July 6, 1954 R. J. HORSTMANN 2,683,242

CONTROL DEVICE AND LIGHTING SYSTEM

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Fig. 1.

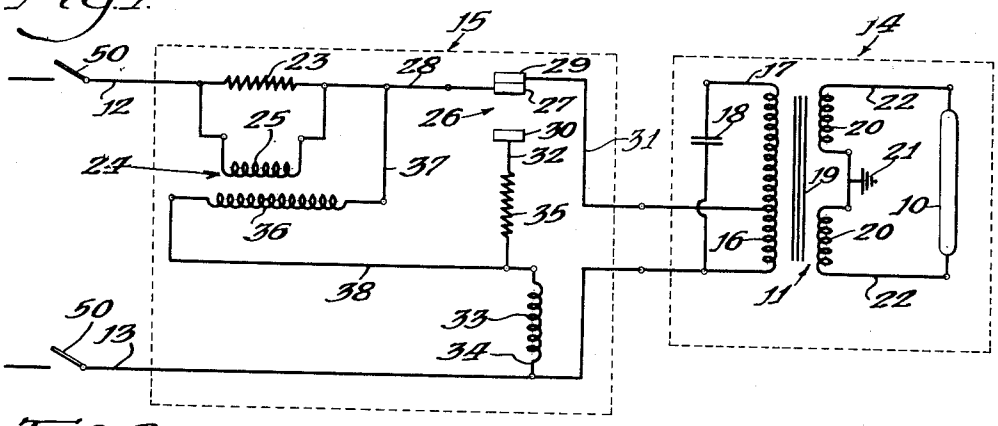


Fig. 2.

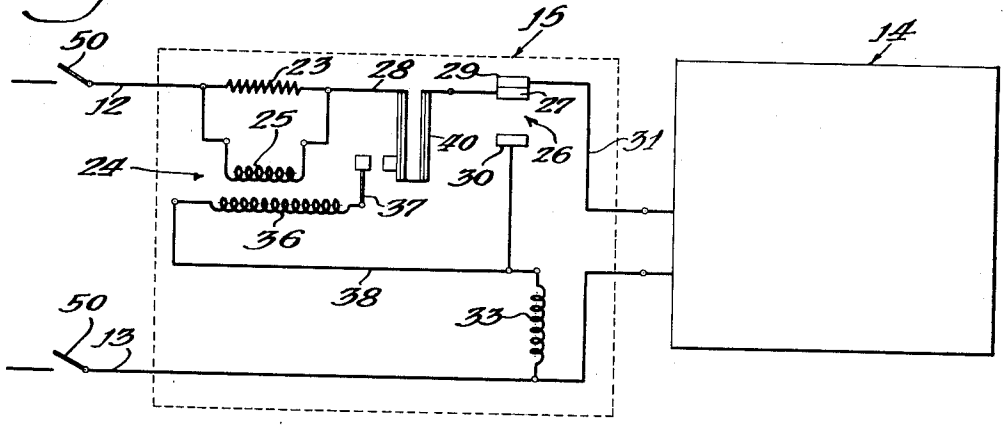
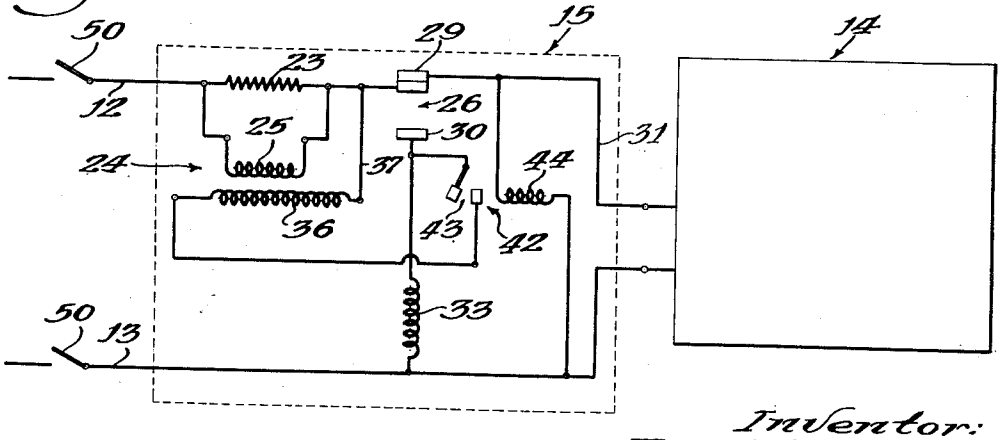


Fig. 3.



