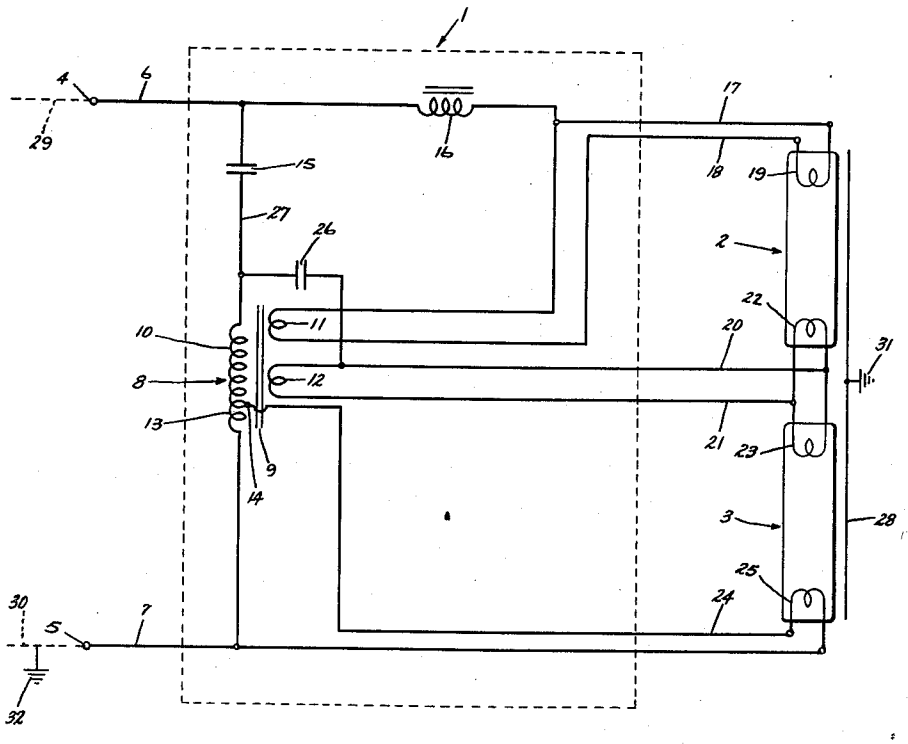
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ELECTRIC DISCHARGE APPARATUS

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ELECTRIC DISCHARGE APPARATUS

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This invention relates to circuits and apparatus for starting and operating gaseous electric discharge lamps from an alternating current source, and more particularly to such circuits and apparatus for use with hot cathode fluorescent lamps.

Some forms of electric discharge lamps presently available employ two thermionic or hot cathodes, one at each end of the lamp respectively, which may be characterized in that the cathodes are continuously heated to electron emission temperature at voltages below the ionization voltage of the gas or vapor in the lamp. One such lamp is the so-called rapid start type as described in U.S. Patent No. 2,774,918, issued December 18, 1956 to Eugene Lemmers, and assigned to the same assignee as the instant application.

Two or more heated cathode discharge lamps are frequently connected in series with a ballast across a high voltage supply source sufficient to start and operate the lamps; for example, across a 550 volt source available for industrial distribution. The circuit apparatus for two such serially connected lamps normally includes a cathode heating transformer for supplying heating current to the lamp cathodes, a starting capacitor for starting first one and then the other of such discharge lamps, a power correcting capacitive impedance for improving input power factor, and an inductive ballasting impedance which limits the current flow through the discharge lamps during operation and which is required due to the negative current characteristic of the lamp.

In such apparatus it has been common practice to connect the primary winding of the cathode heating transformer directly across the supply line or across the lamps. This has resulted in a transformer having a low current, high voltage primary requiring a primary winding of very fine wire, which is in general expensive to manufacture. In order to reduce the cost of the apparatus, it would be desirable if a cathode heating transformer could be used having a low voltage, high current primary.

Accordingly, it is a primary object of this invention to provide an improved electrical circuit and apparatus for starting and operating heated cathode, electric discharge lamps where the cathode heating transformer is connected for energization at a relatively low voltage.

Briefly stated, according to the present invention, the improved electrical circuit and apparatus comprises a cathode heating transformer having a primary winding in series circuit relation with an impedance having sufficient voltage drop thereacross to limit the voltage drop available for the transformer. The impedance-transformer series circuit is connected across input means adapted to be connected across an alternating current source which is adapted to be connected across at least one discharge lamp in series with a current limiting impedance or ballast, and which source is of sufficient magnitude to start and operate the lamps.

