

[54] **FLUORESCENT DIMMING CIRCUIT WITH D-C FLICKER ELIMINATION**

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[58] Field of Search **307/252 N, 252 B, 252 T; 323/24, 36, 39; 315/DIG. 4, DIG. 5**

[56] **References Cited**

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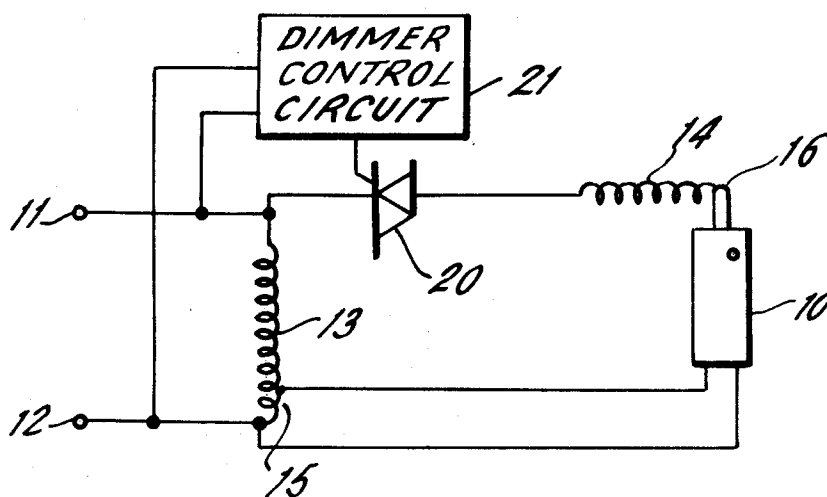
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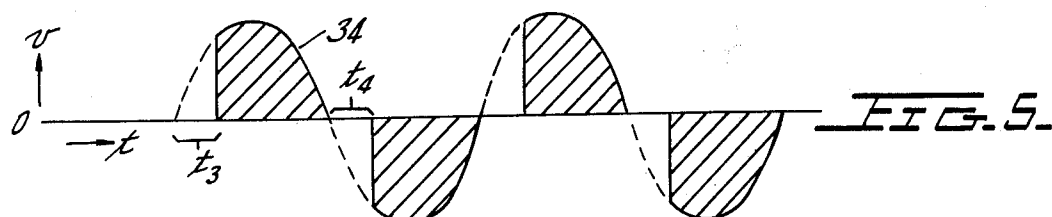
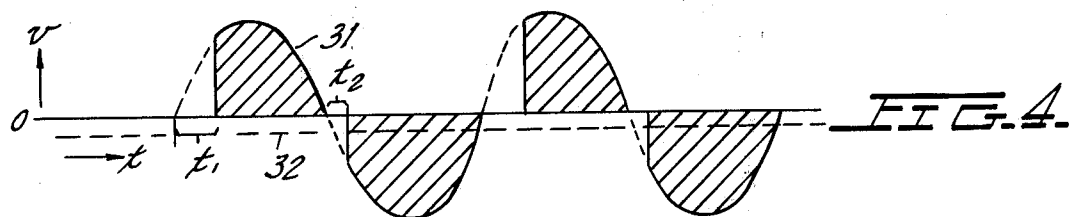
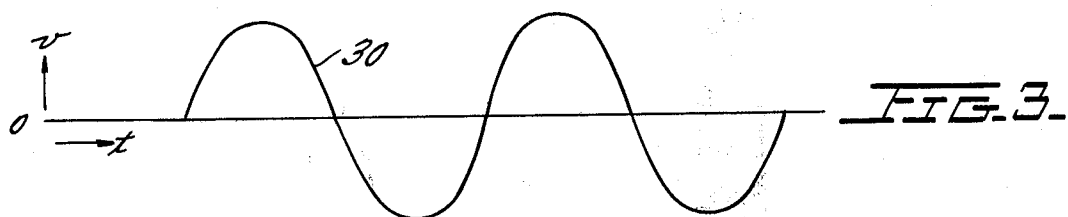
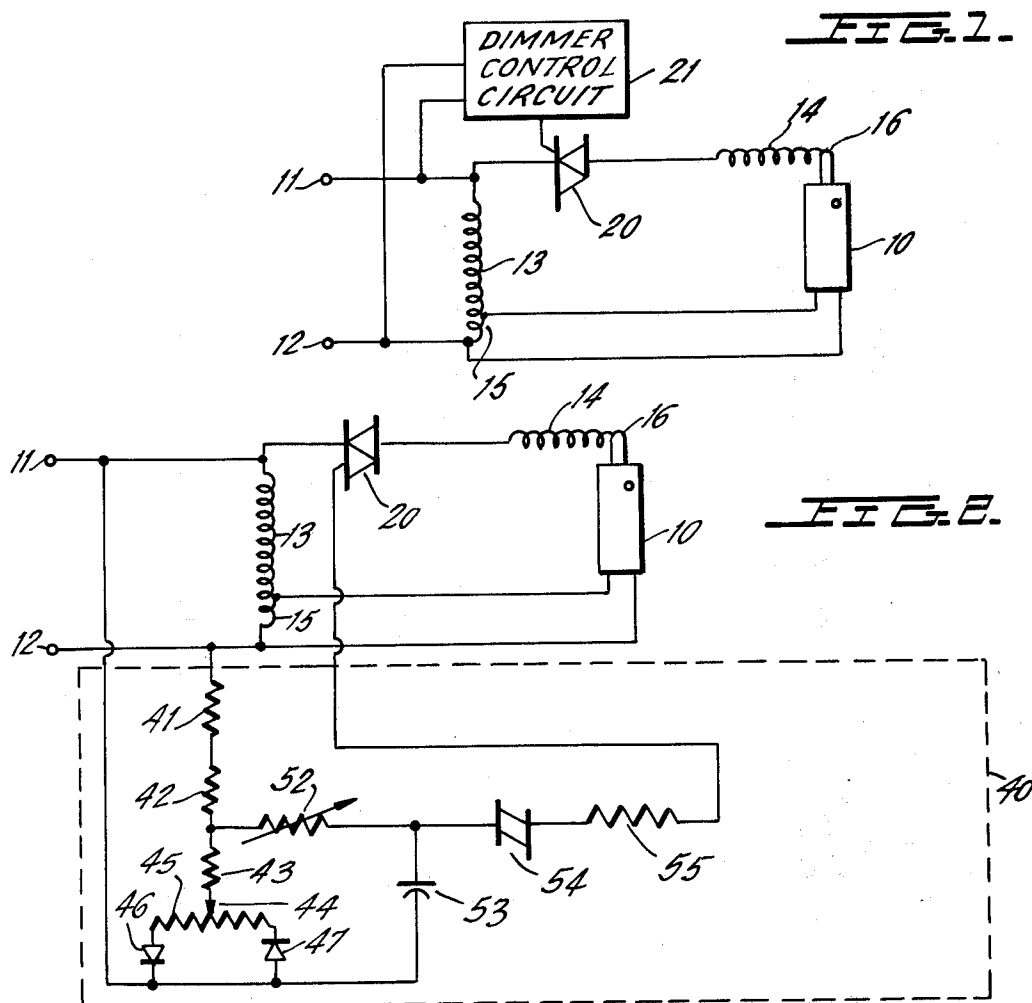
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[57] **ABSTRACT**

