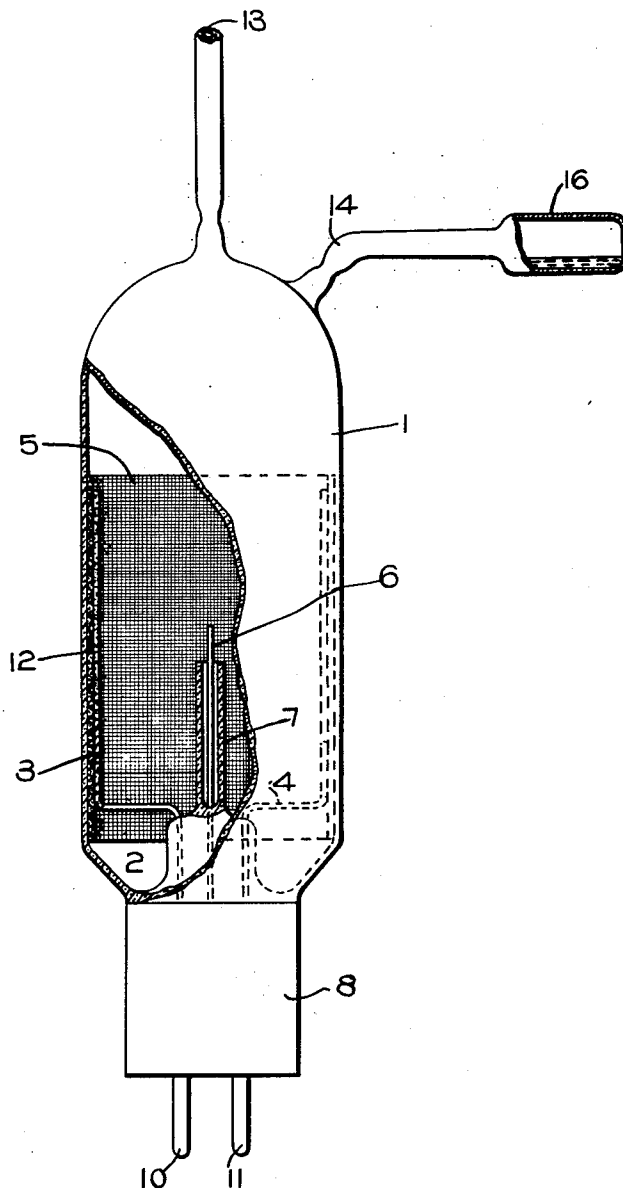


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ELECTRIC DISCHARGE DEVICE

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WITNESSES:

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ELECTRIC DISCHARGE DEVICE

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6 Claims. (Cl. 250—27.5)

My invention relates to electric-discharge de-
vices and particularly to devices of the type in
which the discharge is initiated or stopped by
changing light conditions.

One object of my invention is to provide a
light-controlled discharge device that is capable
of handling a substantial amount of current.

Another object of my invention is to provide
a light-controlled relay that is capable of being
energized by alternating currents.

Another object of my invention is to provide
a light-controlled discharge device which requires
a definite voltage for actuation, when illuminated
and another definite voltage for actuation, when
in darkness.

Another object of my invention is to provide
a light-controlled discharge device that is not
subject to objectionable deterioration in use.

A very definite need has arisen for a light-
controlled relay that is capable of giving an out-
put current sufficient in amount for the actua-
tion of small mechanisms, such as circuit break-
ers, alarm systems and the like.

It has been customary, according to the prior
art, to utilize either selenium cells or photo-
electric cells of the Kunz type employing potas-
sium hydride, followed by thermionic amplifiers,
for this purpose but such devices have been
costly, expensive to maintain in satisfactory
working order and erratic in operation. Too
many variable factors have entered into the op-
eration of the usual photo-electric cell controlled
relay systems, with the result that they have not
proved absolutely dependable.

By my present invention I have combined, into
a single, unitary device, a photo-electric cell
and a relay capable of passing a relatively large
amount of current. In brief, I have modified the
now well known voltage-stabilizing glow-tube by
the introduction therein of a light-sensitive
element for initiating the ionization in order to
cause the main discharge to start when the tube
is exposed to light.

The novel features which I consider char-
acteristic of my invention are set forth with par-
ticularity in the appended claims. The invention
itself, however, both as to its organization and
method of operation, together with further ob-
jects and advantages thereof, will best be under-
stood by reference to the following description,
taken in connection with the accompanying
drawing.

The single figure of the drawing is a side ele-
vational view of a preferred embodiment of my
invention, a portion of the glass envelope being

broken away in order to more clearly illustrate
the interior construction of the device.

It has been established by experiment that, if
there are enough free electrons and ions in the
gas to enable a discharge to take place at a defi-
nite voltage, the introduction of more electrons
and ions uniformly distributed throughout the
gas and without initial velocity does not appre-
ciably affect the break-down voltage.

