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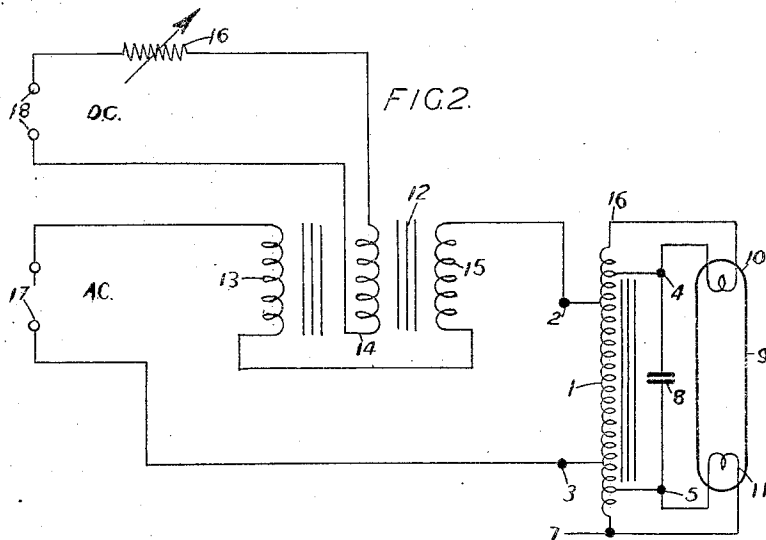
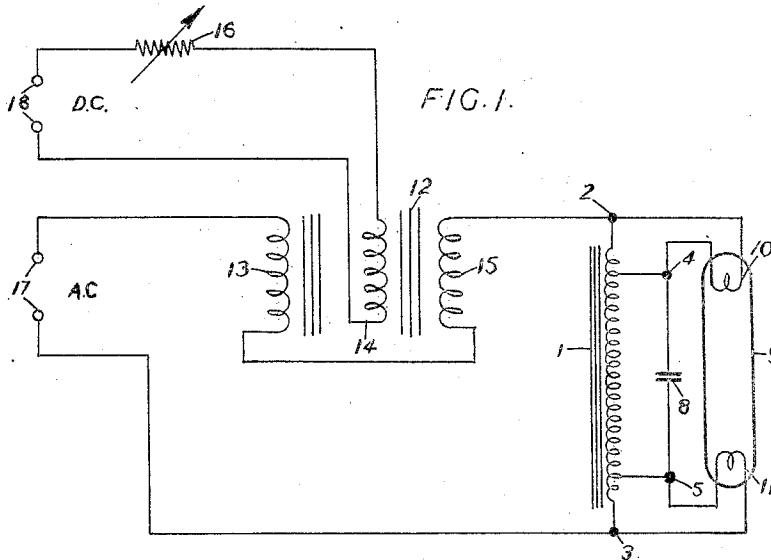
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2,458,277

CONTROL OF ELECTRIC DISCHARGE LAMPS

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2 Sheets-Sheet 1



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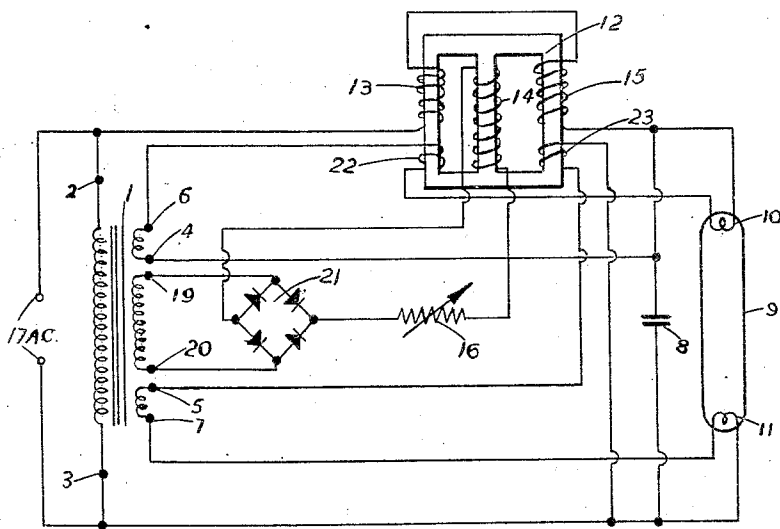
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FIG. 3.



