

Aug. 22, 1961

P. W. KRUSE
HOLDING SWITCH

2,997,630

Filed Aug. 30, 1956

2 Sheets-Sheet 1

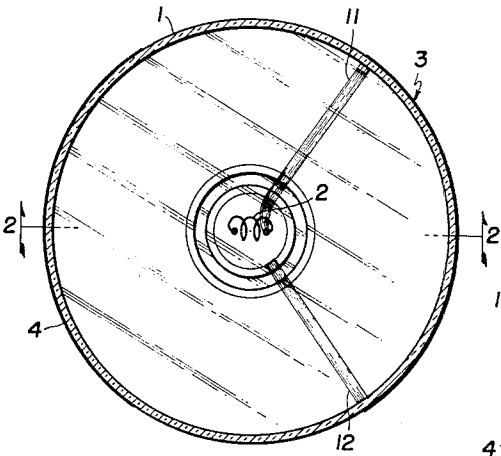


FIG. 1

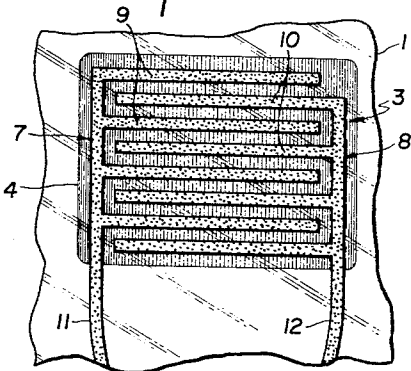


FIG. 3

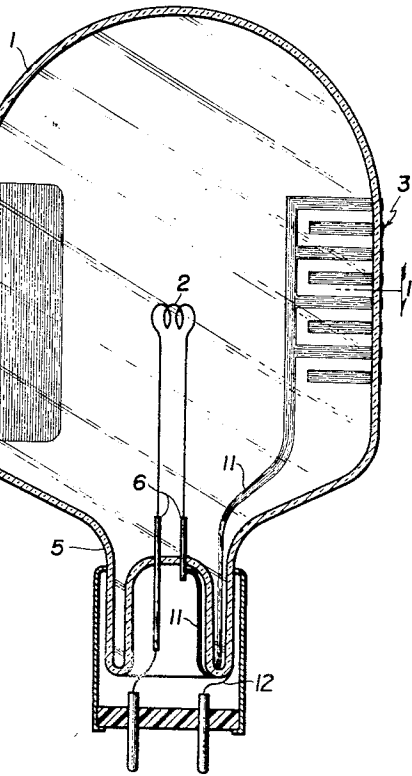


FIG. 2

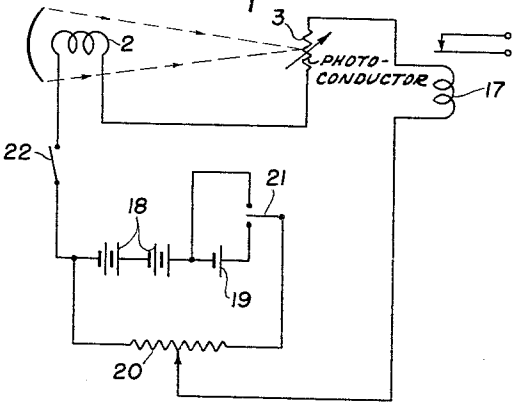


FIG. 5

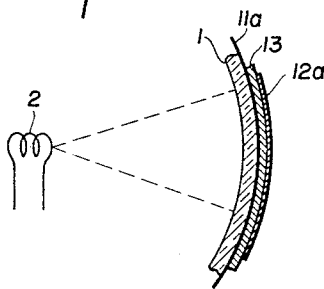


FIG. 4

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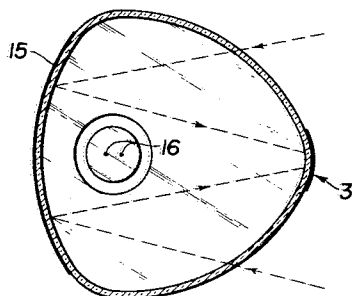


FIG. 6

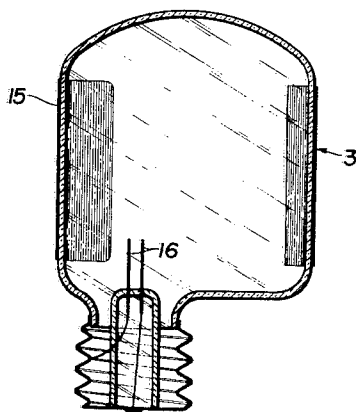


FIG. 7

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1

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HOLDING SWITCH

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Filed Aug. 30, 1956, Ser. No. 607,193

4 Claims. (Cl. 317-125)

This invention relates to light sensitive switches and is particularly directed to means for triggering and holding a circuit in response to minute quantities of radiant energy.

