Sept. 7, 1965 MAMORU KURATA ETAL 3,205,404

DIMMER FOR DISCHARGE LAMPS

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FIG. 1

PRIOR ART

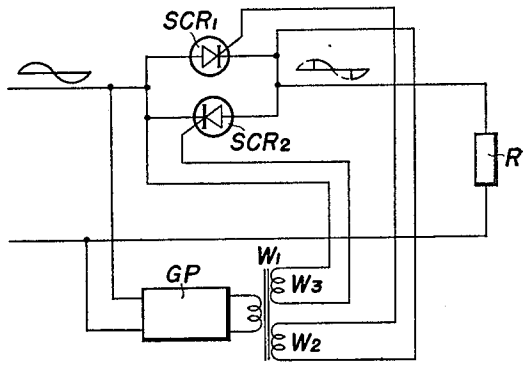

FIG. 2

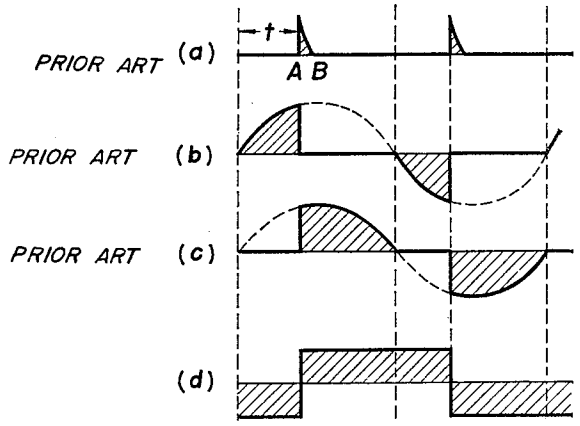

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FIG. 3

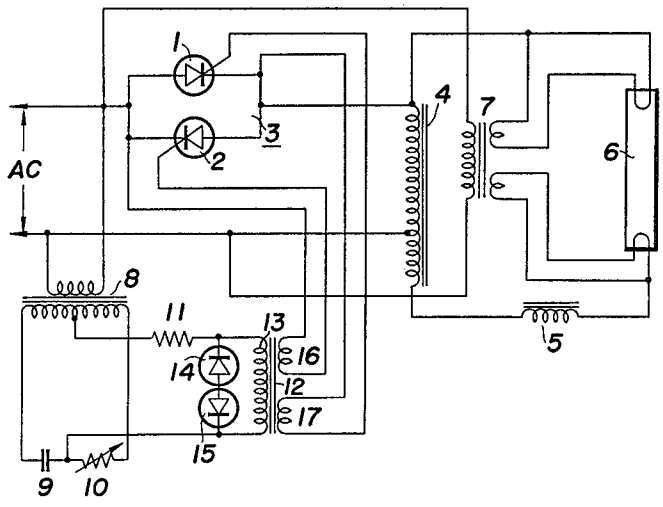
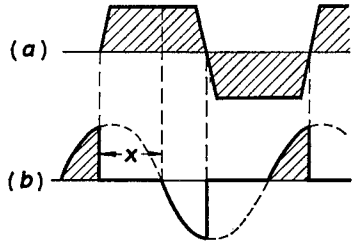


FIG. 4



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DIMMER FOR DISCHARGE LAMPS

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1 Claim. (Cl. 315—194)

This invention relates to a dimmer, or illumination control device for discharge lamps.

Dimmers of various types have been used for varying electric current supplied to electric lamp load to vary the intensity of illumination. With recent advance of semiconductor rectifiers it has been proposed to use a pair of silicon controlled rectifier elements, connected in parallel, but with opposite polarities, as the control device for varying the current flowing through illuminating lamps. It was found that while such a control device operates satisfactory for ordinary incandescent lamps, it is unable to control current flowing through discharge lamps because they include substantial amount of inductance in the form of ballasts, for example.

Accordingly the object of this invention is to provide a novel dimmer for discharge lamps.

More specific object of this invention is to provide a novel dimmer comprising a pair of reversely connected silicon controlled rectifier elements which can satisfactory control current flowing through discharge lamps including ballasts.

According to this invention a dimmer comprising a conduction controller is connected between a source of alternating current and an inductive load including one or more discharge lamps and ballasts. The conduction controller incudes at least one semiconductor, such as silicon controlled rectifier element for varying the alternating current supplied to said discharge lamp or lamps. A phase shifting circuit and a cramp circuit are provided to supply a gate signal of rectangular wave form to the gate electrode of the rectifier element. In this manner the width of the gate signal is substantially increased to assure positive triggering of the rectifier element. By proper adjustment of the phase shifting circuit the current supplied to the discharge lamp and hence its intensity of illumination can be varied to any desired value.

The features of the invention which are believed to be novel are set forth with particularity in the appended claims. The invention itself, however, as to its organization together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawings, in which:

FIG. 1 shows a circuit diagram of a prior dimmer for incandescent lamps;

FIG. 2 is a waveform chart wherein *a*, *b*, *c* and *d* indicate waveforms of various portions of FIG. 1;

FIG. 3 shows a circuit diagram of one embodiment of this invention; and

FIG. 4 is a waveform chart wherein *a* and *b* indicate waveforms of portions of FIG. 3.

Referring now to the accompanying drawings, there is shown in FIG. 1 an example of the prior art dimmer including silicon controlled rectifier elements (for the sake of simplicity, hereinafter called as "rectifier elements") for controlling current flowing through incandescent lamps. Thus, in series with an incandescent lamp load R is connected to a conduction controlling device including a pair of reversely poled parallel rectifier elements SCR_1 and SCR_2. A suitable gate pulse generator GP is provided to impress the control pulses across the gate and the cathode electrode of the respective rectifier

element. As is well known in the art the phase of said control pulses are varied to control the current flowing through the rectifier elements and hence the intensity of illumination of the incandescent lamps.