The invention, together with additional objects and advantages thereof, will be best understood from the following description of a specific embodiment read in connection with the accompanying drawing, in which the single figure is a schematic view of a discharge circuit and apparatus according to the invention.

Referring to the single figure, there is illustrated the improved electrical circuit 1 having output terminals adapted to be connected to lamps 2, 3 and having input terminals 4, 5 on input lines 6, 7 adapted to be connected across a source of alternating current supply voltage 29, 30. The electrical circuit 1 includes a cathode heating transformer 8 having a magnetic core 9 on which is primary coil 10, first and second secondary coils 11, 12, in inductive relation to the primary 10 and in isolated electrical relationship therewith, and a tap 14 on the primary 10 forming a winding constituting the section of the primary 10 between line 7 and tap 14 as a third cathode heating secondary coil 13. It is to be understood, of course, that the third secondary coil 13 could also be of the electrically isolated type. The primary 10 of transformer 8 is serially connected with an impedance 15 across input lines 6 and 7, the impedance 15 being of sufficient magnitude to have a significant voltage drop across it, thereby reducing the voltage available across the transformer 8. As herein illustrated, the impedance 15 is a capacitive impedance or power correcting capacitor and thereby serves the additional function of improving the power factor of the circuit at the input terminals 4, 5.

While the apparatus of the present invention may be suitably used with a single discharge device, as herebefore stated, the preferred embodiment is connected to operate a pair of serially connected discharge lamps 2, 3. With a pair of discharge lamps 2, 3 operatively connected to the circuit, the discharge lamps 2, 3 are serially connected with a current limiting impedance or ballast 16 across input lines 6, 7; thereby being in parallel relation to the series circuit of the primary winding 10 and capacitor 15. The cathode heating secondaries 11, 12 and 13 each have electrical leads for supplying cathode heating current to the cathodes of the discharge devices; secondary 11 is connected by means of lines or leads 17 and 18 to cathode 19 of discharge device 2; secondary 12 is connected by means of lines or leads 20 and 21 to cathode 22 of lamp 2 and to cathode 23 of lamp 3 thereby supplying cathode heating current to the cathodes which serially join lamps 2 and 3; secondary 13 supplies cathode heating current through lines or leads 7 and 24 to cathode 25 of lamp 3.

As is known in the art, a starting capacitor 26 is operatively connected across one lamp to effect sequential starting of the lamps; as shown, starting capacitor 26 has one end connected to the line 27 joining the capacitor 15 and primary 10, and has the other end secured to one line 20 of secondary 12 which is common to one cathode 22, 23 of each lamp 2, 3.

In a conventionally installed rapid-start lighting system, the lamps 2, 3 are in close proximity and therefore capacitively coupled to a conducting part here shown as fixture 28, which is in electrical circuit relation with the low potential side of the supply source 29, 30. Normal residential and commercial electrical distribution systems in this country generally have the low potential side thereof grounded. The electrical circuit may then consist of ground 31 on the fixture 28 and ground 32 on the low potential side 30 of the supply source. As is well known, an auxiliary starting aid circuit is thereby formed which aids in the starting of the lamps.

In a typical apparatus, the discharge lamps 2, 3 may each comprise a fluorescent lamp, General Electric Company Catalogue No. 96T12, designed to draw 0.8

amperes. The supply source may consist of a 550 volt, 60 cycle alternating source. The ballast **16** may have a value of 1.38 henries and will limit the current flow through the lamps, after starting, to 0.8 R.M.S. amperes. A 2.51 mfd. capacitive impedance **15** will restrict the current flow to the primary **10** of the cathode heating transformer 8 to 0.5 amperes; under these conditions, the cathode heating transformer **8** will have a 27 volt potential drop across its primary. The cathode heating transformer **8** is arranged with the proper turns ratio so that 3.5 volts is supplied to each cathode. The starting capacitor **26** may have a value of 0.075 mfd.

The above described circuit, according to the instant invention, will consume approximately 332 volt-amperes in the ballast **16**; 28 volt-amperes in the cathode heating transformer **8**; and 286 volt amperes in the power correcting capacitor **15**. The prior high voltage transformer (General Electric Company Catalogue No. 89G726) used in the same application consumes 680 volt-amperes (corresponding to the combined ballast **16** and cathode heating transformer 8). The power correcting capacitor consumes 554 volt amperes.