A fluorescent tube is connected in series with a triac device which is provided with a phase control firing circuit for firing the triac each half cycle. The triac firing circuit is provided with a variable resistance control circuit to compensate against the asymmetric firing of the main triac due to asymmetry in the components in the firing circuit.

5 Claims, 5 Drawing Figures





FLUORESCENT DIMMING CIRCUIT WITH D-C FLICKER ELIMINATION

BACKGROUND OF THE INVENTION

This invention relates to a novel fluorescent lamp dimming circuit, and more particularly relates to a novel phase control circuit for controllably conductive devices, such as triacs and thyristors, which insures the symmetrical firing of the controllably conductive devices on alternate half cycles.

Fluorescent tube dimming circuits are well known and generally comprise the use of a triac or, if desired, oppositely poled thyristors which are connected in the ballast circuit of the fluorescent lamp. The devices control the point within each half cycle at which line a-c voltage is applied to the lamp. In this manner the a-c current applied to the lamp can be varied in order to provide dimming of the lamp.

A common problem with fluorescent lamp dimmers is that the phase control circuits do not fire symmetrically for alternate half cycles of the input power. When the output of the dimmer to the fluorescent lamps is asymmetrical, due to asymmetries in various components of the dimmer, a d-c component is produced in the lamp voltage and the fluorescent lamps will flicker. The use of the dimmer becomes undesirable.