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CONTROL OF ELECTRIC DISCHARGE LAMPS

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8 Claims. (Cl. 315—284)

1

This invention relates to alternating current control apparatus for hot cathode discharge lamps of the type in which the two discharge electrodes are each associated with an electron emissive filament which is electrically heated during the starting up of the lamp to assist the subsequent striking of the main electric discharge between the two electrodes. The control apparatus according to the present invention is used to control such lamps during starting up or striking and during the steady running condition. It is not material to the operation of the present invention whether or not the lamps used are provided with a fluorescent coating.

The usual form of control apparatus for gas discharge lamps of the type described consists of a discharge current limiting choke connected at one end to one pole of the alternating current supply and at the other end to one end of one filament of the lamp. The other end of this filament is connected through a starter switch, usually of a special form, to one end of the second filament. The other end of the second filament is connected to the other pole of the alternating current supply, completing the series circuit across the alternating current supply. An additional switch is also provided to make or break the connection of the series circuit with the live line of the supply. When this switch is closed a series circuit is made through the limiting choke and the two filaments connected in series through the closed starter switch. The resistance of the filaments in series with the reactance of the choke are such that the rated heating current flows through the filaments. This current raises the temperature of the filaments, causing them to become electron emissive and producing local ionization of the gas in the lamp. The starter switch, connected between the two filaments, is usually arranged to open automatically after the filament heating current has been flowing for some time. This interruption of the current flowing through the limiting choke induces a high surge voltage, which appears between the electrodes of the lamp causing the main discharge to strike between them. After the lamp has lit, the discharge current is maintained at the rated value for the lamp by the discharge current limiting choke which has the correct reactance value for this purpose.

The object of the present invention is to provide a control apparatus by means of which a lamp of the type described may be continuously dimmed to extinction and, if required, at once relit and its brightness increased continuously to the normal operating brightness.

2

The ability to dim such lamps is desirable for a number of specialised purposes requiring control of brightness such as the dimming of lighting in places of entertainment or, when a number of lamps of different colour are used, for the selective dimming of the lamps for colour control. Such dimming and re-lighting is not possible with the usual form of control gear described, because the striking voltage of the lamp is higher than the working voltage and because the operation of the starting switch and the heating of the filaments takes some time after the extinction of the lamp before the main discharge can be re-started.

According to the present invention, a control apparatus for operating a gas discharge lamp of the type described, has a variable reactive element for controlling the discharge current of the lamp when running and means for providing an electric heating supply to each of the two filaments of the lamp and automatically reduces the heating supply as the discharge current increases from zero to the desired operational value and automatically increases the heating supply as the discharge current decreases.

According to one form of the present invention, such a control apparatus has a transformer and a discharge current limiting choke, the transformer having a primary winding wound for approximately the voltage of the alternating current supply and connected in series with the limiting choke across the alternating current supply and effectively in parallel with the gas discharge path of the lamp and having two secondary windings each supplying one of the lamp filaments and wound to supply the required heating current and voltage when nearly the full supply voltage is applied to the transformer primary; the two secondary windings are insulated from each other and applied between them is a voltage sufficient to strike the lamp when the filaments are heated, the choke having an auxiliary direct current winding, the discharge current of the lamp, being determined by the magnitude of a uni-directional magnetic flux in the choke core due to the auxiliary winding.

According to another form of the present invention, the control apparatus has a discharge current controlling reactance consisting of one or more reactive elements connected in series with the lamp and a transformer, the transformer having a primary winding connected in parallel with the series combination consisting of the lamp and at least one of the reactive elements and having two secondary windings each wound to supply the required heating current and volt-

age to one of the lamp filaments, the reactance being arranged to induce into the two filament circuits a voltage increasing with the lamp discharge current and opposing the voltage from the transformer secondary windings, one reactive element having a magnetic core carrying a reactive winding and an auxiliary direct current winding, the discharge current of the lamp being controlled according to a uni-directional magnetic flux in the said magnetic core, due to the direct current flowing in the auxiliary winding.

The variable reactance which may be used is described in the specifications of the copending patent application No. 30,444/45. The alternative filament circuit arrangements for supplying a heating current for the two filaments of a lamp of the type described and for reducing the filament supply as the main discharge current of the lamp increases, are described in the provisional specifications accompanying the co-pending patent applications Nos. 30,445/45 and 2,552/46.

In order that the invention may be more clearly understood and readily carried into effect, three examples of control apparatus will now be described with reference to the accompanying drawings, of which:

Figure 1 is a circuit diagram of the apparatus in its most simple form, using an auto-transformer associated with the lamp and the nature of the D. C. supply to the auxiliary winding of the controlling reactance being omitted for clearness.