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Fig. 4.

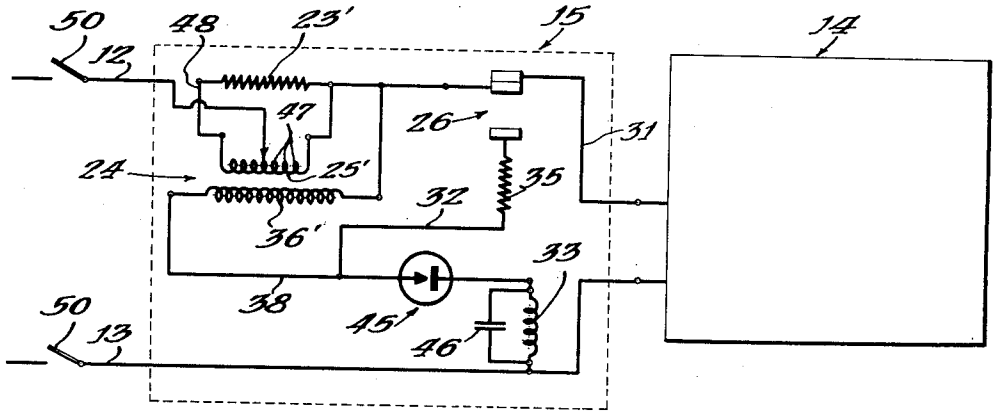
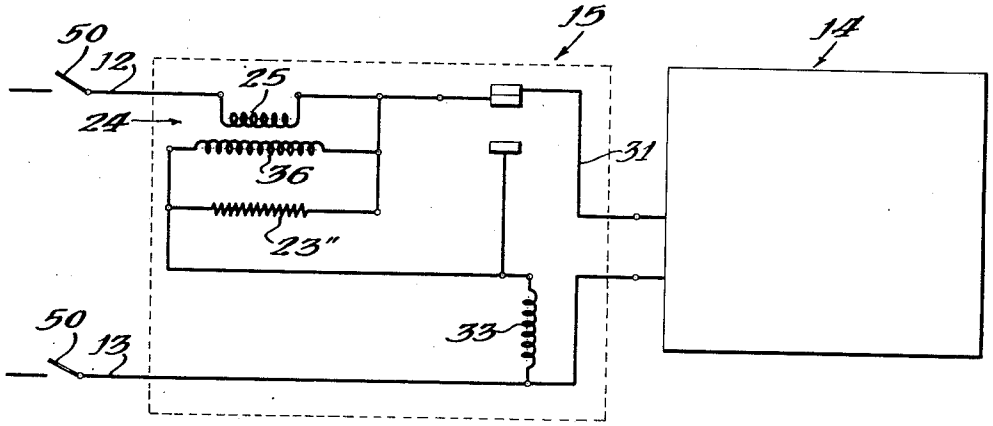


Fig. 5.



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Fig. 6.

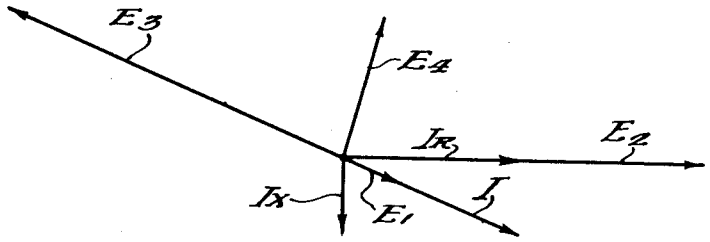


Fig. 7.