The pulse generator GP comprises, for instance, a pulse generating circuit including a unijunction transistor as the principal operating element or an equivalent circuit, said pulse generator being coupled to the respective rectifier elements SCR_1 and SCR_2 through a transformer having a primary winding W_1 and two secondary windings W_2 and W_3. When a pulse as shown in FIG. 2*a* is applied across the gate and cathode electrodes of the rectifier elements SCR_1 and SCR_2, these rectifier elements conduct alternately. Then the waveform of the voltage across the anode and cathode electrodes will be as shown in FIG. 2*b* so that the voltage across the load R will be as shown in FIG. 2*c*. Thus, the intensity of the illumination of the lamp can be varied by changing the phase t of this gate control pulse over a range from zero to π thereby to vary the conduction period of the rectifying elements. However, in the case of an inductive load comprising a discharge lamp and a ballast associated therewith, the inductance of the load operates to prevent rapid change of the load current, so that the load current can not build up to a current level at which the rectifier elements SCR_1 and SCR_2 can continue conduction during the time interval from an instant A at which the gate pulse is applied to instant B at which the pulse diminishes. Thus, it will be seen that the control device as shown in FIG. 1 can not be used as a dimmer for discharge lamps.

In accordance with this invention this defect can be obviated by supplying a rectangular A.C. gate voltage as shown in FIG. 2*d* across the gate and cathode electrodes of the respective rectifier elements in lieu of the gate pulse indicated by FIG. 2*a*. By using such a rectangular gate voltage having sufficient width the controlled rectifier elements can easily attain the required conduction maintaining current level.

This invention will be considered in detail by referring to FIG. 3 wherein a source of alternating current A.C. is connected to a pimary winding of a step up transformer **4** via a conduction control device **3** including a pair of reversely connected controlled rectifier elements **1** and **2** and a discharge lamp **6** is connected across the secondary side of the transformer **4** through a choke coil **5**.

There is also provided a transformer **7** with its primary winding connected across the A.C. source and the secondary windings connected to the opposite filaments of the discharge lamp **6**.

The gate signal pulse generating circuit for the controlled rectifier elements **1** and **2** comprises a phase shifting circuit including a condenser **9** and a variable resistor **10** connected in series across the secondary winding of a transformer **8**. The primary winding **13** of a coupling transformer **12** is connected through a resistor **11** between a mid-tap of the secondary winding of the transformer **8** and a junction between said condenser **9** and resistor **10**. A pair of serially connected Zener diodes **14** and **15** of opposite polarity are connected across said primary winding **13**. Secondary windings **16** and **17** are respectively connected across the gate and cathode electrodes of said controlled rectifier elements to supply gate signal to the gates.

The operation of this invention is as follows: In the gate signal generating circuit, the output voltage from the phase shifting circuit comprising the condenser **9** and the variable resistor **10** is transformed into a square wave as shown by FIG. 4*a* by the action of the Zener diodes **14** and **15** and is then supplied to the primary winding **13** of the coupling transformer **12**.

Therefore, voltages induced in the secondary windings **16** and **17** and having similar waveform are supplied

across the gate and cathode electrodes of the controlled rectifier elements **1** and **2** to cause the respective rectifier elements to conduct during an interval *x* in each half cycle. Thus, the voltage across the anode and cathode electrodes of each rectifier elements will be indicated by a heavy solid line as shown in FIG. 4*b*. As will be clear to those skilled in the art, the intensity of illumination of the discharge lamp connected across the secondary winding of the transformer **4** can be adjusted to any desired value by varying the variable resistor **10**. In accordance with this invention the gate signal supplied to the controlled rectifier elements **1** and **2** is not in the form of a pulse but has substantial width by the action of the zener diode so that even when supplying an inductive load the current flowing through the rectifier element can attain conduction maintaining value before the gate signal diminishes to zero, thus assuring positive control.

Thus, this invention provides a novel dimmer for a discharge lamp including a ballast which can positively control the current flowing through such an inductive load by applying a gate signal of rectangular waveform generated by a phase shifting circuit and a cramp circuit across the gate and cathode electrodes of a semiconductor controlled rectifier element.

It will be understood, of course, that while preferred embodiments of this invention have been illustrated, various changes may be made without departing from the spirit of this invention and it is intended in the appended claim to cover all such changes as fall within the true spirit and scope of this invention.

What is claimed is:

A dimmer for a discharge lamp, comprising in combination;

a first transformer including a primary with first end leads for connection across an A.-C. source, conduction control means between said end leads and said primary including a pair of rectifier elements with gate and cathode electrodes, said rectifier elements being disposed for passing current in opposite phase across said primary, a secondary including end leads for connection to opposite filaments of a discharge lamp, and a choke coil in series with said secondary end leads and said discharge lamp;

a second transformer including a primary with end leads connected to said first end leads and two separate secondary windings each for connection to said opposite filaments;

a third transformer having a primary with end leads connected to said first end leads, a secondary with a center tap, a capacitor and a variable resistor in series with said secondary and having a junction point therebetween;

a fourth transformer primary connected between the center tap of said third transformer secondary and said junction point, a pair of zener diodes connected in series and in opposite polarity across said fourth transformer primary winding, and;

a pair of fourth transformer secondary windings connected across the gate and cathode electrodes of said rectifier elements.

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