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APPARATUS FOR FLASHING FLUORESCENT LAMPS
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Fig. 1

HIS ATTORNEY

## 1

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## APPARATUS FOR FLASHING FLUQRESCENT LAMPS

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14 Claims. (Cl. 315-98)

My invention relates to apparatus for flashing fiuorescent lamps repetitively between "on" and "ofi" conditions or between two stable conditions of different luminous intensity such as may be used, for example, in flashing sign applications.

Apparatus for flashing fiuorescent lamps has not in the past found wide commercial application principally because of problems of life and reliability. When operated with conventional ballasts and flashers, the severe duty placed upon the fiuorescent lamps by such frequent starting and stopping with the consequent frequent ionization and partial or total deionization of the gas within the lamps causes the lamps quickly to burn out. In addition, starting has not always been instantaneous so that the flashing cycle has not been reliable.

Accordingly, a general object of the invention is to provide apparatus for flashing fiuorescent lamps having improved life and reliability.

Another object of the invention is to provide apparatus for flashing fluorescent lamps in which the energy shock to the components, and particularly to the lamps, during the flashing periods is reduced, thereby to improve the life and reliability of these components.
A further object is to provide a high-reactance transformer suitable for use in apparatus for flashing hotcathode fluorescent lamps.
In general, in accord with my invention, a high-reactance transformer or "ballast" and a flasher switch are arranged for connection between an alternating-current source and a fluorescent lamp of the hot-cathode type to ignite and control the current to the lamp. Heating windings on the transformer are constructed for continuously heating the cathodes to static temperatures (without lamp discharge) considerably above the normal or "rated" static temperatures when the lamp is used for general lighting applications. I have discovered that this elevation in the static temperature of the cathodes results in an improvement in the life of the lamp as well as greater reliability in starting when the lamp is repetitively flashed. It will be appreciated that if the cathodes of the lamp were operated at this elevated static temperature in applications where the lamp was lighted continuously, or for long periods of time, the lamps would prematurely burn out.

In accord with a further feature of the invention; an impedance element is preferably connected in parallel with the flasher switch for passing at least a small current to the lamp during open periods of the switch. Since lamp current is not completely extinguished every few seconds, the gas around the cathodes or filaments of the lamps does not become completely deionized and restarting is facilitated and not such a severe shock to the lamp. In addition, since the flasher switch does not interrupt full current, the duty on the switch as well as the tendency to arc across its contacts is substantially reduced thereby prolonging the life of the switch.

The novel features believed characteristic of the in-
vention are set forth in the appended claims. The invention itself, however, together with further objects and advantages thereof will be easily understood by referring to the following description taken in connection with the accompaniing drawing in which the sole figure is a circuit diagram of apparatus embodying one form of the invention.
Referring to the drawing, there is shown a high-reactance inductive device in the form of a ballast transformer 10 connected in circuit with a repeating or flasher switch 11 to receive power through input terminals 12 and to control the current to a fluorescent lamp 13. The term "flasher switch" is used herein to connote any switch which repetitively and cyclically opens and closes a pair of contacts to make and break the circuit with opened and closed flashing periods of less than one minute duration. Ballast transformer 10 has a primary winding 14 and a secondary winding 15 arranged on discrete portions of a central elongated leg 16 of its magnetic core. These windings are surrounded by yoke-core portions 17 having inwardly directed sections 18 between windings 14 and 15 extending into close proximity with the central core leg 16 to form magnetic-flux-shunting paths therewith and thereby to provide the desired highinductive reactance for ballasting the lamp. Fluorescent lamp 13 is of the hot-cathode type as shown, having thermionic filamentary activated electrodes for cathodes 29, 21 at opposite ends adapted to be continuously energized by heating windings 22 and 23 arranged on the primary winding section of transformer 10. Lamp 13 is mounted in close proximity with the grounded electricconducting plate or strip member 24 to facilitate starting. Primary winding 14 is connected across input terminals 12 through a disconnecting-type socket 25 for one end of lamp 13. Removal of lamp 13 from socket 25 functions to disconnect lead 26 from filament lead 27 thereby to interrupt power to primary winding 14.

Flasher switch $\mathbf{1 1}$ is shown as a thermally flexing bimetal switch but may be of any conventional type such as those employing a motor rotating a cam which opens and closes the switch contacts every few seconds. Flasher switch 11 is connected in series circuit with lamp 13 to control the current supplied thereto. Preferably, switch 11 is connected, as shown, between the high-voltage end of primary winding 14 and the low-voltage end of secondary winding 15. In this way, lamp 13 is connected to be energized by an autotransformer circuit including primary winding 14, flasher switch 11 and secondary winding 15 connected in series.

In the ballast, a small capacitor 29 is connected between the heating windings 22 and 23 and a resistance 28 is connected from one winding to the ballast case and thence to ground in order to suppress generation of highfrequency radiations.