In accordance with the patent statutes, we have described what at present is considered to be the preferred embodiment of our invention. However, it will be obvious to those skilled in the art that various changes and modifications may be made in the disclosed circuit without departing from the true spirit and scope of our invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What is claimed as new and desired to secure by Letters Patent of the United States is:

1. Apparatus for operating heated cathode discharge lamps from a source of alternating current supply of sufficient voltage to start and operate the lamps, comprising a pair of input leads adapted to be connected to the source of supply current, a first impedance, a cathode heating transformer having a primary winding, a series circuit connecting said first impedance and said primary serially across said input leads, said first impedance providing a sufficient voltage drop during operation of said lamps to substantially limit the voltage across said primary winding, secondary windings associated with said primary winding and having leads for supplying cathode heating current to the cathodes of said lamps, an inductive current limiting impedance, a junction joining one end of said series circuit and said inductive current limiting impedance with one of said input leads, and circuit means for connecting said lamps in series with said inductive current limiting impedance across the said source of supply current and in parallel relation to the series circuit of the transformer primary winding and said first impedance.

2. An apparatus according to claim 1 wherein said first impedance is a power factor correcting capacitor.

3. A lighting system for operating at least one heated cathode discharge lamp from a source of alternating current supply of sufficient voltage to start and operate the lamp, comprising at least one heated cathode discharge lamp, a pair of input leads adapted to be connected to the source of supply current, a first impedance, a cathode heating transformer having a primary winding serially connected to the first impedance across the input leads, said first impedance providing a sufficient voltage drop during operation of said lamp to substantially limit the voltage across said primary winding, secondary windings associated with said primary winding and having leads connected to supply cathode heating current to the cathodes of the lamp, an inductive current limiting impedance, a junction joining said first impedance and said inductive current limiting impedance with one of said input leads, and circuit means connecting said lamp in series with said inductive current limiting impedance across the said supply current in parallel relation to the series circuit of the transformer primary winding and the first impedance.

4. Apparatus for operating at least two serially connected heated cathode discharge lamps from a source of alternating current supply of sufficient voltage to start and operate the lamps, comprising a pair of input leads adapted to be connected to the source of supply current, a first impedance, a cathode heating transformer having a primary winding, a series circuit connecting said first impedance and said primary serially across said input leads, said first impedance providing a sufficient voltage drop during operation of said lamps to substantially limit the voltage across said primary winding, secondary windings associated with said primary winding and having leads supplying cathode heating current to the cathodes of the lamps, an inductive current limiting impedance, circuit means for connecting the serially connected lamps in series with said current limiting impedance across said source of supply current in parallel relation to the series circuit of the transformer primary winding and said first impedance, a junction joining one end of said series circuit and said inductive current limiting impedance with one of said input leads and a starting capacitor operatively connected in circuit relation across one of said lamps to effect sequential starting of the lamps.

5. An apparatus according to claim 4 wherein said first impedance is a power factor correcting capacitor.

6. A lighting system for operating at least two serially connected heated cathode discharge lamps from a source of alternating current supply of sufficient voltage to start and operate the lamps, comprising at least two serially connected heated cathode discharge lamps, a pair of input leads adapted to be connected to the source of supply current, a power factor correcting capacitor, a cathode heating transformer having a primary winding serially connected to said power factor correcting capacitor across the input leads, said power factor correcting capacitor providing a sufficient voltage drop during operation of said lamps to substantially limit the voltage across said primary winding, secondary windings associated with said primary windings and having leads connected to supply heating current to the cathodes of the lamp, an inductive current limiting impedance, a junction joining said power factor correcting capacitor and said current limiting impedance with one of said input leads, circuit means connecting the serially connected lamp in series with said current limiting impedance across said voltage supply current in parallel relation to the series circuit of the transformer primary winding and said capacitor, and a starting capacitor operatively connected in circuit relation across one of said lamps to effect sequential starting of the lamps.

7. Apparatus for operating heated cathode discharge lamps from a source of alternating current supply source of sufficient voltage to start and operate the lamps, comprising input means adapted to be connected to the source of supply current, an impedance, a cathode heating transformer having a primary winding serially connected to the impedance and operatively connected across the current supply source, said impedance providing a sufficient voltage during operation of said lamps to substantially limit the voltage across said primary winding, secondary windings associated with said primary winding and having leads for supplying cathode heating current to the cathodes of said lamps, and circuit means for connecting said lamps operatively across the supply current supply source; said circuit means providing an inductive impedance limiting the current through said lamps.

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