Figure 2 is a circuit diagram of a similar arrangement using a step-up auto-transformer associated with the lamp and

Figure 3 is a circuit diagram of an alternative form of apparatus, the D. C. supply being obtained through a rectifier from the A. C. supply.

In Figure 1 an auto-transformer 1 has a primary winding between the terminals 2, 3 wound for nearly the full voltage of the alternating current supply. At each end of the primary winding 2, 3, a portion of the winding between the terminals 2, 4 and between the terminals 3, 5 is tapped off to form two secondary windings. The secondary 2, 4 is connected across the filament 10 of the gas discharge tube 9 and the secondary 3, 5 is connected across the filament 11.

A condenser 2 of value 0.02f. is connected across the lamp electrodes associated with the two filaments 10, 11. The end 3 of the transformer primary 2, 3 is connected to one pole of the alternating current supply 17 and the other end 2 is connected to the other pole of the A. C. supply 17 through a variable reactance 12.

The variable reactance 12 is a choke having a shell type laminated core, the choke winding being in two parts 13, 15, one part on each of the outer limbs of the core, the two parts 13, 15 being connected in series astatically so that little or no magnetic flux from them passes through the central limb of the core. An auxiliary direct current winding 14 is wound on the central limb of the core and the uni-directional magnetic flux due to this winding 14 is controlled by varying the direct current from a local D. C. supply 18 flowing through the winding 14. This control is effected by the adjustment of the variable resistance 16 connected in series with the winding 14 and the D. C. supply 18.

The free end of the choke winding 15 is connected to the transformer primary at the terminal 2 and the free end of the choke winding 13 is connected to the other pole of the A. C. supply 17 as described.

In Figure 2, the primary of the transformer 1 does not include the whole winding 6, 7 but is tapped off between the terminals 2, 3. Secondary windings 6, 4 at 7, 5 are tapped off and the ends of the winding and are connected respectively to the filaments 10 and 11 of the lamp 9 as in the circuit arrangement of Figure 1. While the output of the secondaries 4, 6 and 5, 7 are the same as for Figure 1, the voltage developed in the section of the winding 4, 5 available for striking the lamp is increased by the step-up action of the transformer 1.

In an alternative form of the invention shown in Figure 3, the variable reactance 12 has additional windings 22, 23, one wound on each of the outer legs of the core. For this reason a different form of schematic representation of the reactance 12 has been adopted in Figure 3 to show more clearly the disposition of the various windings of the variable reactance 12. The transformer 1 has its primary winding 2, 3 connected directly across the A. C. supply 17. The low-voltage secondary winding 6, 4 is connected in series with the choke winding 22 across the filament 10 of the lamp 9. The winding 7, 5 is similarly connected in series with the choke winding 23 across the filament 11. The choke windings 22, 23 are connected into the lamp filament circuits in such sense as to provide a voltage increasing with the lamp discharge current flowing through the windings 13, 15, and opposing the voltage from the transformer secondary windings 6, 4 and 7, 5.

The transformer 1 has an additional winding 19, 20 which is connected across a bridge-connected rectifier 21 in order to provide a D. C. supply for the auxiliary winding 14. The variable resistance 16 is connected in series with this supply as in the circuits of Figure 1 and Figure 2.

The operation of the alternative circuit arrangements described with reference to Figure 1, Figure 2 and Figure 3 is similar and detailed differences will be appreciated more fully by reference to the co-pending applications No. 30,445/45 and No. 2,552/46.

As the direct current flowing through the auxiliary winding 14 of the variable reactance 12 is reduced by increasing the value of the variable resistance 16, the inductance of the variable reactance 12 is increased and the discharge current of the lamp 9 is reduced. This reduction of the lamp discharge current increases the supply to the lamp filaments 10, 11. In the case of the circuits of Figure 1 and Figure 2, this results from the increased voltage appearing across the transformer primary 2, 3. In the case of the circuit of Figure 3, this results from the reduction of the opposing voltage in the choke windings 22, 23.

The variable reactance 12 is designed for the type of lamp 9 used and the voltage and frequency of the A. C. supply 17 so that by the necessary adjustment of the direct current flowing in the winding 14, the inductance of the variable reactance 12 may be increased to the point where the main discharge through the lamp 9 is extinguished. In this condition, the supply to the lamp filaments 10, 11 is such that by reducing the inductance of the variable reactance 12 once more, the lamp 9 may be at once rekindled, and the discharge current, and hence the brightness of the lamp 9 increased at will up to its maximum operating condition.