In accord with one aspect of the invention, an impedance element 30 is preferably connected in parallelcircuit relation with, for example, by being directly connected across the terminals of, flasher switch 11. Impedance element 30 is preferably a resistor, as shown, but may alternatively be a capacitor or inductor.
In accord with the invention heating windings 22 and 23 of transformer 10 are constructed to apply voltage across the heating filaments of the cathodes 20,21 of the lamps considerably higher than the conventional continuously applied voltage thereby to increase the current through the windings sufficiently to elevate the static temperature of the cathodes considerably above their normal or "rated" static temperatures. The phrase "static temperature of the cathode" is used herein to connote the temperature at the hottest point of the cathode when the cathode is continuously heated by ex.
ternally applied voltage in the absence of a lamp discharge. The phrase "rated static temperature of the cathode" is used herein to connote the temperature at the hottest point of the cathode in the absence of lamp discharge when the cathodes are contimuously heated by applied voltage equal to the "rated" voltage as stated or recommended by the lamp manufacturer for use in normal lighting applications where the lamp may be lighted for widely varying or prolonged periods of time.
More specifically, one type of widely used hot-cathode lamp known as the "rapid start" lamp is adapted for continuous heating by a steady-state cathode voliage rated for normal lighting applications at about 3.6 volts. The cathodes of these rapid-start lamps achieve static temperatures of about 650 -degrees centigrade under such rated voltages and without lamp discharge at which temperatures the lamp usually burns out in about 24 hours when flashed. In accord with my invention, I have found that by increasing the number of turns on the heating windings 22, 23 of transformer 10 from the nermal 30 turns to about 35 turns to apply a cathode voltage of about 4.6 volts, instead of the usual 3.6 volts, the static temperatures of the cathodes are increased to about 860 -degrees centigrade and fluorescent lamp life and reliability are appreciably increased when these lamps are flashed by suitable flashing apparatus, such as shown in Figure 1. Tests show that the number of instantaneous starts before burn out in lamps operating with such higher static-cathode temperatures is several hundred times the number of instantaneous starts before burn out in lamps operating under normal or rated static-cathode temperatures. The range of appreciable improvement is where the cathodes achieve static temperatures from 800 -degrees centigrade to 930 -degrees centigrade which, in "rapid start" fluorescent lamps, corresponds to an applied voltage range from 4 to 5.25 volts.
The reason for this phenomenal improvement is believed to be a reduction in the intensity of ion bombardment of the cathode during starting due to the increased cathode temperature and the consequent decrease in the potential difference, commonly called "cathode fall" between the cathode and the plasma of the lamp.
In the operation of the circuit of Figure 1, the voltage across the autotransformer-connected windings 14 and 15 with switch 11 closed is sufficient to ignite fluorescent lamp 13. Once lamp 13 fires, the high reactance of the secondary winding portion of transformer 10 provides the necessary ballasting action compensating for the negative-resistance characteristic of the lamp. When the contacts of flasher switch 11 open due to the flexure of the thermally-sensitive element therein, the current through the secondary-winding portion of the autotransformer and consequently through lamp 13 is limited by the magnitude of the impedance element 30 . Impedance element 30 is particularly valuable in improving the reliability and life where the starting voltage from the transformer is only slightly greater than the rated ignition voltage of the lamp involved. The ohmic value of the impedance element $\mathbf{3 0}$ is selected to give the desired reduction in lamp brightness without extinguishing the current flowing through the lamp 13. By proper selection of the impedance element 30 it has been found possible substantially to completely extinguish the light emitted from lamp 13 without extinguishing the current flowing therethrough. In order to obtain the benefits of more reliable starting, however, the impedance of element 30 should not be so large as to limit the lamp current to less than one half of one percent of the operating lamp current when the lamp is at normal brilliance. Typical values of impedance element 30 for controlling a 40 -watt hot-cathode fluorescent lamp are from 30,000 to 50,000 ohms to give a lamp current during the "off" periods of switch 11 of about three milliampers, corre-
sponding to about one percent of rated light output of the lamp.

