Aug. 25, 1953 C. E. WILLIAMS 2,650,326

DIMMING CIRCUIT AND APPARATUS FOR FLUORESCENT LAMPS

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Fig. 1.

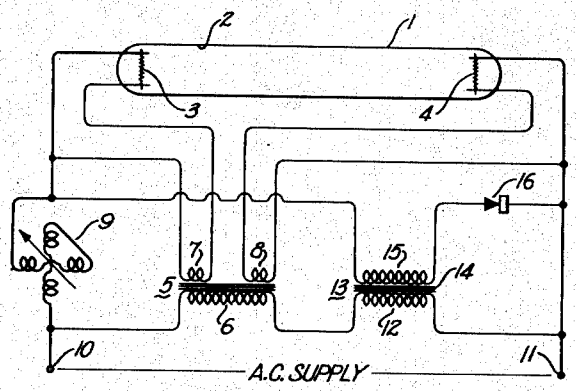


Fig. 2.

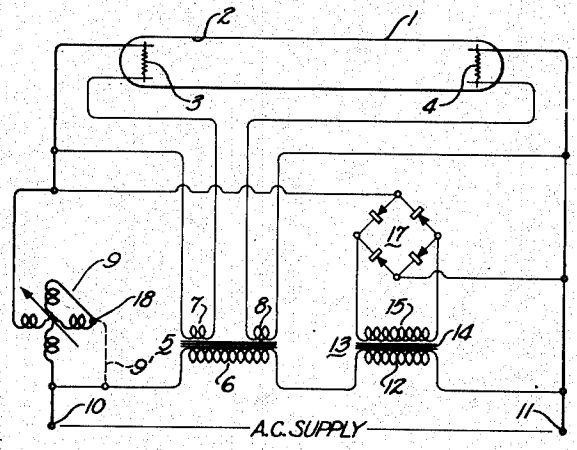
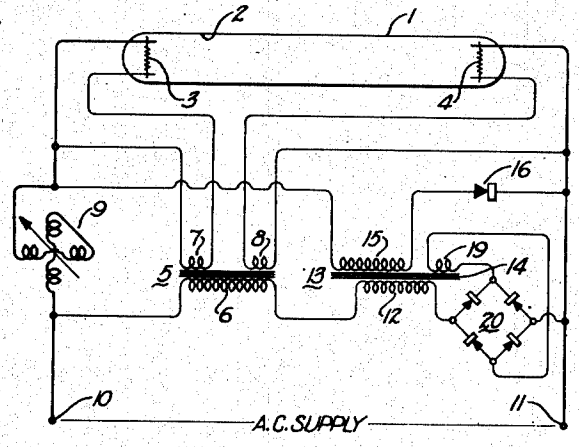


Fig. 3.



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DIMMING CIRCUIT AND APPARATUS FOR FLUORESCENT LAMPS

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3 Claims. (Cl. 315—98)

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This invention relates generally to circuits for controlling the luminous intensity of electric discharge devices, and more particularly to a dimming circuit for a fluorescent lamp operated from an alternating current supply of substantially constant voltage.

It is possible to control the luminous intensity of a fluorescent lamp by means of a circuit comprising an adjustable ballast impedance in series with the lamp for varying the discharge current therethrough, and a filament transformer for supplying heating current to its electrodes. With such an arrangement, the electrodes of the lamp are heated by the discharge, as well as by the current supplied from the filament transformer. Accordingly, it is desirable to reduce the heating current to the electrodes as soon as the lamp is started, so that the temperature of the electrodes remains approximately the same during operation as at starting, that is, before the discharge has been established. However, I have found that with known circuits, variations in discharge current produced by different adjustments of the ballast impedance for varying the luminous output of the lamp, result generally in undesirable variations of the total electrode heating.

Accordingly, it is an object of my invention to provide a new and improved circuit for automatically maintaining the temperature of the electrodes in a fluorescent lamp at a substantially constant value, during operation as well as during starting of such a lamp.

Another object of my invention is to provide a circuit for varying the heating current supplied to the electrodes of a fluorescent lamp during the operation thereof at different levels of intensity, in a manner to maintain the electrode temperature substantially constant.