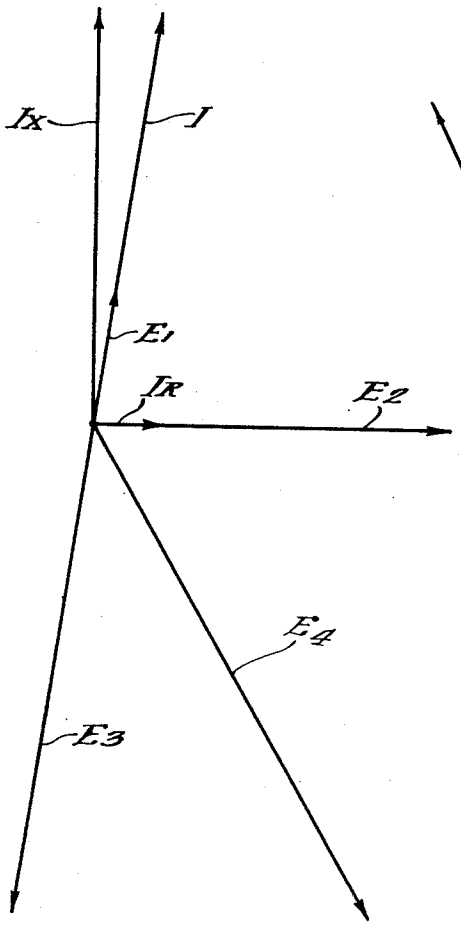
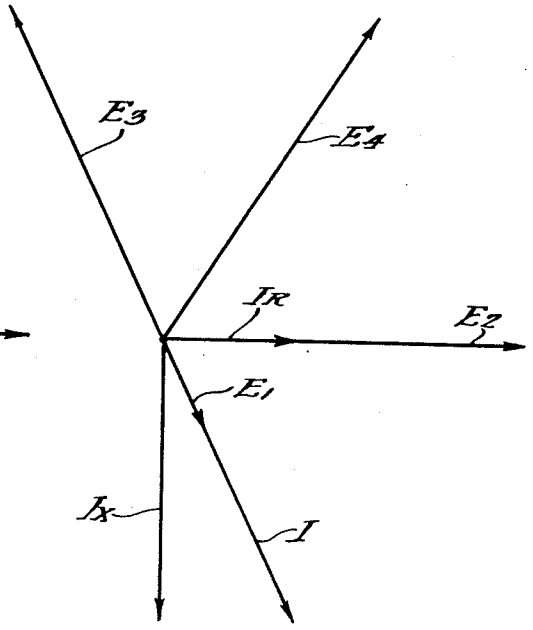


Fig. 8.



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UNITED STATES PATENT OFFICE

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CONTROL DEVICE AND LIGHTING SYSTEM

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Application February 16, 1949, Serial No. 76,738

9 Claims. (Cl. 315—126)

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This invention relates to a control device and to a lighting system including the same.

My invention is particularly well adapted for use in a lighting system embodying gaseous conduction tubes. For that reason, the following description has reference to my invention as applied to such a lighting system.

Lighting systems embodying gaseous conduction tubes of the type known as neon tubes and cold cathode tubes include a high reactance transformer for supplying the proper voltage for operation of the tube. One characteristic of such systems is that a dangerously high voltage is induced in the secondary circuit. When the secondary circuit is broken, due to tube failure or the like, certain of the parts are still energized, and constitute a source of danger to the electrician who replaces a tube. Control or protective devices have been proposed which automatically open the primary circuit when the secondary circuit is broken, thereby causing the whole system to go dead. Thus, an electrician is protected against shock when replacing a burned out tube, or in otherwise repairing the system.

Such protective devices generally include a circuit breaker which is controlled by the existence or non-existence of a current flow in the secondary circuit. Such an arrangement has the disadvantage of requiring leads from the secondary circuit to the circuit breaker. The problems in insulating such high voltage leads are such that it has generally been found necessary to locate the circuit breaker immediately adjacent the transformer. Since the transformer is frequently located in an inaccessible position, this disadvantage constitutes a serious obstacle to the use of such control devices in certain types of installations.

It is an object of this invention to provide an improved electric system having a control device in the primary circuit which does not require separate leads from the secondary circuit.

Another object is to provide an improved lighting system in which the secondary circuit is protected against short circuit and open circuit conditions.

Still another object is to provide an improved lighting system of the type described which includes a high reactance transformer which is compensated so that the system can be operated at a substantially unity power factor and which also includes circuit breaking means in the primary circuit which is controlled solely by the load as reflected in the primary circuit.

A further object is to provide an improved control device, the action of which is controlled by a phase shift in the load current.

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A still further object is to provide a control device which is responsive to certain unusual changes in the conditions of the load circuit, but which is not sensitive to the transients which occur when the circuit is initially closed.

Other advantages, features and objects will become apparent as the description proceeds.

With reference now to the drawings in which like reference numerals designate like parts:

Fig. 1 is a diagram illustrating a preferred embodiment of my invention;

Figs. 2, 3, and 4 are diagrams illustrating modified forms of my invention;

Fig. 5 is a diagram illustrating a further modification of my invention; and

Figs. 6, 7 and 8 are vector diagrams illustrating certain voltage and current relationships in the foregoing circuits under different conditions.