In the forms of control apparatus described

with reference to the accompanying drawings, the variable reactance used is a choke whose inductance value is varied by a direct current flowing through an auxiliary winding. This form lends itself to easy remote control, but it will be appreciated that other forms of variable reactance, while not necessarily providing the advantage of remote control, may nevertheless be used for dimming and rekindling the discharge lamp. Similarly, a variable resistance may be used in circuits similar to those described with reference to Figures 1 and 2, that is, those which do not require voltages induced by the variable reactance into the lamp filament circuits.

In a normal installation practice, a lamp of the type described is fitted in a metal trough reflector or other metal fitting. The metal fitting is earthed, and this has been found to assist the ready striking of the lamp. With control apparatus according to the present invention, it is particularly desirable that the gas discharge lamp should be contained in a metal fitting in this way.

We claim:

1. Control apparatus for a hot cathode gas discharge lamp of the type having two discharge electrodes, each associated with an electron emissive filament, comprising in combination a reactive element, means for varying the reactance of said reactive element, means providing an electric heating current for each of said filaments, and means for applying a striking voltage between the said two discharge electrodes, said reactive element being connected in series with said discharge lamp across an alternating current supply, and said means for providing filament heating currents and said means for applying a striking voltage being controlled by the discharge current of said lamp to decrease the filament currents and said striking voltage from their operative values as the discharge current increases from zero to the required running value for said discharge lamp and to increase said currents and voltage to their operative values as the discharge current falls to zero.

2. Control apparatus for a hot cathode gas discharge lamp of the type having two discharge electrodes, each associated with an electron emissive filament, comprising in combination a transformer and a variable reactive element, the said transformer having input terminals arranged in series with the said variable reactive element for connecting across an alternating current supply and having two output windings wound to supply the required heating current to the lamp filaments when nearly the full supply voltage is applied to the said input winding, one of the said output windings being connected to each end of a third output winding wound to provide a sufficient voltage to strike the said gas discharge lamp when the said filaments are heated and when nearly the full supply voltage is applied to the said input terminals.

3. Control apparatus for a hot cathode gas discharge lamp according to claim 2 in combination with a variable resistive element, the said variable reactive element having a magnetic core, and a reactive winding and an auxiliary winding both wound on said core, said auxiliary winding being arranged in series with said resistive element for connecting across a direct current supply.

4. Control apparatus for a hot cathode gas discharge lamp according to claim 3, said variable reactive element having a shell-type laminated magnetic core and a second reactive winding

wound on said core and connected astatically in series with said reactive winding.

5. Control apparatus for a hot cathode gas discharge lamp of the type having two discharge electrodes, each associated with an electron emissive filament, comprising in combination a transformer, a variable reactive element and a variable resistive element, the said transformer having input terminals for connecting across an alternating current supply, a first output winding wound to supply at least the striking voltage of said discharge lamp, and two further output windings wound to supply the required heating current for the lamp filaments, said reactive element having at least one reactive winding wound on a magnetic core, two output windings inductively coupled to said reactive winding and an auxiliary winding wound on said core and arranged in series with said variable resistive element for connecting across a direct current supply, said reactive winding being connected in series with said discharge lamp across said first output winding of said transformer and the output windings of said reactive element being wound to supply a voltage substantially equal to the filament supply voltage for said discharge lamp when the required operating discharge current of said discharge lamp flows through said reactive winding and connected each in series with one of said further output windings of said transformer in the sense to oppose the output voltage of said further output windings, each such series combination being connected across one of the filaments of said discharge lamp.

6. Control apparatus for a hot cathode gas discharge lamp of the type having two discharge electrodes, each associated with an electron emissive filament, comprising in combination means including a source of alternating current for supplying heating currents to said filaments, a variable impedance control element, a circuit connecting said lamp and said impedance element in series to said source whereby the discharge current of the lamp may be varied by varying the impedance of said control element, and means controlled by said discharge current for varying said heating currents inversely with variations in said discharge current.

7. Control apparatus according to claim 6 wherein said filament heating currents are supplied from a transformer connected in shunt to the discharge electrodes of said lamp.

8. Control apparatus according to claim 6 wherein said variable impedance control element comprises a transformer device having a reactive winding connected in series with the discharge electrodes of said lamp, and including a pair of secondary windings arranged in inductive relation with said reactive winding and connected in the supply circuits of said filaments in opposing relation to the heating currents flowing therein.

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