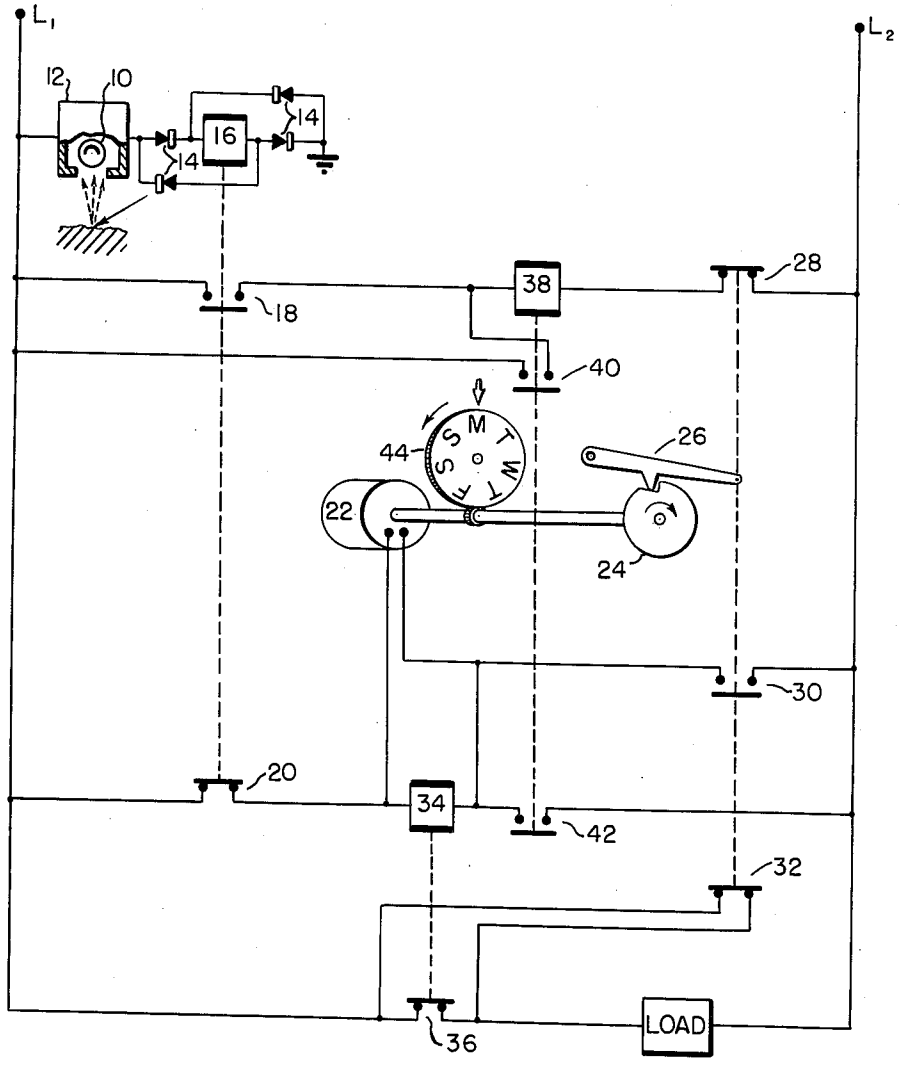
May 8, 1962 R. F. BENWAY ET AL 3,033,969

PHOTOELECTRIC OFF-PEAK CONTROL SWITCH

Filed March 16, 1959



INVENTORS
RICHARD F. BENWAY
DOUGLASS F. TULLOCH

BY KENWAY, JENNEY, WITTER & HILDRETH

ATTORNEYS

United States Patent Office 3,033,969 Patented May 8, 1962

3,033,969

PHOTOELECTRIC OFF-PEAK CONTROL SWITCH

Richard F. Benway, Roslindale, and Douglass F. Tulloch, Milton, Mass. (both % Boston Edison Co., 39 Boylston St., Boston 12, Mass.)

Filed Mar. 16, 1959, Ser. No. 799,741
7 Claims. (Cl. 219—20)

This invention relates to electric hot water heaters and more particularly to a novel and improved control for automatically disconnecting an electric hot water heater from a power line during periods of peak loading on the system.