In accordance with my invention, the above-mentioned objects are achieved by including, in series with the primary of a filament transformer of a fluorescent lamp, a saturable reactor whose impedance is automatically controlled by the adjustment of a ballast impedance utilized to vary the intensity of the luminous output of the lamp. The impedance of the saturable reactor is varied by providing it with an auxiliary magnetization controlling winding to which a direct current is supplied through rectification of the alternating voltage appearing across the lamp.

For further objects and advantages and for a better understanding of my invention, attention is now directed to the following description and the accompanying drawings. The novel features of my invention will be more particularly pointed out in the appended claims. In the drawings:

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Fig. 1 is a schematic diagram of a circuit embodying my invention and illustrating the basic features thereof.

Fig. 2 is a schematic diagram of a circuit embodying my invention and containing certain modifications to improve the operating characteristics.

Fig. 3 is a schematic diagram of a similar circuit containing a feed-back network to provide a feature of more sensitive response to adjustments in intensity.

Referring to Fig. 1 there is shown an electric discharge device 1 in the form of a lamp comprising a tubular envelope 2, containing a rare gas such as argon or neon, or a mixture thereof, at a pressure of a few millimeters, and a small quantity of mercury. The lamp has sealed into its ends a pair of filamentary thermionic electrodes 3 and 4, each illustrated as consisting of a coil of tungsten wire coated with a material of high electron emissivity, such as alkaline earth oxides like barium or strontium oxides. If desired, device 1 may be a low pressure positive column lamp of the fluorescent type, wherein the envelope is coated internally with a suitable luminescent material.

Heating current is provided to the filamentary electrodes by means of a transformer 5, having a primary 6, and a pair of secondaries 7 and 8 connected to filamentary electrodes 3 and 4 respectively. The main discharge circuit for device 1 is constituted by connecting the electrodes 3 and 4, in series with an adjustable ballast 9, across a pair of input terminals 10—11, adapted to be connected to an alternating current supply of substantially constant voltage, such as ordinary supply mains. Adjustable ballast 9 has been represented as an inductive variometer; however, it may take any other suitable form of variable impedance, preferably reactive for economy in operation.

Primary winding 6 of filament transformer 5 is connected, in series with the regulating winding 12 of a saturable reactor 13, across input terminals 10—11. Reactor 13 comprises, in addition, an iron core 14, and an auxiliary magnetization controlling winding 15, through which direct current may be passed in order to vary the total magnetization of core 14. In accordance with well-known principles, the impedance of winding 12 may be decreased substantially by augmenting the current through auxiliary winding 15 up to a point beyond the knee of the magnetic saturation curve of core 14. Winding 15 is connected, in series with a rectifier 16, across the lamp electrodes 3 and 4.

In the operation of the circuit, when an electric discharge device, such as a fluorescent lamp, is connected in the manner shown and described, and input terminals 10—11 are connected to an alternating current supply, a relatively large current initially passes through the primary of filament transformer 5 and through regulating winding 12. This is due to the fact that, when voltage is first supplied to the circuit and before a discharge has started in device 1, practically no voltage drop occurs across adjustable ballast 9 and a relatively high voltage exists across the lamp electrodes. Accordingly, a large rectified current flows through auxiliary winding 15, which magnetizes core 14 above the knee of its characteristic saturation curve and reduces the impedance of regulating winding 12 to a low value. Accordingly, a large current flows through primary 6 of filament transformer 5, and the secondary heating current resulting therefrom quickly raises the temperature of electrodes 3 and 4 to an electron-emitting condition.

The large voltage existing across electrodes 3 and 4 causes the discharge to strike as soon as the electrodes are sufficiently heated. The voltage across the lamp then falls, due to the voltage drop produced by the discharge current flowing through ballast 9. This results in a decrease of the rectified current flowing through auxiliary winding 15 associated with regulating winding 12, whose inductance accordingly increases and thereby reduces the current flowing through the primary of filament transformer 5. The reduction of primary current through transformer 5 in turn reduces the secondary heating current supplied to the lamp electrodes. By properly proportioning the magnitudes of the electrical constants involved, I have found that it is possible to reduce the heating current just sufficiently, that, in conjunction with the additional electrode heating produced by the discharge, the electrodes are maintained substantially at the correct operating temperature.