In Fig. 1, the reference numeral 10 designates one or more lamps of the neon or cold cathode type. A transformer 11 is provided for supplying power to the lamp. Supply leads 12 and 13 supply power to the transformer through the usual double pole switch 50, such as a wall switch. The lamp 10 and transformer 11 together comprise a load which is indicated generally by the reference numeral 14. A control device 15 is disposed between the load and supply leads 12 and 13.

The transformer 11 comprises a primary winding 16 and a condenser winding 17 connected across the primary winding 16 and inductively coupled thereto. A condenser 18 is connected in series with the condenser winding 17. The transformer also includes a core 19 and a secondary winding 20 which is here shown as being in two sections. There may be a mid-point ground 21 between the two sections so as to provide for balanced operation of the secondary circuit. The transformer 11 is a high reactance transformer of a type commonly used in neon or cold cathode systems, and the condenser 18 and condenser winding 17 are provided to correct the power factor. Thus, the load 14 as a whole is designed to operate at a power factor of between 90% and 100%.

The lamp 10 is connected to the secondary 20 by means of leads 22.

The control device 15 comprises a resistance 23 connected in series in the primary circuit, a control transformer 24 and a relay 26. The control transformer 24 comprises a primary winding 25 and a secondary winding 36, the primary winding being shunted across the resistance 23.

The relay includes a movable contact 27 which is connected by a lead 28 to the resistance 23 and primary 25. The relay also includes two stationary contacts 29 and 30, the former being connected by lead 31 to the primary 16 of the supply transformer and the latter being connected by a lead 32 to the actuating winding 33 of the relay. The movable contact is normally biased against the stationary contact 29 so as to maintain a circuit through the transformer 11. The arrangement is such that when the actuating winding 33 is initially energized so that the movable contact 27 engages the stationary contact 30, the line current will hold the relay in operated position. If desired, an impedance 35 may be disposed between the actuating winding 33 and the stationary contact 30 so that the current flow through the winding 33 may be limited. This impedance, when used, is preferably a resistance, although other types of impedance may be used in certain situations. A lead 34 connects the actuating winding 33 to the supply lead 13.

The secondary 36 of the control transformer 24 is shunted across the gap between contacts 27 and 30, and is connected to lead 28 by means of a lead 37, and is connected to the actuating winding 33 by a lead 38. The connections are such that the secondary voltage is in bucking relationship to the line voltage. The turn ratio of the control transformer 24 is such that the voltage induced in the secondary 36 is equal in magnitude to the line voltage, but opposes the same. Thus, when the load is drawing a current of substantially unity power factor, there will be either no current passing through the shunt circuit including the secondary 36 and the actuating winding 33 of the relay or else the current will be sufficiently small as to not cause the relay to operate.

This relationship of the electrical quantities involved is shown in Fig. 6 in which E_1 is the voltage across the primary 25, E_2 the voltage across leads 31 and 13, E_3 the voltage across secondary 36 and E_4 the voltage across the relay actuating winding 33. I is the current drawn by the load, I_R is its resistive component and I_X its reactive component.

Fig. 6 represents the circuit at normal operating conditions under a lagging load of about 90% power factor. The voltage E_3 of the secondary 36 is of the same magnitude as E_2, which is substantially the line voltage, but E_3 is 180° out of phase with the load current I, if the reactance of the control transformer 24 be disregarded. Hence, E is approximately 155° out of phase with E_2, assuming 90% lagging power factor. Thus E_4, which is the vector sum of E_2 and E_3, is of considerably less magnitude than either one.

When the tube circuit is opened, the electrical quantities will be substantially as shown in Fig. 7. Here the current I leads the line voltage E_2 by substantially 90° with the result that the voltage across the secondary 36 and the actuating winding 33 will be as shown by the vectors E_3 and E_4, if the reactance of the transformer 24 is disregarded.

Fig. 8 shows a short circuited condition in the tube circuit. Here the current I is practically 90° lagging with respect to the line voltage E_2, and the vectors E_3 and E_4 represent the voltages of the various parts under the same conditions set forth in connection with Figs. 6 and 7.