As is well known, during the early evening hours of certain undeterminable days of each year electric power companies experience a demand for electric power which far exceeds the highest normal power demand. This excessive demand usually occurs during the period from shortly preceding to shortly after sunset and is often referred to as peak loading. Inasmuch as the peak loads occur during a period which is of fairly short duration, often not longer than two hours, it is highly desirable from an economic standpoint to provide some means to reduce the demand during this period in order to minimize the requirements in plant capacity that would otherwise be required to meet the power demand of the peaks of this period. In order to reduce the power demand it is, of course, necessary to remove certain loads during the peak load period, and the most common type of load which is adaptable to off-peak operation is the domestic hot water heater.

The fact that the starting time and the duration of the peak load periods vary from day to day complicates the problem of accurately controlling the period of disconnection of the heater from the power line. Various methods of control have been used, such as wired remote controls and wired high frequency signaling devices, but these present obvious problems of complication and cost. The conventional electric powered time switch is therefore the most common presently used method of control.

The electric time switch is, however, a preset device which cannot provide for variations in the actual starting time or duration of peak loads, and therefore has to be set to disconnect the heater from the line for a predetermined period which begins sufficiently early and lasts sufficiently long to encompass safely all peak loads. This may necessitate a shut-off period of from four to five hours. Also, if a power failure should occur, the conventional time switch is unable to correct for the period of outage, and accordingly the cut-off period of the switch will be in error by the duration of the outage. If there are several outages over an interval of time, the timing may become completely unrelated to the peak period. This necessitates a periodic manual resetting of all time switches, which entails an undesirable expense to the power company. While spring wound carry-over mechanisms may be provided in conventional electric powered time switches, this added structure substantially increases the cost of the switch, and the mechanical clock-type escapement and associated elements present an increased problem of maintenance, labor and expense.

It is the object of this invention to provide a novel and improved control for off-peak operated domestic hot water heaters which will accurately and automatically control the removal of the heater from the power line in accordance with the daily variations in starting times of the peak load periods and which will eliminate any cumulative errors due to power outages.

It is a further object of this invention to provide an off-peak control of the type described which is relatively simple and economical yet which will provide trouble-free operation over extended periods without maintenance.

The primary object of the invention is achieved in one embodiment thereof by providing a control means responsive to the outdoor incident light level and operatively associated with an electric timer motor which through suitable control means actuates a switch for energizing and de-energizing the heater. In this manner, the starting time of the shut-off period of the heater will vary in accordance with the variations in time of sunset or in accordance with unusual weather conditions that result in an abnormal reduction in light level and consequent onset of peak system loads. Because of the accurate correlation of heater control with the actual day-to-day peak load conditions, the heater shut-off period may be of shorter duration than possible with conventional time switches while at the same time the total demand on the power company will be proportionately reduced during the period desired. A more detailed understanding of the invention and its features may be had by reference to the accompanying drawing which is a schematic representation of a light responsive off-peak hot water heater control embodying the present invention.

With reference to the drawing, the specific embodiment of the invention shown therein comprises a light responsive element 10 disposed in a housing 12 adapted to be mounted on an exterior wall of a building and having an aperture in the bottom thereof so that the light responsive element 10 is responsive to incident light reflected from the ground. The light responsive element 10 is connected between a power line L_1 of a pair of lines L_1, L_2 and rectifying means comprising rectifiers 14 arranged in a single phase bridge configuration. While the line voltage supplied across power lines L_1 and L_2 will generally be approximately 240 volts, the normal operating voltage of the heater or other load, the photocell operates between one side and ground and hence in a 120 volt circuit. The light responsive element in the preferred embodiment is a cadmium sulfide cell or, in other words, is of the photoconductive type. The use of a photoconductive means for the light responsive element in the control is to be preferred over photovoltaic means, which could be utilized, in view of the reduced number of elements necessary in a photoconductive circuit of this type.

The coil of a relay 16 is connected in the rectifier bridge circuit 14 and is provided with a pair of normally open contacts 18 and a pair of normally closed contacts 20.

The control of this invention further includes an electric timing motor 22 drivingly connected to a cam 24 which engages and controls the movement of a switch-actuating follower 26 operatively engaged with a pair of normally closed contacts 28, a pair of normally open contacts 30, and a pair of normally closed contacts 32. The control also includes a fail safe relay having a coil 34 and a pair of normally closed contacts 36. Lastly, the control of FIG. 1 includes a setting up relay 38 having two pairs of normally open contacts 40 and 42.

