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H. T. ADKINS

3,237,057

PHOTOELECTRIC CELL

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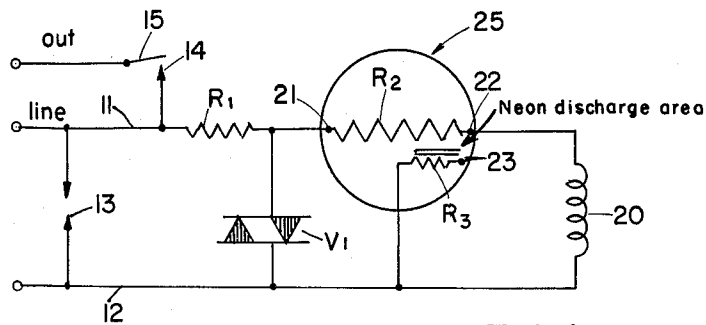


FIG. 1

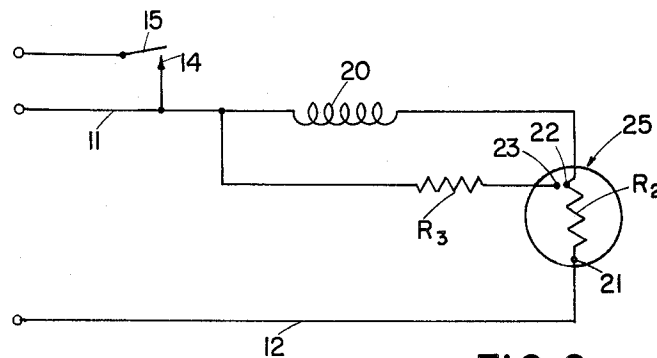


FIG. 2

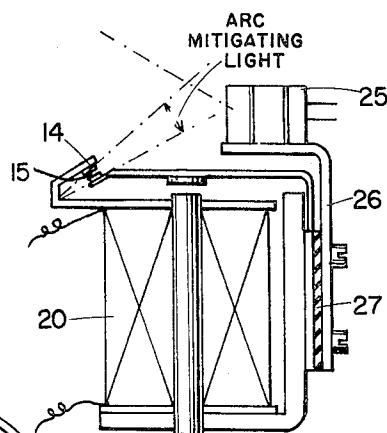


FIG. 3

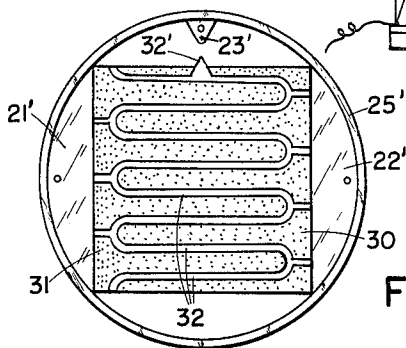


FIG. 4

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PHOTOELECTRIC CELL

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1 Claim. (Cl. 317-124)

This invention relates to photocell controlled relay circuits and, more particularly, to such circuits including A.-C. relays and novel means for substantially eliminating chatter of such A.-C. relays or to decrease switching time of D.-C. relays.

Photocell controlled relay circuits of this general type are frequently used to control the switching on and off of street lamps in accordance with ambient light conditions. When a D.-C. circuit is used together with a snap action D.-C. relay, substantially no problem is presented. However, the use of direct current in such circuits requires additional rectification and extensive filtering equipment when it is desired to operate the circuits on the normally available power from commercial mains, which is usually 60-cycle alternating current. A circuit of this type which can be energized directly with alternating current and use A.-C. relays would be much simpler in configuration and much less expensive to construct and install.

However, when it is attempted to use an alternating current relay in such a circuit, the problem of chatter arises due to the 60-cycle alternations of the applied potentials. This chatter, which occurs over a relatively limited range of voltage variation, can rapidly destroy the relay. Hence, in order to enable an A.-C. relay to be used in an A.-C. energized control circuit of this type, involving a photocell as the relay control, means must be provided whereby such chatter may be substantially eliminated.

