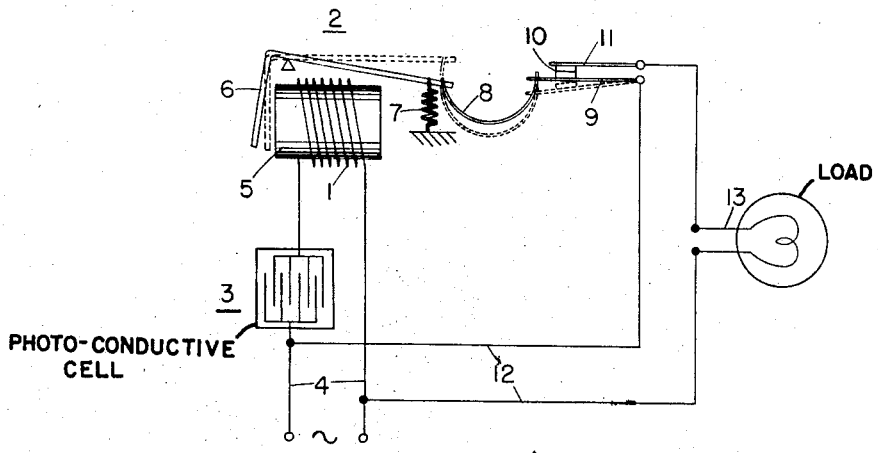
Nov. 17, 1959 C. D. BAYLEY 2,913,637

PHOTOCONDUCTIVE CONTROL CIRCUIT

Filed Dec. 28, 1955



Inventor:
Charles D. Bayley
by, Richard E. Horley
His Attorney

United States Patent Office 2,913,637 Patented Nov. 17, 1959

2,913,637

PHOTOCONDUCTIVE CONTROL CIRCUIT

Charles D. Bayley, Ipswich, Mass., assignor to General Electric Company, a corporation of New York

Application December 28, 1955, Serial No. 555,956

3 Claims. (Cl. 317—128)

My invention relates to photoconductive control circuits particularly suited for turning street lights on and off at desired ambient light levels.

Controllers using a photoemissive cell have heretofore been employed to turn on a street light at evening when daylight falls below a predetermined level and to turn the street light off in the morning when daylight rises to the point where artificial illumination is no longer required. In these controllers the output of the cell is amplified one or more times and used to operate a direct current electromagnetic relay whose contacts are connected in the lighting circuit. Since the increase and decrease in current of the photoemissive cell is gradual in accordance with its response to the gradual change in light level, a regenerative action is built into the amplifier circuit so that an initial gradual increase or decrease of current flow to the relay winding is abruptly changed in response to this initial change in current flow in order to impart a snap action to the relay which will prevent destructive arcing at its contacts which would otherwise occur due to the light contact pressure immediately preceding separation and closure of its contacts.

Photoconductive cells have also been employed in light sensitive controls for turning street lights on and off at desired ambient light levels. These cells have not been connected in circuit with the winding of a relay across the alternating current source of supply because the gradual change in current through the cell resulting from the gradual change in light level to which it responds produces contact chatter and arcing at the contacts of the relay which control the lamp current which may be of the order of 5 amperes or more with an inrush of ten times this value for tungsten filament lamps. This chattering is introduced by the combined effects of frequency oscillations of the alternating current, slow rate of change in cell resistance and the slow rate of change of the small current in the operating winding of the relay. To overcome these difficulties the alternating current of the supply has been rectified and fed through the photoconductor to the winding of a sensitive direct current relay whose contacts are consequently not subjected to frequency oscillations and whose contacts are more positively closed in response to small changes in the control current supplied to its winding. Usually, a condenser is connected across the winding of this relay to eliminate the effect of pulsations in the rectified current. In these controls the contacts of the direct current relay are connected in circuit with the operating winding of a power relay across the alternating current supply and the contacts of the power relay are employed for controlling the lamp circuit current. Since the positive action of the direct current relay imparts a positive action to the contacts of the power relay, satisfactory operation is obtainable. The duty on the contacts of the direct current relay is light since only the small current of the winding of the power relay is controlled thereby. In thus applying photoconductive cells to street lighting control, the use of a direct current pilot relay to operate the alternating current power or load circuit relay is in accordance with accepted practice for constructing other light sensitive photoconductive controllers that have been used for dimming automobile headlights and for similar control functions.