The life of a 40 -watt rapid start lamp using the circuit described above with a flashing cycle of one second "on" and one second "off" has exceeded 12-million flashes. With ballast circuits where a single ballast transformer controls the current to more than one lamp connected in series, it will be appreciated that the impedance element 30 connected in parallel with flasher switch 11 controlling the series current to these lamps must be proporionally smaller to provide the desired minimum lamp current.
While I have described above a particular embodiment of the invention, many modifications may be made.
15 It is to be understood, therefore, that I intend, by the appended claims, to cover all such modifications as fall 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. Apparatus for flashing a fluorescent lamp of the hot-cathode type from an alternating-current source, comprising a high-reactance transformer for connection between said source and said lamp to ignite and ballast said lamp, said transformer having a pair of cathodeheating windings constructed to supply heating current to the respective lamp cathodes sufficient to elevate the static temperatures of said cathodes considerably above their rated static temperatures for normal lighting applications, and a flasher switch connẹted in series with said transformer to control current to said lamp.
2. The apparatus of claim 1 including an impedance element connected in parallel circuit with said switch for passing current to said lamp during open periods of said switch.
3. Apparatus for flashing a hot-cathode fluorescent lamp from a source of alternating current comprising a high-reactance ballast transformer for connection to said lamp having a primary winding for connection across said source, a secondary winding making autotransformer connection with said primary winding and a pair of heating windings for connection to the cathodes of said lamp, said heating windings being constructed to apply heating voltage to the lamp cathodes sufficient to raise the static temperature of said cathodes considerably above their rated static temperatures, and a flasher switch connected in series with said secondary winding for controlling current to said lamp.
4. The apparatus of claim 3 wherein said heating windings are constructed to apply heating voltage to the lamp cathodes sufficient to raise the static temperature of said cathodes to between 800 -degrees and 930 -degrees centigrade.
5. The apparatus of claim 3 including an impedance element connected across said flasher switch for passing current to said lamp during open periods of said switch.
6. Apparatus for flashing a hot-cathode fluorescent lamp from a source of alternating current comprising a ballast transformer for connection to said lamps and having a primary winding for connection across said source, a secondary winding, and heater windings for connection to the cathodes of said lamp, said heating windings being constructed to supply heating current to the lamp cathodes sufficient to raise the static temperatures of said cathodes considerably above their rated static temperatures for general lighting applications, a flasher switch making autotransformer connection between said primary and secondary winding to control current to said lamp, and an impedance connected across said flasher switch for passing current to said lamp during open periods of said switch.
7. Apparatus for flashing a hot-cathode fluorescent lamp from a source of alternating current comprising a high-reactance ballast transformer having a primary winding for connection across said source, a secondary winding for connection to said lamp, and heating windings
for connection to the cathodes of said lamp, a flasher switch in series circuit relation with said secondary winding to control current to said lamp, and an impedance connected in parallel-circuit relation with said flasher switch for passing a small current to said lamp during open periods of said switch.
8. The apparatus of claim 7 wherein said impedance element has an impedance sufficient to pass a current in the neighborhood of one percent of rated-lamp current during said open period of said switch.
9. Apparatus for flashing a fluorescent lamp comprising a high-reactance device for connection between said source and said lamp to energize and ballast said lamp, a flasher switch connected in series circuit with said device to control current to said lamp, and an impedance element connected in parallel circuit with said flasher switch for passing current to said lamp during open periods of said switch.
10. In combination, a hot-cathode fluorescent lamp, a high-reactance ballast transformer having a primary winding for connection across a source of alternating current, a secondary winding connected to said lamp and heating windings connected to the cathodes of said lamp and proportioned to supply current thereto to achieve a temperature in said cathodes from 800 -degrees centigrade to 930 -degrees centigrade in the absence of a discharge through said lamp, and a flasher switch connected in circuit with said secondary winding to control discharge current through said lamp.
11. The apparatus of claim 10 including an impedance element connected in parallel with said switch for passing current to said lamp during open periods of said switch.
12. A high-reactance transformer for use in apparatus for flashing a fluorescent lamp of the hot-cathode type comprising a magnetic core having a primary winding for connection to said source, a secondary winding, and a pair of cathode-heating windings, said cathode heating windings being wound over the primary winding and constructed to supply heating voltages across the respective cathodes of a lamp in the range of from 4 to 5.25 volts to achieve a lamp cathode static temperature in the range of 800 -degrees to 930 -degrees centigrade.
13. Apparatus for flashing a fluorescent lamp of the hot cathode type from an alternating current source comprising a high reactance transformer for connection between said source and said lamp to ignite and ballast said lamp, said transformer having a pair of cathode heating windings constructed to supply heating voltage to the respective lamp cathodes sufficient to elevate the static temperatures of said cathodes considerably above their rated static temperatures for normal lighting applications, and flashing means for periodically and cyclically interrupting current to said lamp from said transformer with flashing periods less than one minute duration.
14. The apparatus of claim 13 wherein said heating windings are constructed to apply heating voltage to the lamp cathodes sufficient to raise the static temperature of said cathodes to between $800^{\circ}$ and $930^{\circ}$ centigrade.

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## UNITED STATES PATENT OFFICE

## CERTIFICATE OF CORRECTION

Patent No, 2,858,478
October 28, 1958

Delmar D. Kershaw

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 29, after the numeral "23" insert a period; line 29, before "arranged" insert - These heating windings 22 and 23 are -m; line 30, after the numeral "10" and before the period insert and preferably wound over the primary winding as illustrated so as to be closely coupled magnetically with the primary winding 14 ma; column 4 , line 25, after "constructed" insert mim and arranged mame line after "supply" insert - and maintain m; line 30, before "said" insert --flash --; Iine 42, after "being" insert - closely coupled to said primary winding and being -w; column 5, line 14 , after "with" insert me the output of --; line 19, after "lamp" and before the comma insert $-\infty$ of the rapid start type --; column 6, line 16, after "constructed." insert mand arranged --; same line after "supply" insert -m and maintain mo.

Signed and sealed this 21st day of July 1959.

## (SEAL)

Attest:
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Attesting Officer

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Commissioner of Patents

