface area at least ten times the free surface of said anode and comprising an underlying layer of magnesium and an outer layer of caesium.

DEWEY D. KNOWLES.

30

35

40

45

50

55

60

65

70

75

105

110

115

120

125

130

135

140

145

150