It will be observed that the voltage of relay actuating winding 33 is much greater under either short circuit or open circuit conditions than it is during normal operation, with the result that this variation in voltage can be utilized to actuate the relay 26. The transformer 24 may be designed so that its reactance will cause the voltages E_3 and E_4 to be somewhat different than that shown in Figs. 6 to 8, but the same, or greater, variation in voltage will be present.

Although my invention is not limited to specific dimensions or windings, the following specifications, which are given merely by way of example, may be employed in constructing a system including a sufficient amount of tubing to load a 5000 volt 120 M. A. high power factor transformer to 80% of short circuit current. The transformer operates from a 60 cycle 115 volt supply line.

The control transformer 24 comprises a primary winding 25 having 39 turns of No. 18 enamel covered wire. The secondary 36 comprises 2300 turns of No. 35 enamel covered wire. The primary and secondary windings are wound on the center leg of a shell-type core of the type known as three-fourths inch center leg scrapless lamination core.

The relay may be any suitable type 60 cycle A. C. relay which will operate at voltages in excess of 40 or 50 volts, but which will not operate at voltages below that point. The resistance 23 may be about half an ohm.

The transformer 11 is of the type known as a 120 M. A. short circuit transformer which is suitably compensated for power factor. Preferably the transformer is of the type having a condenser winding although it may be any other type of high power factor transformer.

In the event that the relay 26 is so sensitive to transient currents that it will operate when the circuit is initially established, means can be provided to delay the operation of the relay for a few cycles, until after such time as the transients have died down. Various means for achieving this result are shown in Figs. 2, 3 and 4.

In Fig. 2, a U-shaped bimetallic element 40 is connected in series with the supply circuit and is arranged to close the circuit between leads 28 and 37 after the current in the supply circuit has heated the bimetallic element. Thus, the shunt circuit which includes secondary circuit 36 and actuating winding 33 will not be established until after the transient currents have died down.

In Fig. 3, a time delay relay 42 is provided to achieve a similar result. The contacts 43 of this relay which are biased to open position, are placed in series with the lead 38 and the actuating winding 33, and the actuating winding 44 of relay 42 is connected across leads 31 and 13. Thus, the cutting in of the shunt circuit is delayed until after the transients have died down. The period of time delay afforded by the relay 42 may be from a few cycles up to one second.

In Fig. 4, a half wave copper oxide rectifier 45 is placed in the shunt circuit between the actuating winding 33 and the junction between leads 32 and 38. This rectifier acts primarily as a resistance load in the shunt circuit and permits the use of a filter condenser 46 around the actuating winding 33 without adding capacitive reactance into the shunt circuit. Thus, that part of the transient currents which pass beyond the half wave rectifier are caused to by-pass the actuating winding 33 and will not operate the relay. The rectifier 45 may be a full wave rectifier if desired, and need not be of the copper oxide type. The half wave copper oxide rectifier specified herein is preferred from a cost viewpoint.

Fig. 4 shows also an alternative arrangement of the resistance 23' and the primary 25'. The latter is provided with a plurality of taps 47 to any one of which the supply lead 12 is adapted to be connected. The resistance 23' is connected to the end of primary 25' by means of a lead 48. With this arrangement various values of line current can be accommodated without changing the voltage across the resistance 23' and secondary 36'. Thus the control device 15 can be manufactured in a standard type which is adapted for use in connection with transformers of various capacities.

Fig. 5 shows an alternative arrangement in which the resistance 23'' is located in the shunt circuit, the resistance being connected in parallel circuit with the secondary 36 of the control transformer. Thus the impedance of the primary 25 is substantially resistive since it reflects the resistive load which is connected to the secondary 36.

While I have shown only certain preferred embodiments of my invention, it will be understood that various modifications and changes may be made in the construction shown without departing from the spirit of my invention as defined in the appended claims.

I claim:

1. A lighting system comprising a gaseous conduction tube, a high reactance transformer having a primary winding, said tube and said transformer being connected to each other and comprising a load, an A. C. supply circuit connected to said primary winding for supplying current to said load at a substantially constant voltage, a control transformer having a control primary winding and a control secondary winding, said control primary winding being connected in said supply circuit in series with said first-mentioned primary winding, a resistance connected in said supply circuit in series with said first-mentioned primary winding and in shunt relationship to said control primary winding to limit the voltage drop across said control primary winding, a relay having means to break said supply circuit at a point between said control transformer and said load and including an actuating winding, a shunt circuit connected across said supply circuit including said control secondary winding, the latter being arranged so that the voltage induced therein is substantially the same as the voltage across said supply circuit, but in opposition thereto, said shunt circuit including said actuating winding, said actuating winding being non-responsive to the voltage applied thereto during normal operation of said tube, but being responsive to the voltage applied thereto when the phase angle of the current drawn by said load is shifted, and condenser means connected to said supply circuit to cause a shift in the phase angle of the current drawn by said load when the tube circuit is opened so that said relay will operate to open said supply circuit thereby de-energizing said tube circuit, said condenser means cooperating with said high reactance transformer during normal operation to provide substantially unity power factor.