It is an object of my invention to provide a photoconductive control circuit which greatly reduces the number of control elements employed and provides for a positive action of the load circuit relay whose contacts can consequently be located directly in the lamp circuit without being subjected to destructive arcing at the time they are opened and closed in response to the slow change in current flow through the photoconductor resulting from the slow change in light level to which the photoconductor is subjected.

It is also an object of my invention to provide a control circuit which is the ultimate in both simplicity and cost as compared to circuits heretofore employed for eliminating undesirable contact chatter and arcing at relay contacts connected in the load circuit.

Further objects of my invention will become apparent from a consideration of the embodiment thereof shown in the accompanying drawing representing in schematic form a control circuit constructed in accordance with these teachings.

In accordance with my invention, the operating winding of a snap-action relay is connected directly in series with a photoconductive cell across the alternating current supply conductors and the comparatively heavy current of the lamp circuit is controlled by the abrupt opening and closing of its contacts at predetermined current values in the operating winding of the relay. The snap action of the contacts of the relay is obtained by using any one of a number of over-center snap-action mechanisms for operating the switch contacts in response to predetermined changes in the energization of its winding. Such a mechanism will maintain a positive pressure between the relay contacts until the mechanism passes through its dead center position so that at no time are the contacts of the relay subject to vibration and arcing due to the frequency of the alternating current supplied to its operating winding and the light pressure and slow movement of its contacts when opening and closing.

In the diagrammatic representation of the embodiment of my invention shown in the drawing, the operating winding **1** of a snap-action relay **2** is connected directly in series circuit with a photoconductor **3** across supply conductors **4** which are directly connectible with an alternating current source of supply of commercial voltage. The winding of the relay encircles its core structure **5** which, depending on the energization of the winding, attracts an armature **6** which is biased by a spring **7** to the full line position shown in the drawing. The relay armature is connected through an over-center snap-action mechanism comprising a bow spring **8** to a flexible support member **9** for one of the contacts **10** of a switch whose other contact is mounted on a support member **11**. When armature **6** of the relay is in the full line position illustrated, the bow spring **8** and contact support **9** are also in their full line positions illustrated. When the relay is energized the armature **6** moves to its dotted line position and the bow spring **8** passes through a dead center position to move switch member **9** to its dotted line position and open contacts **10** of the switch **9, 11**. When the relay winding **1** is de-energized, the parts of the relay return to their full line positions again closing the contacts of switch **9, 11**. The contacts **10** of this snap-actuated switch complete the connection of the lamp circuit **12** across the alternating current supply conductors **4**. One or more lamps

13 are connected in multiple or series circuit relation with one another for energization through this lamp circuit from the source of supply.

The particular over-center snap-action switch mechanism represented in the drawing is but one of many forms of such mechanism which may be employed. So long as the mechanism imparts a positive pressure to the relay contacts until over-center movement of the actuating mechanism is about to begin and then rapidly opens or closes these contacts by a selfcompleting action so that the contacts pass through a position of zero pressure substantially instantaneously, the requirements of my invention will be satisfied. The mechanism may be referred to as a toggle switch without a zero contact pressure point or by the more commonly accepted definition of being a snap-action switch. In all instances, the mechanism will be an over-center device with a rapid movement of the elements thereof through the dead center position of the device.