In accordance with the present invention, it has been found that such chatter-free operation may be obtained in a manner whereby, responsive to a decrease in the resistance of the photocell due to an increasing light level, a rapid build-up or amplification of the light effective or incident on the photocell is obtained, so that there is a rapid decrease in the photocell resistance and thus a rapid increase in the relay current, as well as the maintenance of the relay current at a relatively high value preventing chatter of the relay. In effect, there is a positive feed-back of light to the photocell, resulting in a rapid pull-in of the relay and resulting in the photocell having a very high slope or light gain at specific ambient light and operating voltage levels.

More specifically, in accordance with one embodiment of the invention, the photocell is provided with a third terminal, which is spaced from one of the usual other two terminals of the photocell to provide a discharge area, and the envelope of the photocell is filled with a suitable light producing gas such as, for example, neon. A particular type of photocell which may be used in this manner is a cadmium sulphide photocell.

When the light level increases, the voltage drop across the cell decreases due to the decrease in the cell resistance. Eventually, the voltage available between the two terminals providing the discharge area reaches a value such that the neon fires or becomes ionized. Thereby, the light level in the photocell increases very rapidly due to the neon discharge, thus providing an even brighter neon glow. The relay coil is thus rapidly fully energized so that the positive feed-back provides the photocell with a very sharp slope light gain characteristic at specific ambient light and voltage levels. This process repeats each cycle of the A.-C. potential. At evening, as the ambient light decreases, the neon is extinguished before the relay drops open. The light differential between energization

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and de-energization of the relay is thus greatly decreased.

A standard photocell with an external neon bulb electrically connected as an internal neon gap is also workable when the cell faces the neon bulb.

As an alternative embodiment of the invention, the neon may be omitted from the photocell envelope if the A.-C. relay contacts face the photocell. When the relay contacts start to break under load, as upon the initiation of chatter, the arc between the breaking contacts generates light. This light increases the total light available on the photocell, thus rapidly decreasing the resistance of the photocell and causing the relay contacts to open.

The photocell having the filling of neon or the like has an advantage. This advantage is due to the neon breaking down and giving off light on the occurrence of transient voltages. Since the photocell is connected to a relay coil which has a high impedance and is capable of withstanding voltage surges of several thousand volts, the relay coil is the ideal point to absorb transient peak voltages. During nighttime, the cell resistance is very high in comparison to that of the relay so that most of the peak voltage transients appear across the cell. This shortens the cell life and changes its calibration. When the cell is filled with neon or similar gas, and when the pressure and the discharge gap are proper, the gas will break down conducting some current and decreasing the voltage across the cell. Further, the light will decrease the resistance of the semi-conductor. The major portions of the transient or peak voltages will thus appear across the relay coil, thus saving the photocell. This prolongs the photocell life, reliability and calibration.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a schematic wiring diagram illustrating one embodiment of the invention utilizing a neon filled photocell envelope;

FIG. 2 is a schematic wiring diagram of a modified form of the invention;

FIG. 3 is an elevation view illustrating a photocell arrangement in which light from the arcing contacts of the relay is directed upon the photocell; and

FIG. 4 is a plan view of one form of photocell embodying the invention.

Referring to FIG. 1, a line voltage may be applied to conductors 11 and 12 across which is connected an expulsion arrester 13 for preventing false operation, as due to lightning flashes and the like. A resistor R_1 is connected in series in the line 11, and this line is provided with a load circuit controlling or load carrying relay contact 14 engageable by the armature 15 of an A.-C. relay 20 to provide the control current for turning on the street lamps or the like.

A photocell 25 is illustrated as having an envelope which contains a luminescent gas such as neon and its internal resistance is represented schematically by the resistor R_2 connected between the usual photocell terminals 21 and 22. The relay coil is connected between terminal 22 and the return line 12, and a varistor V_1 may be connected between lines 11 and 12.

In accordance with this embodiment of the invention, the photocell is provided with a third terminal or contact 23 which is spaced from the contact or terminal 22 to provide a discharge area between these two contacts. Contact 23 is illustrated as connected through a resistor R_3 to the line 12, and resistor R_3 represents either the high resistance through the bulk of the cadmium sulphide or may represent an external resistor.