It is believed that the specific connections of the various elements of the control will be most easily understood from the following description of operation of the device taken in connection with the drawing. The condition of the circuit as shown in the drawing is representative of a low light level condition, such as during the night-time hours following a peak load period when the photoconductive cell 10 will be for all intents and purposes non-conducting. At this time the relay 16 will be de-energized so that its contacts 18 will be open to maintain relay 38 de-energized. The relay 34 and timing motor 22 will be de-energized in view of the normally open contacts 30 and 42. The parallel connected

normally closed contacts 32 and 36 connect the load between the power lines L_1 and L_2 so that during the night-time off-peak hours, with all of the relays and the timing motor de-energized, the water heater represented by the "load" will be energized, as is desired.

During the early morning hours, as the light level rises the cell 10 will become sufficiently conductive to energize the relay 16, resulting in the closing of the contacts 18 to energize the relay 38. The energizing of the relay 38 will result in closing of its sealing or holding contacts 40 and also of its contacts 42. The relay 34 and motor 22 are, however, not energized at this time, inasmuch as the normally closed contacts 20 will now be open. The contacts 32 and 36 will, of course, remain closed, and the heater will remain energized.

When the light level subsequently lowers, normally at or about sunset, the cell 10 will become sufficiently non-conducting to de-energize the relay 16. The attendant opening of contacts 18 will not de-energize the setting up relay 38 because of its holding contacts 40. On the other hand, the attendant closing of contacts 20 will now effect the energizing of the relay 34 and the motor 22 through the previously closed contacts 42. Also, at the same time the contacts 36 will be opened so that only the contacts 32 connect the heater to the power lines. A predetermined relatively short interval after energizing of the motor 22 and relay 34, the contacts 30 will be closed to lock in the relay 34 and motor 22, and the contacts 32 will be opened to disconnect the heater from the power lines. At the same time, the contacts 28 will be opened to de-energize the setting up relay 38.

The time delay between energizing of the relay 34 and opening of the contacts 32, while not absolutely necessary, is desirable in order to compensate for short intervals of unusually low light levels such as might occur due to a partial sun eclipse or a passing of unusually heavy cloud formations. This time delay is provided in the exemplary control shown by the sloping side of the notch on the cam disc 24. In other words, the time it takes the cam follower 26 to be moved out of the notch and onto the periphery of the disc is the time delay, and in a preferred embodiment is approximately six seconds. As will be apparent, this time delay could also be provided by other suitable means, such as a thermal time delay relay in the motor circuit. As will also be apparent other suitable switch actuating means could be substituted for the specific cam arrangement phase such as an automatically resetting timing device.

Upon expiration of a predetermined time of operation of the motor 22, the contacts 32 will be closed to reconnect the heater to the power line. The contacts 30 will be opened at the same time to de-energize the motor 22 and relay 34 and close the contacts 36. The contacts 28 will also at the same time be closed to condition the circuit for energizing of the relay 38 upon subsequent energizing of the relay 16 and closing of its contacts 18. When the light level again rises sufficiently to make the cell 10 conducting, the relay 16 will be again energized as previously described.

The time of operation of the motor 22 and thus the time that the heater is disconnected from the power line is set in a preferred embodiment at approximately two and one-half hours. The fact that the control will automatically remove the heater from the power line at the time the light level diminishes sufficiently, regardless of the variation in this time each day, permits a much shorter time of de-energizing of the heater than possible with time switch controls, with an attendant substantial reduction in service calls from customers who have exhausted their hot water supply. It will be noted that false operation of the control during the daylight hours or power outages will merely affect the off time of the heater for the particular day but will not affect the operation of the control on subsequent days. Also, as will be apparent, the provision of the parallel connected, normally closed, contacts 32 and 36 to connect the heater to the power line assures a fail safe circuit.

As has been indicated, the device may experience a false operation, or a power line failure, without disturbing the subsequent operation and the timing thereof. In order to afford an indication to supervisory personnel when there have been such interruptions within the period since installation or previous inspection, a disc 44 may be provided, having legends to identify the days of the week. The disc is driven at one-seventh the speed of cam 24, and hence rotates one-seventh of a revolution for each day that the control completes a cycle. When the device is installed, the disc is set with the proper day designation opposite the index mark. Upon subsequent inspection, a comparison of the indication with the actual day of the week will show whether there have been failures, and these can be correlated with known power failures, if any, to reveal whether the device has operated properly or has experienced a failure in the absence of any power interruption.