In the past, firing symmetry has been obtained only by very carefully selecting and balancing the components used in the assembly of the dimmer. Even when this was done, however, after the dimmer was completely assembled asymmetries were found due to diverse factors such as soldering, and the like, during the assembly of the dimmer which are extremely hard to control.

BRIEF SUMMARY OF THE INVENTION

The present invention provides a novel control circuit arrangement for eliminating asymmetry in an a-c phase control circuit by a single and easy adjustment which can be made after complete assembly of the dimmer. More particularly, in accordance with the invention, the reference voltage in the adjustable timing circuit is derived from an adjustable resistor which produces a reference voltage for each half cycle of operation of the firing circuit. After assembly of the complete dimmer, the device can be forced to fire symmetrically on positive and negative half cycles simply by an adjustment of the single adjustment resistor which increases the reference voltage for one half cycle while decreasing the reference voltage for the other half cycle. Thus, asymmetries due to any particular component can be easily and quickly adjusted after assembly of the dimmer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates a conventional fluorescent lamp and ballast with a triac device for producing dimming of the lamp.

FIG. 2 is a detailed circuit diagram of a dimmer control circuit constructed in accordance with the invention and applied to the fluorescent lamp and ballast circuit of FIG. 1.

FIG. 3 shows the input voltage applied to the ballast terminals in FIGS. 1 and 2.

FIG. 4 shows the asymmetric firing of the triac in FIG. 1 which would produce a flicker in the fluorescent lamp light output.

FIG. 5 illustrates the symmetrically balanced firing for both positive and half cycles which can be easily obtained by a simple adjustment after assembly of the dimmer in FIG. 2.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring first to FIG. 1, there is schematically illustrated a typical conventional circuit for operating and dimming a fluorescent lamp 10 which can be any commercially available lamp. It should be noted that the lamp 10 can generally be any type of gas discharge lamp or other load. The input voltage to lamp 10 is obtained from terminals 11 and 12 which may be connected to a conventional 120 volt 60 hertz outlet, although it will be apparent that other a-c sources of any desired industrial or residential type could be employed.

A conventional ballast consisting of transformer windings 13 and 14, which are coupled in the usual fashion, are connected as shown with small tap sections 15 and 16, respectively, serving as heater windings for the filaments at either end of tube 10. In order to control the application of voltage to the tube 10, and to obtain dimming of the tube light, a conventional triac device 20 is connected in series with winding 14 and tube 10. It will be obvious to those skilled in the art that the triac 20 could be replaced by equivalent controllably conductive devices, such as oppositely poled thyristors or the like.

A dimmer control circuit 21 is then connected to the gate electrode of triac 20, where the dimmer control circuit 21 is normally a conventional phase control circuit which derives its operating power from the main line connected to terminals 11 and 12.

The normal operation of the circuit of FIG. 1 is illustrated, for example, in FIGS. 3 and 4, where FIG. 3 shows the traditional sinusoidal wave shape 30 of the voltage applied to terminals 11 and 12.

FIG. 4, which is on the same time base as FIG. 3, illustrates the wave shape 31 of the voltage which is applied to tube 10 and coils 14 and 16. More or less dimming is obtained by causing more or less phase control over the point at which lamp conduction (shown by the cross-hatched area in FIG. 4) starts in each half cycle. In FIG. 4, and on positive half cycles, the lamp voltage has been delayed by the delay in firing of triac 20 for a longer time t_1 than the delay t_2 for negative half cycles which are shorter than t_1 . The differences in the delay at which triac 20 is fired on positive half cycles, as compared to negative half cycles, is due to asymmetries in the firing circuit which, in the past, have not been correctable after the assembly of the conventional phase control firing circuit. These asymmetries produce a d-c component shown in dotted line 32 in FIG. 4 and cause a flicker in the fluorescent tube.

FIG. 5 illustrates a wave shape 34 for voltage to be applied to tube 10 and coils 14 and 16 in which the time delays t_3 and t_4 for positive and negative half cycles are equal. Thus, there is no d-c component in the lamp voltage and no d-c flicker of the light of the tube. This characteristic has been difficult to obtain in prior art dimmers and has been obtained only through the exercise of great care in the selection and assembly of the phase control circuit components.

