This invention relates to circuits used to control the brightness of low-pressure discharge lamps of the hot-cathode type. A low-pressure discharge lamp is one which operates normally at a temperature which exceeds the ambient temperature by not more than 60° C. Filament lamps may be fed through adjustable dimming means capable of reducing the light emission progressively to zero. If coloured light is required as, for example, in theatre lighting, colour filters can be fitted in front of the filament lamps. The efficiency of the combination of filament lamp and colour filter is very low. The use of fluorescent discharge lamps has been suggested for colour lighting, since, by suitable choice of the luminescent material, a wide range of colours can be produced without the use of filters. The disadvantage of such lamps is that with normal circuits, consisting of a lamp in series with a choke and the filamentary lamp electrodes connected in series for starting by a glow or thermal switch, only a limited range of brightness is available. Attempts to use low voltages result in erratic and intermittent operation. Circuits suitable for the brightness control of fluorescent lamps have been described in pending applications Serial No. 116,756.

The principal object of this invention is to provide circuits in which two or more low-pressure discharge lamps can be dimmed substantially by operation of a dimmer control consisting of a single adjustable impedance.

Another object is to provide circuits in which two or more low-pressure discharge lamps can be dimmed substantially and which employ wiring arranged in known manner and constituting dimming circuits for incandescent lamps.

According to this invention an electric discharge lamp circuit includes two or more low-pressure electric discharge lamps of the hot-cathode type having two electrodes, or two or more groups of such lamps, each lamp, or group of lamps being connected between the terminals of a secondary winding of an associated matching transformer, the primary windings of the matching transformers being connected in series, means for supplying to the series-connected primary windings a primary alternating current which is progressively variable by a dimmer control while the lamps are operating, and means for supplying heating current continuously to each of the electrodes of the lamps at least over the lower part of the operating range of brightness of the lamps, the arrangement being such that both said means are supplied from the same source of power, and the circuit including ballast impedance for limiting the lighting current flowing in each lamp. Such ballast impedance may be distributed among the separate secondary circuits including the discharge lamps or lumped in the series-primary circuit. It may be provided by one or more distinct impedance elements or combined, at least in part, with the matching transformers or the dimmer control. The said dimmer control may consist of an adjustable impedance or in some cases a variable-tapped transformer which may be an autotransformer.
dimmer control and the common ballast impedance, its saturation being varied by operation of a variable resistor 24, which is connected in series with a saturating winding 25 of the reactor between terminals 26 and 27 of a D. C. power source. It will be apparent that a separate ballast impedance can be provided; in which case the variable reactor 23 constitutes only the common dimmer control.

Each pair of lamps is connected in series across the secondary winding 11 of their associated matching transformer 12. The two electrodes 16 and 17 at the junction of the two lamps are connected in series and are supplied with heating current from a separate secondary winding 28 of the heating transformer 18. A resistor 29 is connected between the terminal L of the power source and the junction of the two lamps. The value of the resistor 29 is so chosen that a small glow discharge representing the lower limit of the controllable range of brightness is maintained in either or both of the lamps. The presence of the resistor ensures that all the lamps will begin to increase at substantially the same rates when the dimmer control is moved from the minimum brightness position. Although the resistor 29 is used in this circuit it will be apparent that any suitable impedance can be used, e.g., a resistor and a capacitor connected in series.

The lamp circuit shown in Figure 3 is similar to that shown in Figure 1 except that the matching transformers 12 are autotransformers. The portions of the autotransformer winding which are connected in series correspond to the primary windings 13 in Figure 1 and each portion is given the reference numeral 13. Similarly, the whole of each autotransformer winding corresponds to a secondary winding 11 in Figure 1 and is given the reference numeral 11. A thermally-responsive relay 30 has a heater winding 31 connected in parallel with its associated secondary winding 11 (only one relay is shown out of the six which would be provided). In response to failure of its associated lamp to strike, after a short delay, the relay 30 connects a dummy impedance 32, equal in value to the impedance of the lamp when struck, in parallel with the secondary winding. Alternatively, the matching transformer 12 may be so designed that the failure of its associated lamp causes saturation without excessive overheating.