In accordance with a notable feature of my invention, if now the inductance of adjustable ballast 9 is varied in order to vary the luminous output of the lamp, the temperature of the electrodes nevertheless remains substantially constant. For instance, when the inductance of ballast 9 is increased in order to diminish the luminous output, the current through lamp 1 decreases. Since an electric discharge device of this type has a negative resistance characteristic, there results an increase in the voltage across the lamp, producing, in turn, an increase in the rectified current flowing through auxiliary winding 15, and a decrease in the inductance of regulating winding 12. It follows therefrom that the heating current supplied by filament transformer 5 to the lamp electrodes increases, and compensates at least approximately for the reduced electrode heating produced by the decrease in the discharge current. The same variations occur in reversed directions when the inductance of variable ballast 9 is decreased in order to augment the luminous output. Thus, the circuit permits operating the lamp at different luminous intensities without subjecting it to too low an electrode temperature which might cause destructive sputtering. Likewise, it prevents operating the lamp at too high an electrode temperature which would cause undue deterioration of the filamentary electrodes.

Referring to Fig. 2, there is shown another embodiment of my invention, wherein the same reference numerals denote corresponding elements, and which has been modified from the circuit shown in Fig. 1 by the provision of a more efficient rectifying circuit. The auxiliary magnetization controlling winding 15 is herein connected across one diagonal of a four rectifier bridge circuit 17. The other diagonal of the bridge is connected across the lamp electrodes, and the bridge accordingly provides full wave rectification. This particular circuit, having a higher rectification efficiency than the simple series rectifying circuit shown in Fig. 1, provides a more sensitive control of the magnetization current. The dotted connection 9' from primary 6 of filament transformer 5 to mid-point 18 of adjustable ballast 9 is illustrated as an alternative connection. This may be used to provide a different degree of corrective action of the filamentary heating current with respect to variations in the lamp discharge current.

Referring to Fig. 3, there is shown yet another embodiment of my invention wherein like reference numerals refer to corresponding elements shown in Figs. 1 and 2, and which has been further modified by the provision of a feed-back circuit which permits a greater range of control by the operation of adjustable ballast 9. The feed-back circuit comprises an additional low impedance secondary winding 19, operating in conjunction with the core 14 of regulating reactor 13, in addition to the former auxiliary winding 15 of higher impedance. Auxiliary winding 19 is connected across one diagonal of a four rectifier bridge circuit 20, whose other diagonal is connected, in series with the primary of filament transformer 5 and regulating winding 12, across terminals 10—11. Bridge circuit 20 provides full wave rectification of the current flowing through the primary 6 of filament transformer 5, and utilizes this rectified current to vary the magnetization of core 14 in a sense to provide a positive feed-back action. Then, in accordance with well-known principles, as the current through regulating winding 12 increases or decreases, in response to increases or decreases of the rectified current through high impedance auxiliary winding 15, the rectified current flowing through low impedance auxiliary winding 19 increases or decreases likewise, and tends to further increase or decrease the current through regulating winding 12. In this way, the effect of small changes in the control current through high impedance auxiliary winding 15 is amplified and its controlling effect augmented.

While certain specific embodiments have been shown and described, it will, of course, be understood that various modifications may be made without departing from the invention. Thus, other types of discharge devices, and likewise other circuit elements performing the functions of adjustable ballast 9 and transformer 5 may be provided. Likewise, the rectifying circuits which have been shown may be modified to equivalent circuits well known in the art. The appended claims are, therefore, intended to cover any such modifications coming within the true spirit and scope of the invention.

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

1. A fluorescent lamp of the gaseous discharge type having a pair of filamentary thermionic electrodes, in combination with apparatus for controlling the luminous output thereof and comprising an alternating voltage supply, an adjustable ballast impedance connected in series with said lamp across said supply, an electrode heat-

ing transformer having a primary winding and a pair of secondary windings connected to respective ones of said electrodes, a saturable reactor having a regulating winding and a magnetization controlling winding, and a rectifier, said primary winding and said regulating winding being connected in series circuit across said supply, and said rectifier and said magnetization controlling winding being connected in series circuit across said lamp.

2. Apparatus as in claim 1 wherein the rectifier is of the bridge type providing full wave rectification of the current through said magnetization controlling winding.

3. Apparatus as in claim 1 and comprising additionally a second magnetization controlling

winding in said reactor, and a full wave rectifier, said second winding and said full wave rectifier being serially included in the series circuit of said primary winding and said regulating winding across said supply to provide a feed back action.

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