I have further established the fact that, if
electrons are introduced near one of the elec-
trodes with an appreciable initial velocity, the
effect on the break-down voltage is very pro-
nounced.

I have accordingly modified the two electrode
tubes referred to previously by introducing means
therein, at the negative electrode, for producing
electrons having a definite velocity and have so
chosen my electron-producing means that it is
controllable by light conditions.

Referring now specifically to the drawing, the
preferred embodiment of my invention comprises
a glass envelope 1 having therein a press 2 in
which are mounted two upright members 3 and
4 attached to and supporting a screen electrode,
or cathode 5, which is in contact with the inner
wall of the glass envelope. In addition, a single
upright electrode or anode 6 is supported from
the press and this electrode is surrounded, for
the greater part of its length, by a glass sleeve
or tube 7 which is continuous with the press
material.

The device may be mounted in a base 8 anal-
ogous to the usual radiotron base from which
extend a plurality of contact elements 10 and
11 that are connected, respectively, to the several
electrodes referred to.

The complete device also contains a definite
amount of potassium hydride 12 which has been
uniformly distributed over the screen and the
inner surface of the glass envelope in contact
therewith.

In the preparation of my device, the envelope
containing the electrodes mounted therein is first
exhausted to .000001 of a millimeter of mercury
or less, if possible, the exhaust pump being con-
nected to a tube 13 sealed to the upper end of the
envelope. An additional tube 14 is also sealed
to the upper portion of the envelope, this tube
communicating with a small capsule 16 contain-
ing potassium.

After exhausting the tube and simultaneously
heating it in an oven to about 500° C. for one
hour, the oven is removed and, while the tube is
still hot, the potassium is heated with a torch

and distilled into the tube. The walls of the tube will cool faster than the inner parts and, consequently, most of the potassium will condense on the walls and screen where it is wanted.

5 As is now well known in the art, the photo-sensitivity of potassium to light may be greatly increased by passing a discharge between the electrodes in an atmosphere of hydrogen, and it is preferable to next employ this method of activation. It is not necessary to describe specifically the manner in which the potassium is treated by hydrogen, this being familiar to those skilled in the art and being thoroughly described in the patent to Kunz, No. 1,381,474.

10 The tube leading to the potassium capsule is next sealed off and, after the hydrogen has been removed, a small amount of argon, helium or neon, or a mixture of these gases, is introduced into the device through the tube previously utilized for the exhaust. The gas pressure, if neon is used, should not be permitted to exceed about 4 millimeters of mercury and, for best results with argon, it should be approximately 2 millimeters. The pressure varies with electrode spacing and the gas used, the figures given being merely illustrative.

20 The tube through which the gas is introduced is then sealed off and the device, insofar as the glass portion and electrodes are concerned, is complete.

30 It is not necessary to mount the device in a base, as illustrated, but this is usually done for purposes of convenience.

In operation, an alternating potential is applied between the central anode 6 and the circular screen cathode 5. By properly choosing the dimensions of the tube, the spacing between electrodes, the kind of gas and the gas pressure, it is possible to so arrange the device that no discharge will take place between the electrodes at any given applied potential, provided the device is kept in darkness.

40 Upon illumination of the potassium-hydride-coated electrode, which functions primarily as a cathode, a large number of photo-electrons are released which have a high initial velocity. The voltage across the tube supplies the added velocity necessary to ionize the gas and to cause the glow discharge. In darkness, since no electrons are emitted from the cathode, the voltage on the tube must produce all of this velocity, and this voltage must, therefore, be considerably higher than when the tube is illuminated.

45 The initial velocity of the electrons is determined by the wave length of the incident light and is, therefore, constant for a given source of light. An increase in the intensity of the light increases the number of electrons released. This increase lowers the breakdown voltage of the tube because, although the total gradient between the electrodes is not changed, the gradient between the anode and an intermediate portion of the path is raised sufficiently to give the space-charge electrons a much higher velocity toward the anode than they had previously. The tube is, therefore, sensitive to changing wave-length and changing intensity of the light.

50 Once the discharge is initiated, the voltage, at which the glow stops, is independent of both the wavelength and the intensity of the incident light. The stopping voltage is determined by the electrode material and the gas and is of the order of the cathode fall of potential of the material and gas used. In other words if the glow is once

started, it will continue, even upon cessation of the light, provided the voltage is maintained.

80 The starting voltage, depending upon the incident light, and the stopping voltage being a constant for any given tube, the difference between these voltages decreases as the light is increased in intensity. These voltages become very nearly equal at high light-intensities.