The lamp circuit shown in Figure 4 includes six groups of two lamps, the dimmer control being the variable resistor 29. It is different from that shown in Figure 2 in that the electrodes of each group are supplied with heating current from secondary windings 20, 21 and 28 on the associated matching transformer 12. Thus both the heating currents for the electrodes and the discharge currents in the lamps are supplied through the matching transformers. The matching transformers should be so designed that adequate heating currents are supplied to the electrodes over the whole of the operating range of the lamps. With such a circuit only a single pair of leads are required to supply the lamps and existing wiring and existing dimmer controls of an incandescent lamp installation can readily be used. Alternatively, separate matching and electrode heating transformers can be provided, and each electrode heating transformer can have its primary winding (19) connected in the secondary circuit of its respective matching transformer and in parallel with the discharge path constituted by the lamp or lamps. The matching transformers 12 are of the leakage-field reactance type and each constitutes a ballast impedance for its respective pair of lamps. The resistor 29 of the circuit in Figure 2 is replaced by a resistor 33 and a capacitor 34 connected in series.

The lamp circuit shown in Figure 5 differs from that shown in Figure 1 in that the matching transformers 12 are of the leakage-field reactance type, each constituting the ballast impedance for its respective lamp, and the common dimmer control is constituted by a variable-tapped autotransformer 35. Terminals 36 and 37 of the autotransformer winding are connected to terminals L and N respectively of the power source. The series-connected primary windings 13 of the matching transformers are connected between the tapping terminals 37 and 36 of the autotransformer 35.

In the lamp circuit shown in Figure 6 the matching transformers 12 are autotransformers of the leakage-field reactance type and the common dimmer control is constituted by a variable resistor 15 and a variable saturable reactor 23 connected in series. The arrangement of this dimmer control can be made such that the reactor 23 controls the brightness from full brightness to say, one-tenth full brightness, and the resistor 15 controls the brightness over the remainder of the range.

In all the above described lamp circuits and the alternatives thereto each single lamp or group of two lamps may be replaced by one or more groups of lamps disclosed in pending application Serial No. 116,756. Also the modifications disclosed in the said application, enabling the brightness of the lamps to be reduced from full brightness to substantially zero brightness, may, if practicable, also be incorporated.

Although all the circuits described above are suitable for six single lamps or six groups of lamps, it will be apparent that circuits in accordance with this invention may include two or more such lamps or groups of lamps.

This application is a division of my application Serial No. 212,212, filed February 23, 1951 which has become Patent No. 2,863,241 granted July 6, 1954.

I claim:

1. An electric discharge lamp circuit including two or more low-pressure electric discharge lamps of the hot-cathode type having two electrodes, or two or more groups of such lamps, each lamp or group of lamps being connected between the terminals of the secondary winding of an associated matching transformer, the primary windings of the matching transformers being connected in series, means for supplying to the series-connected primary windings a potential difference which is progressively variable by a dimmer control while the lamps are operating, and means for supplying heating current continuously to each of the electrodes of the lamps at least over the lower part of the operating range of brightness of the lamps, the arrangement being such that both said means are supplied from the same source of power, and the circuit including ballast impedance for limiting the lighting current flowing in each lamp.

2. An electric discharge lamp circuit as claimed in claim 1, wherein the said ballast impedance comprises a single ballast impedance element connected in the series-primary circuit of the matching transformers.

3. An electric discharge lamp circuit as claimed in claim 1, wherein the said ballast impedance comprises, at least in part, the matching transformers.

4. The combination of claim 1, in which the group of lamps connected across the secondary of at least one of the transformers includes two lamps in series, with a capacitive impedance connected across one of said two lamps.

References Cited in the file of this patent

UNITED STATES PATENTS

2,665,394 Arvidsson et al. ********* Jan. 5, 1954