It has been proposed to connect in series a light source, a photocell, and a voltage source, so that the photocell may serve as a switch for turning the light on and off in response to light applied to the cell. It has been discovered according to this invention that by directing the rays of the serially-connected light source to the photocell, the regenerated energy can be made to hold the circuit closed.

It is the object of this invention to provide a reliable trigger and holding switch embodying the principles of regenerated light energy between a serially-connected light source and a photocell.

The objects of this invention are attained by forming the electrodes and photoconductive materials of a photocell directly on the glass wall of a light bulb so that the operative portion of the photocell is in close proximity to the source of light within the bulb. The photocell electrodes and light source terminals are connected in series so that when the bulb is plugged into a voltage source, it becomes a self-contained unitary trigger and holding switch.

The above mentioned and other features and objects of this invention and the manner of attaining them will become apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

FIGS. 1 and 2 are horizontal and vertical sectional views, respectively, of one bulb embodying this invention;

FIG. 3 is an enlarged plan view of the photocell of FIGS. 1 and 2;

FIG. 4 is an enlarged detail sectional view of another photocell of this invention;

FIG. 5 is a circuit diagram; and

FIGS. 6 and 7 are horizontal and vertical views, respectively, of another bulb embodying this invention.

The bulb 1 contains a light-producing filament 2 which may be of the incandescent type as shown or may comprise two coated cathodes for ionizing gas within the bulb after the fashion of the typical glow tube. On one wall of the bulb is formed the photocell 3, the terminals of which are connected in series with the light source 2. If desired, a reflecting mirror surface 4 is coated on the inside or outside of the bulb opposite the photocell.

More specifically, the device of this invention may comprise a glass bulb 1 of the miniature or headlight type. One end of the bulb is shaped with the neck 5 containing a reentrant stem with the usual press and exhaust tubulation (not shown). Two lead-in conductors 6 are sealed gas-tight in the press. The filament 2 supported on the two lead-ins may be of the conventional tungsten wire, although the composition of the filament may be selected for its spectral characteristics which match the spectral characteristics of the photocell 3. One lead-in is cut short on the outside of the press, so that it does not extend through the base.

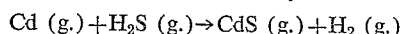
The photocell 3, according to an important feature of this invention, comprises two electrodes 7 and 8, best shown in FIG. 3. The electrodes, conveniently, are made by painting thin strips of conductive metal paste on the

2

outside surface of the bulb. The electrodes are preferably painted in the shape of inter-digital fingers 9 communicating with lead-in strip 11, while fingers 10 communicate with lead-in strip 12. One paste which has given excellent results comprises silver chloride powder of commercial grades mixed with sufficient ethyl cellulose to handle with a brush or spray gun. Suitable masks are convenient for establishing the long narrow spacings between the parts of the two electrodes.

When the metal coatings of the electrodes are dried, and baked if necessary, to establish a good bond to the glass, the entire inter-digital area is overcoated with a paint or paste of photoconductive material. Such material may comprise the luminescent grade of cadmium sulphide, CdS, which has been doped with certain impurities such as traces of copper and chlorine and fired at elevated temperatures in a combustion or crucible furnace. Alternatively, the photoconductive overcoating may be laid down on the electrodes by depositing the cadmium sulphide from the vapor phase. That is, cadmium sulphide may be evaporated in a gas, such as a mixture of H₂ and H₂S and condensed on the electrode area of the bulb. The very thin and polycrystalline cadmium sulphide surface thus produced on the substrate is considerably thinner than the cadmium sulphide paint, as mentioned. Either coating exhibits wide variations of resistance between the terminals of the photocell and responds to different levels of illumination upon the surface of the cell. The illuminated resistance is designed to conduct ample current to supply the needs of the light source 2.

The CdS surfaces may also be prepared on the bulb in two other ways. First, Cd is sublimed from a boat in a combustion oven at 900° C. It is carried downstream by N₂ gas to a point where it reacts with a mixture of H₂ and H₂S gases. CdS is formed by the reaction:



The CdS condenses on a substrate placed at a zone of the furnace at 800° C. Second, commercial CdS powder, with impurities added, is mixed in a H₂O paste and spread on the glass. This is fired in a controlled atmosphere and becomes a photoconductive surface.

Alternatively, the electrodes may consist, as shown in FIG. 4, of a transparent conductor film 11a, such as stannic chloride, deposited from the vapor on the bulb 1 and an opaque conductor 12a such as silver paste, with the CdS layer 13 disposed in between in sandwich form. In this case, the CdS layer should be thin in order to achieve a high electric field strength for low voltages. A sublimed layer of CdS is preferred to the powder in this case.

The back or outside surface of the prepared photocell should be covered with an opaque black paint to mechanically protect the photocell as well as to exclude ambient light. It is necessary, of course, to allow some portion of the bulb to be transparent in order that light from an external source may be used to trigger the photocell. It might be necessary to place the photocell at the end of a long black tube which can be aimed at the triggering source. It has been found that an ordinary tungsten filament can easily be made to match the current capacity of the photocell. Generally, the current requirements of a glow tube are less than that of an incandescent filament.