85 For this reason, if the device is used with a source of alternating potential, the portion of the wave passed will be unsymmetrical. In other words, the discharge in light might start at 125 volts, continue throughout the crest of the voltage wave and cease only when the voltage has fallen to 85 volts. This discrepancy between starting and stopping voltages may probably be due to the fact that the luminous discharge itself serves to liberate an additional number of photoelectrons from the cathode.

90 The difference between the breakdown voltage in light and the breakdown voltage in the dark may be made quite large, as, for example, a tube which I have constructed containing argon at a pressure of .1 of a millimeter mercury breaks down in the dark at 645 volts but, in a light intensity of 300 ft. candles, it requires only 182 volts.

95 In the utilization of my device as a light-controlled relay, it is preferable to connect it in series with an indicating device directly across a source of commercial-frequency alternating potential of 110 volts or higher. In order to insure that a destructive current will not pass through the tube when the discharge takes place, it is preferable to also insert a high resistance in series with the tube and the indicating device.

100 If the tube is properly chosen to suit the voltage available, no current will pass between the electrodes when the device is in darkness. Upon illumination, the discharge is started in the manner previously explained and continues for each alternate half cycle of the exciting current so long as the illumination is constant.

105 Should the light intensity be lowered below the critical point, the discharge will stop, provided the characteristics of the device are so chosen that even the peak voltage of the source is insufficient for the initial ionization in darkness.

110 If a direct-current source is employed, instead of an alternating-potential source, the discharge, once initiated by the liberation of the photo-electrons, will continue until the voltage of the source is reduced. For this reason, it is preferable to employ an alternating-potential source for actuation of my device.

115 The current density that I have found best is approximately 1 milliamperere per square inch of cathode surface in either the argon or neon-filled tube and, using this current density, a tube approximately equal in overall dimensions to the usual 201-A type radiotron will pass 10 to 14 milliamperes safely.

120 By reason of the fact that the cathode has a large cylindrical surface and the anode is substantially a point, the amount of inverse current passed by my improved relay is less than 1% of the main current. The preferred form of my device is accordingly self-rectifying and may be utilized on alternating-current circuits to operate direct-current relays of the usual type. It is of course possible, by using electrodes of equal size, to largely eliminate the rectifying function.

125 Although I have found, by experiment, that argon and neon seem to give the best results, it is my belief that any other gas which is inert

with respect to potassium might be used to equal advantage, and I do not intend to be limited to the use of neon, argon, or helium.

My light-controlled relay is useful in any system in which circuit changes or movements of apparatus are desired in response to changing light conditions. It is particularly useful in inaccessible situations where a complicated thermionic amplifier could not be relied upon to always respond to the output of a photo-tube of the usual type. It is also of value in situations where a substantial current output is needed in order to actuate relatively large relays or other apparatus.

Among the situations in which my device may be utilized to advantage may be mentioned systems for controlling street lighting in suburban districts, the control of lights in beacons or isolated light-houses and similar situations which require absolute reliability coupled with large-current control.

It is believed obvious that my device may also be utilized to advantage in systems such as counting devices, flash-over-protection systems for generators and fire protection systems.

The sensitivity of my device remains substantially constant over a temperature range from -10° centigrade to $+50^{\circ}$ centigrade, the latter temperature being near the melting point of potassium. It is accordingly not necessary to provide elaborate shielding means if the daily range in temperature does not exceed this.

Many other modifications will be apparent to those skilled in the art, and my invention is, accordingly, not to be limited except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. A light sensitive glow discharge device comprising an envelope of insulating material, an electrode comprising a perforate electrically-

conductive material in contact with said envelope and a photo-electrically active material adjacent thereto, and another electrode insulated from the first-mentioned electrode.

2. A light sensitive glow discharge device comprising an envelope of insulating material, an electrode comprising a perforate electrically-conductive material in contact with said envelope and a photo-electrically active material adjacent thereto, a gaseous atmosphere and another electrode insulated from the first-mentioned electrode.

3. A light sensitive glow discharge device comprising an envelope of insulating material, an electrode comprising a perforate electrically-conductive material and a photo-electrically active material adjacent thereto, a gaseous atmosphere and another electrode insulated from the first-mentioned electrode.

4. A light sensitive glow discharge device comprising an envelope of insulating material, an electrode comprising an electrically-conductive mesh in contact with said envelope and a photo-electrically active material adjacent thereto, and another electrode insulated from the first-mentioned electrode.

5. A light sensitive glow discharge device comprising an envelope of insulating material, an electrode comprising a reticulated electrically conductive material and photo-electrically active material adjacent thereto, and another electrode insulated from the first-mentioned electrode.

6. A light sensitive glow discharge device comprising a point anode, a cathode having a cylindrical surface, a light sensitive material about said cathode, and a noble gas, said light sensitive material under the influence of light cooperating to reduce the breakdown potential of said gas.

DEWEY D. KNOWLES.

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