2. A lighting system comprising a gaseous conduction tube, a high reactance transformer having primary and secondary windings, an A. C. supply circuit connected to said primary winding for supplying current thereto at a substantially constant voltage, said gaseous conduction tube being connected in series to said secondary winding, a control transformer having a control primary and a control secondary winding, said control primary winding being connected in said supply circuit in series with said first-mentioned primary winding, a resistance connected in said supply circuit in series with said first-mentioned primary winding and in shunt relationship to said control primary winding to limit the voltage drop across said control primary winding, a relay having means to break said supply circuit at a point between said control transformer and said first-mentioned transformer and including an actuating winding, a shunt circuit connected across said supply circuit at a point between said control transformer and said circuit breaking means and including said control secondary winding, the latter being arranged so that the voltage induced therein is substantially the same as the voltage across said supply circuit, but in opposition thereto, said shunt circuit including said actuating winding, said actuating winding being non-responsive to the voltage applied thereto during normal operation of said tube, but being responsive to the voltage applied thereto when the phase angle of the current drawn by said tube and supply transformer is shifted, condenser means connected to said supply circuit to cause a shift in the phase angle of the current drawn by said load when the tube circuit is opened so that said relay will operate to open said supply circuit thereby de-energizing said tube circuit, said condenser means cooperating with said high reactance transformer during normal operation to provide substantially unity power factor, and means to maintain said relay in operated position.

3. A lighting system as claimed in claim 2 in which said means to maintain said relay in operated position includes means for establishing a by-pass shunt circuit which by-passes said control secondary winding and which includes said actuating winding.

4. A lighting system as claimed in claim 2 which includes means for preventing operation of said relay by the transient currents occasioned by the initial energization of said supply circuit.

5. A control device adapted for connection in the primary circuit of a high power factor lighting system, to which primary circuit, a voltage is to be applied from an A. C. source, which includes a gaseous conduction tube, a high reactance supply transformer, and power factor correcting means, comprising a control transformer having a primary winding and a secondary winding, said primary winding being connected in series in said primary circuit, a resistance connected in said primary circuit in shunt relationship to said primary winding, the impedance of said resistance being substantially less than the impedance of said primary winding, a relay having movable contact means disposed between said control transformer and said supply transformer for breaking the primary circuit to said supply transformer and for establishing a shunt circuit around said supply transformer, said relay also including an actuating winding in said shunt circuit, means connecting the secondary winding of said control transformer in shunt relationship across said movable contact means and in series with said actuating winding, the turn ratio of said primary and secondary windings being such that the voltage induced in said secondary winding is substantially equal in magnitude to the voltage across said primary circuit, but in opposed phase relationship thereto whereby said relay will remain in unoperated position during

normal operation of said lighting system, but will operate to cut out said supply transformer when the phase angle of the current drawn by said supply transformer is shifted.

6. A control device as claimed in claim 5 including means for delaying the energizing of said actuating means when said tube is initially energized.

7. A control device as claimed in claim 5 having a bimetallic element connected in series in said primary circuit and contact means cooperating with said bimetallic element to establish the circuit through said secondary winding after said primary circuit has been initially energized, said contact means being normally in open circuit position when said primary circuit is not energized.

8. A control device as claimed in claim 5 having a circuit closing means in series circuit connection with said secondary winding and cooperating therewith to establish a shunt circuit around said movable contact means of said relay, and a second actuating winding connected in said primary circuit in shunt relationship with said supply transformer for operating said circuit closing means when said primary circuit is initially energized, said second actuating winding and said circuit closing means constituting a time delay relay.

9. A control device as claimed in claim 5 having a rectifier disposed in said shunt circuit at a point between said actuating winding and the point where said secondary winding is connected to said shunt circuit, and by-pass filter means shunted across said actuating winding to filter out the transient currents occasioned by the initial energization of said primary circuit.

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