To increase the feedback coupling between the light source and the photocell, the reflecting mirror 4 is deposited on the bulb opposite the photocell. The mirror may be aluminized or chromium applied to either the inside or outside surface of the bulb.

While the bulb may be round, as suggested in FIGS. 1 and 2, it may, if desired, be irregular in cross-section, as shown in FIGS. 6 and 7, where one side 15 is specifically designed to focus internal and/or external light on the

photocell 3. Also, in FIGS. 6 and 7, the light source comprises the two coated electrodes 16 and a sufficient filling of inert gas, such as neon, to glow brightly when ionizing potentials are applied to the electrodes.

The painted leads 11 and 12, FIG. 3, of the cell extend downwardly over the wall to the base of the bulb. Lead 11 is connected to one side of the filament by means of a lead-in cut off near the press. The lead 12 is connected directly to one base pin. The other base pin is connected to the other side of the light source filament by means of the other lead-in. Because the bulb 1 is transparent, the fingers 9 and 10 are shown in solid line form.

In FIG. 5 is shown one circuit application of the trigger and holding device of this invention. The filament 2 (or gaseous discharge path) and photoconductor 3 are connected in series with a load 17 such as the control winding of a relay. This series circuit is connected, in turn, across the voltage source 18 with a tapped end cell 19. The terminal voltage of the source is adjustable as by a shunt potentiometer 20. The end cell 19 is switched into or out of the series circuit by the single pole, double throw switch 21. The terminal voltage of the source 18, with and without the end cell 19, may be adjusted, respectively, to a value above and below the voltage which will illuminate the light source 2 for a given or predetermined level of light applied to photocell 3. For example, with the lower terminal voltage applied, the dark resistance of the photocell may be just sufficiently high to prevent action, and so that light of some small predetermined level on the photocell will trigger the circuit on. Once the filament 2 is illuminated, the feedback radiant energy to the photocell will hold the circuit on. Interruption of the circuit can then be effected only by an external switch such as 22.

Minute amounts of light on photocell 3 will fire the circuit and energize and hold the load 17.

If it is desired to activate the photocell and achieve holding action without an external light providing the trigger, this may be achieved using the action of voltage alone from the end cell. Let the photocell be in the dark and the resistance and voltage such that the light source 2 is just below the point of illuminating. Switching in an additional voltage from the end cell by means of 21 raises the overall voltage sufficiently such that the voltage on the light source is raised to a point where it triggers. The feedback light decreases the resistance of the photocell to such an extent that when the switch 21 is returned to its initial position to remove the end cell 19 holding is achieved. In order to stop the action, switch 22 is opened. This can be used as a bi-stable element which can be triggered on by a voltage pulse or by a light beam or by a combination of the two and can be triggered off and returned to its initial condition by a negative voltage pulse.

While the principles of the invention have been described in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention.

What is claimed is:

1. In combination in a holding device, a bulb, a light source in the bulb, photoconductive material having high dark resistance and low light resistance on the bulb wall,

spaced electrodes contacting said material, a relay with a control winding; said winding, said electrodes and said light source being connected in series, and means for selectively applying different predetermined voltages across the series circuit, said voltages being, respectively, above and below the voltage required to illuminate said light source at a predetermined resistance value of the photoconductive material between said electrodes.

2. In combination, a bulb, a light source in said bulb, photoconductive material having high dark resistance and low light resistance on the wall of said bulb, two spaced electrodes contacting said material, said material being directly exposed to said light source, a load, and a voltage source; said light source, said electrodes, said load and said voltage source being connected in series, said voltage source providing a voltage insufficient to excite said light source when said material is in darkness but sufficient to maintain said light source excited when said material is irradiated, means for applying an auxiliary voltage to said light source for exciting the latter when said material is in darkness, means for removing said auxiliary voltage from said light source, and means for interrupting current flow in the aforesaid series circuit.

3. In combination, a bulb, a light source in said bulb, photoconductive material having high dark resistance and low light resistance on the wall of said bulb, two spaced electrodes contacting said material, said material being directly exposed to said light source, a load, and a voltage source; said light source, said electrodes, said load and said voltage source being connected in series, said voltage source providing a voltage insufficient to excite said light source when said material is in darkness but sufficient to maintain said light source excited when said material is irradiated, means for raising the voltage of said voltage source for exciting said light source when said material is in darkness, and means for interrupting current flow in the aforesaid series circuit.

4. In combination, a bulb, a light source in said bulb, photoconductive material having high dark resistance and low light resistance on the wall of said bulb, said material being directly exposed to said light source, a layer of light-reflective material on the wall of said bulb disposed to reflect light from said source onto said photoconductive material, and means regeneratively coupling said source and said photoconductive material together, whereby excitation of said light source reduces the resistance of said photoconductive material which in turn causes further excitation of said light source.

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