I prefer to employ a cadmium sulfide cell as the photoconductor although it is quite obvious that other types of photoconductive cells may be employed. Since the relay that I have used requires about 6 milliamperes of exciting current to operate it, the cell, of course, must be capable of passing this current when excited by one foot candle of illumination since it is also desirable to have the controller operate with this sensitivity. I have used a microcrystalline layer type cadmium sulfide cell in which the sensitive material has been deposited by an evaporative process on its support member although it is, of course, possible to use any cadmium sulfide layer type cell such as those in which the sensitive layer has been applied to its support by spraying, silk screening, or simply spreading the material in a thin layer on its support. The cell that I have employed is of the interdigital electrode type as has been indicated in the drawing. It, of course, does not necessarily require this construction since other broad area type cells having area type electrodes, at least one of which is transparent, may be used. In order to prevent destructive heating of the cell, in accordance with my invention the impedance of the cell for the photocurrent flow required to operate the relay controlled thereby is preferably substantially equal to the impedance of the relay winding. This arrangement will impose a selflimiting condition on current flow through the cell which will protect it from overheating. Both the cell and the relay must be capable of withstanding the alternating current line voltage to which they are directly subjected. The particular cell that I have used, as previously stated, is capable of supplying to a relay winding of about 10,000 ohms 6 milliamperes at a line voltage of 120 volts and one foot candle of illumination when its impedance is of the order of 10,000 ohms. The dark impedance of this cell is of the order of one megohm.

The arrangement I have provided is the ultimate in both simplicity and cost as compared with photoconductive controls heretofore proposed. The use of a snap-action relay having its winding connected directly in series with the photoconductive cell across the alternating current supply conductors and having its contacts in the lighting circuit, makes it possible to eliminate the heretofore employed direct current circuits which required a rectifier and a capacitor for the operation of a direct current pilot relay which in turn controlled the energization of the winding of a power relay whose contacts were in the lamp circuit. The contacts of a snap-action relay are under a positive pressure when closed and since these contacts are rapidly closed or opened at predetermined current values, arcing at these contacts is reduced to a minimum and a controller embodying such a relay will give the dependable and trouble-free operation required thereof. Obviously, my invention is not limited in its application to controlling street lights for which it is particularly suited but may be used in other light sensitive controls where operating conditions are similar to those encountered in street lighting control.

As previously indicated, various types of snap-action relays and various types of photoconductive cells may be employed without departing from the spirit and scope of my invention. I consequently, intend to cover in the appended claims all such modifications of my invention as fall within the true spirit and scope thereof.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A control circuit comprising supply conductors directly connectible with an alternating current source of supply of commercial voltage, an alternating current relay having contacts and means including a winding and an over-center snap-action mechanism operated thereby for moving said contacts substantially instantaneously into and out of a positive pressure engagement with one another when said mechanism passes through its dead center position, a photoconductive cell operable at the commercial voltage of said supply conductors and capable of supplying an operating value of current to said winding of said relay, said cell having electrodes connected directly in series circuit with the operating winding of said relay across said supply conductors, and load circuit conductors connected across said supply conductors through the contacts of said relay.

2. A control circuit comprising supply conductors directly connectible with an alternating supply of commercial voltage, an alternating current relay having contacts and means including a winding and an over-center snap-action mechanism operated thereby for moving said contacts substantially instantaneously into and out of a positive pressure engagement with one another when said mechanism passes through its dead center position, a photoconductive cell connected directly in series circuit with said operating winding of said relay across said supply conductors, the impedance of said cell for the photocurrent flow required to operate said relay being substantially equal to the impedance of said winding of said relay in order to limit current flow in said circuit and the heating of said cell, and load circuit conductors connected across said supply conductors through the contacts of said relay.

3. A control circuit comprising supply conductors, an alternating current relay having contacts and means including a winding and an over-center snap-action mechanism operated thereby for moving said contacts substantially instantaneously into and out of a positive pressure engagement with one another when said mechanism passes through its dead center position, a photoconductive cell having a layer of microcrystalline cadmium sulfide material sufficient in area to supply an operating value of current to said winding of said relay and electrodes in engagement with said layer of cadmium sulfide material, means for connecting said electrodes of said cell in series circuit with said winding of said relay across said supply conductors, and load circuit conductors connected across said supply conductors through the contacts of said relay.

References Cited in the file of this patent

UNITED STATES PATENTS

Re. 19,199	Knowles	June 5, 1934
2,042,109	Lamb	May 26, 1936
2,238,620	Blackburn	Apr. 15, 1941
2,451,850	McArthur	Oct. 19, 1948
2,774,015	White	Dec. 11, 1956
2,776,357	Porath	Jan. 1, 1957

OTHER REFERENCES

"Relay Engineering," 1945, pub. by Struthers-Dunn, Inc., Philadelphia, Pa. pp. 212–214 and 342–343.