The preferred shielding of the cell 12 from direct sunlight so that it is responsive only to outdoor incident light reflected from the ground makes the cell relatively unresponsive, at night, to passing automobile lights or nearby street lights and in the daylight hours makes it less sensitive to the effects of passing clouds and shade variations.

As will be apparent from the foregoing, the control of this invention will assure that the water heater will be automatically de-energized during the peak load period each day, while the off time of the heater is reduced by as much as 50 percent as compared to that required with conventional time switches. The fewer service calls caused by customers who have exhausted their hot water supply during the peak period together with the elimination of an elaborate mechanism resetting program provides an increased economy in maintenance for the power company. Also, the normal variations in incident light level between individual customers assures that the de-energizing and thus the subsequent energizing of the many heaters on a particular portion of the power system will be staggered to avoid excessive instantaneous loads when the heaters are put on the line.

While the invention has been described and illustrated in terms of a specific embodiment, it is to be understood that the invention is not limited to this embodiment but rather that it is to be limited only by the appended claims which shall include within their scope all structure which logically falls within the language of these claims.

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

1. In combination, an electric hot water heater, switch means connected to the water heater for energizing and de-energizing the same, timer means for effecting actuation of said switch means to de-energize the water heater for a predetermined interval and upon expiration of said interval to energize the water heater, and light responsive means for effecting actuation of said timer means and thus initiation of the predetermined interval of de-energizing of the water heater as a result of a reduction in light level to a predetermined value.

2. In combination, an electric hot water heater, switching means connected to the water heater for energizing and de-energizing the water heater, actuating means for the switch means including an electric motor, second switch means for de-energizing the motor after a predetermined time interval of operation of the motor, and light responsive means for energizing the motor as a result of a decrease in light level to a predetermined value to effect actuation of said switching means to deenergize said water heater.

3. In combination, an electric hot water heater, switch means connected to the water heater for energizing and de-energizing the water heater, means for actuating the switch means to de-energize the heater for a predetermined time interval and upon expiration of said interval

to energize the heater including an electric motor and means to de-energize the motor after a predetermined time interval of operation thereof, and light responsive means for energizing the motor in response to a reduction in light level to a predetermined value to effect actuation of said switch means to deenergize said water heater.

4. An off-peak electric hot water heater control comprising switch means connected to an electric hot water heater for the energizing and de-energizing thereof, means responsive to a reduction in outdoor light level to a predetermined level for actuating the switch means to de-energize the water heater for a predetermined interval of time which is substantially less than the normal duration of the night time hours and upon expiration of said interval to re-energize the water heater including an electric motor and a light responsive element, and additional switch means to prevent energizing of the motor following a de-energizing thereof until the light level has sequentially raised beyond and fallen at least to said predetermined light level.

5. An off-peak electric hot water heater control comprising switch means connected to an electric hot water heater for energizing and de-energizing the hot water heater, means for actuating said switch means to de-energize the water heater for a predetermined interval and upon expiration of said interval to energize the water heater including an electric drive motor, second switch means responsive to operation of the motor for a predetermined time interval to de-energize the motor, a relay connected to the motor for energizing the motor, and a

photoconductive element connected to the relay to effect operation thereof to energize the motor as a result of a reduction in light level to a predetermined value.

6. Apparatus according to claim 5 having means actuated by the motor for indicating a past failure of the apparatus to complete an operation.

7. An off-peak electric hot water heater control comprising a switch connected to an electric hot water heater for energizing and de-energizing the water heater, an electric motor, actuating means driven by the motor for actuating the switch to de-energize the water heater for a predetermined interval substantially less than the normal duration of the night time hours and upon expiration of said predetermined time interval to energize the heater, a relay for energizing the motor, an incident light responsive photoconductive cell connected to the relay for operating the relay to energize the motor as a result of a reduction in light level to a predetermined value, and a second switch operated by said actuating means for de-energizing the motor simultaneously with the energizing of the water heater upon expiration of the predetermined interval of de-energizing of the water heater.

References Cited in the file of this patent

UNITED STATES PATENTS

1,861,288	Weill	May 31, 1932
2,368,774	Osterheld	Feb. 6, 1945
2,377,441	Osterheld	June 5, 1945
2,415,966	Osterheld	Feb. 18, 1947
2,446,450	Ziegler	Aug. 3, 1948
2,450,983	Osterheld	Oct. 12, 1948