FIG. 2 shows the novel circuit of the invention which provides a novel and simple means for adjusting the firing circuit, so that it fires symmetrically on positive and negative half cycles, where the adjustment can be easily made after assembly of the dimmer. In FIG. 2 components similar to those of FIG. 1 have been given similar identifying numerals. Thus, FIG. 2 simply shows the details of a dimmer control circuit 40 within dotted lines in FIG. 2 which replaces the prior art dimmer control circuit 21 of FIG. 1. Note that any desired type of controllably conductive device can be used in place of triac 20 and that any desired type of gas discharge tube can be used in place of fluorescent lamp 10.

The control circuit 40 includes a voltage divider circuit containing resistor 41 which is connected in series with the reference resistor 43. Reference resistor 43 is, in turn, connected to the wiper arm 44 of adjustable resistor 45. The opposite ends of adjustable resistor 45 are then connected to oppositely poled diodes 46 and 47 which are connected to the input power terminal 12.

An adjustable resistor 52 is then connected to the top of reference resistor 43 and is connected to a timing capacitor 53 and is also connected to an a-c trigger device 54 which is, in turn, connected to the gate of triac 20 through the current limiting resistor 55.

In the circuit of FIG. 2, the adjustable resistor 52 is the ultimate dimming adjustment device and the degree of phase control applied during positive and negative half cycles is controlled by the adjustment of this resistor. The symmetry between the phase control applied to positive and negative half cycles is, however, easily controlled through the adjustment of the wiper arm 44 of the adjustable resistor 45. This may be a factory adjustment which is made after assembly but before enclosing the circuit in a housing. Alternatively, the adjustment can always be accessible externally of the housing so that adjustment can be made to compensate for component aging and the like.

In operation, and assuming that the main dimmer resistor 52 has been set to a given value and that wiper arm 44 is also positioned at a given value, the circuit including resistor 52 and capacitor 53 will serve as a timing circuit which will charge capacitor 53 to a given value sufficient to fire the a-c trigger 54 after a time dependent upon the voltage appearing at the junction between the reference resistor 43 and resistor 41. The firing of trigger 54 will, in turn, inject a firing current into the gate of triac 20.

The reference voltage at the top of resistor 43 can be set to one value for positive half cycles and to another value for negative half cycles through the adjustment of wiper arm 44 of adjustable resistor 45, since this will produce an unbalance in the resistance to the right of arm 44 for negative half cycles as compared to the left of arm 44 for positive half cycles. Thus, a simple adjustment at resistor 45 will increase the firing time, for example, for positive half cycles and decrease the firing time for negative half cycles and vice versa. Thus, the simple adjustment of this one component can adjust for

asymmetries in any part of circuit 40 which would cause a difference in the time of firing for positive half cycles as compared to the time of firing for negative half cycles.

Although this invention has been described with respect to preferred embodiments, it should be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of this invention be limited, not by the specific disclosure herein, but only by the appended claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows.

1. A controlled energizing circuit for a gas discharge lamp; said energizing circuit including an a-c power source, an inductive ballast, a bidirectional controllably conductive device, and a phase control circuit for controlling the points in the positive and negative half waves of said a-c power source at which said bidirectional controllably conductive device begins to conduct; said ballast coupling said a-c power source to said gas discharge lamp; said bidirectional controllably conductive device being connected in series with said lamp and permitting current flow to said lamp only after said bidirectional controllably conductive device is fired; said phase control circuit including trigger circuit means for applying a firing signal to said bidirectional controllably conductive device; a charging circuit coupled to said trigger circuit means for operating said trigger circuit means when said charging circuit is charged to a given voltage, and an input reference voltage circuit for driving said charging circuit; said input reference voltage circuit including an adjustable resistor means having a wiper arm and first and second oppositely poled diodes having first terminals connected to the opposite ends of said adjustable resistor means; second terminals of said oppositely poled diodes and said wiper arm, respectively, being connected to said a-c power source; said input reference voltage circuit defining separate reference voltages to said charging circuit for positive and negative half waves, respectively, of said a-c power source, whereby adjustment of said wiper arm of said adjustable resistor means is adjustable to compensate against the asymmetric firing of said bidirectional controllably conductive device.

2. The circuit of claim 1 wherein said bidirectional controllably conductive device consists of a triac.

3. The circuit of claim 1 wherein said gas discharge lamp is a fluorescent lamp.

4. The circuit of claim 1 which further includes dimmer control circuit means for controlling the amount of phase control in both positive and negative half cycles which is produced by said phase control circuit.

5. The circuit of claim 1 wherein said charging circuit includes a resistance-capacitance circuit having a given charging characteristic for a given input voltage.

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