The arrangement operates in the manner previously described. As the ambient light level rises, the resist-

ance R_2 decreases so that the voltage drop between terminals 21 and 22 decreases, with the voltage at the terminal 22 approaching that at the terminal 21. At a certain time, the voltage at terminal 22, with relation to terminal 23, is such that there is a discharge through the neon between these terminals 22 and 23. The neon thus glows, increasing the light level available upon the photocell and thereby even more rapidly decreasing the resistance R_2 and increasing the current through the photocell and thus through the relay coil 20. Thereby, the relay 20 is effectively switched without chatter, even on 60-cycle alternating current.

FIG. 2 illustrates a variation of the invention in which the line 12 is a neutral line connected directly to terminal 21 of the photocell, the terminals 22 and 23 being as indicated. The resistance across the photocell is schematically indicated by the resistor R_2 , and the resistor R_3 is indicated as an external resistor. This arrangement operates in the same manner as indicated for FIG. 1, in that, as the resistance R_2 decreases with an increase in the available light level, the potential of terminal 22 with respect to that of terminal 23 eventually reaches a point where there is a discharge through the neon within the photocell envelope. The increase in light incident upon the photocell due to the discharge through the neon even more rapidly decreases the resistance R_2 , thus increasing the current drawn through the coil 20 and holding this coil in despite the cyclic variations in the applied A.-C. potential. More specifically, as the photocell resistance decreases, the voltage drop across the relay coil 20 increases to eventually provide a voltage at terminal 22 which is such, with respect to that at terminal 23, that the gas will break down.

FIG. 3 illustrates an arrangement in which the light from the arcing of the relay contacts 14, 15 under load is directed upon the photocell. Referring to this figure, the photocell 25 is mounted upon an L-shaped bracket 26 which is secured to the relay housing with the imposition of a piece of dielectric 27. Relay 20 and cell 25 are connected in a control circuit in the same manner as shown in FIGS. 1 and 2. Cell 25 is so positioned that it faces the relay armature and contacts 14 and 15. Hence, the moment the relay starts to chatter, with resultant arcing across the load carrying and load circuit controlling contacts 14 and 15, the light due to such arcing is incident upon the photocell and decreases the resistance thereof to increase the current flow through the relay coil 20 and thus fully break the contacts 14 and 15. This arrangement has substantial benefits even on D.-C. power supply circuits. As the photocell current slowly increases the relay contacts begin to open and arcing starts due to the load current. The arcing will decrease cell resistance, throwing the relay and immediately ending the arcing.

FIG. 4 is a plan view of a photocell embodying the invention, of the three terminal type. The photocell has a sealed envelope 25' of glass filled with neon gas in which is mounted a rectangular body 31 of porcelain or other dielectric material. Body 31 carries opposing segmental portions of metal forming the terminals 21' and 22', and also has a third metal piece forming the terminal 23'. Between terminals 21' and 22', the surface of the body 31 is formed with a sinusoidal or undulating groove filled with the light sensitive material 32. This material electrically interconnects terminals 21' and 22'. In this photocell, the potential field gradient between material 32 at the point 32', and electrode 23' is much higher than the electric field potential gradient from terminal 21' to terminal 32. Thus, the gap between terminals 22' and 23' will break down much sooner than the gap between terminals 21' and 22' to emit light due to the breakdown of the neon gas.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

A photocell controlled relay circuit, comprising, in combination a source of A.-C. potential; a photo-resistance cell; a relay including an operating coil, having an energizing current value and a de-energizing current value, and transferable load circuit controlling contacts fully transferred only responsive to the current through said relay coil attaining either of said values; and a control circuit including said source, said cell and said coil, whereby the current through said coil is dependent upon the ambient light incident upon said photocell; the load circuit controlling contacts of said relay being arranged in incident light transmitting operative relation with said photocell whereby, upon the initiation of arcing between said contacts as the contacts begin to open underload as the current through said relay coil increases toward one of said values, the light level on said photocell is increased to decrease the resistance of said photocell to increase the current flow through said relay coil rapidly to a value sufficient to open the contacts fully.

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