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NON-RESONANT STARTING CIRCUIT FOR HIGH PRESSURE
DOUBLE JACKETED MERCURY LAMPS
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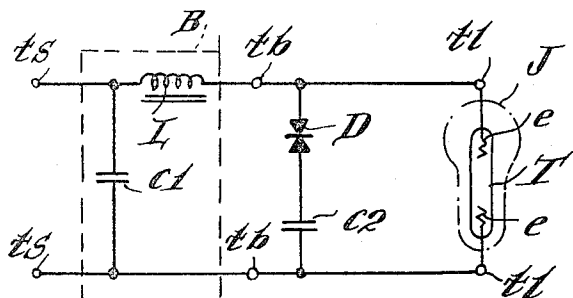


Fig. 1

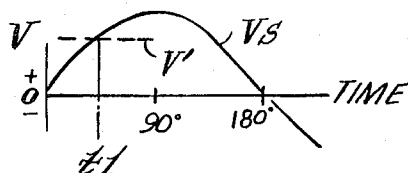


Fig. 4

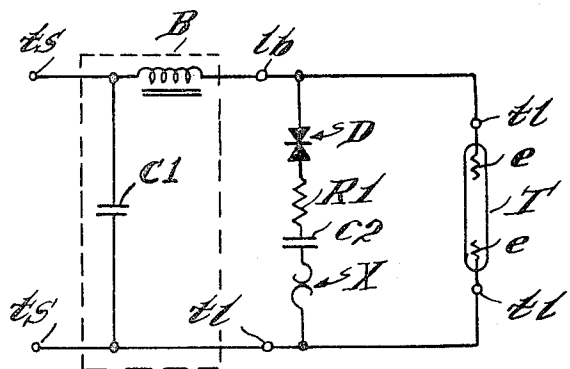


Fig. 2

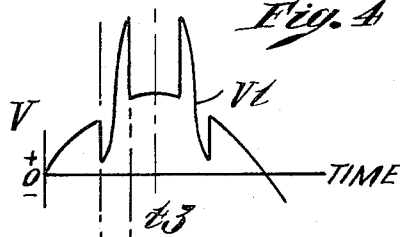


Fig. 5

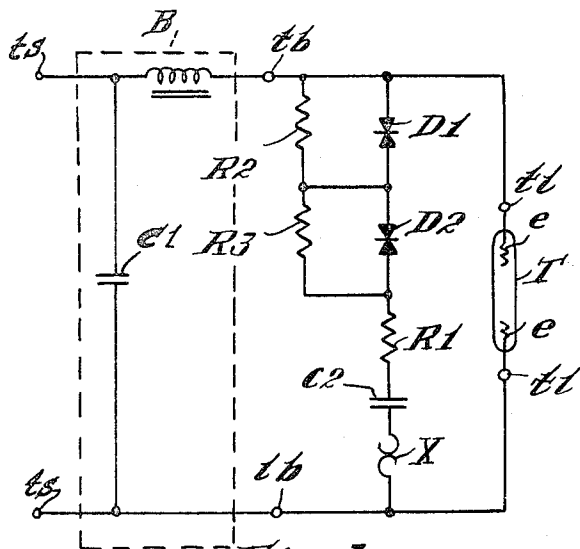


Fig. 3

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NON-RESONANT STARTING CIRCUIT FOR HIGH PRESSURE DOUBLE JACKETED MERCURY LAMPS

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1 Claim. (Cl. 315-242)

ABSTRACT OF THE DISCLOSURE

A circuit for starting a high pressure, double jacketed mercury lamp with a ballast inductance in series with the lamp and a solid state, bidirectional breakdown device and a capacitor in series-parallel with the lamp, the inductance and capacitor having a non-resonant charging time constant such as to apply an abrupt lamp starting voltage jump to the lamp during each half-cycle of an alternating current supply.

This invention relates to electrical discharge devices in general, and particularly to high pressure alternating current vapor discharge devices such as mercury and mercury-iodine lamps.

High pressure lamps, for example, comprise an outer jacket enclosing an inner arc tube containing a fill of mercury, an inert gas at a high pressure above one atmosphere, and in some lamps an additional halogen such as iodine. In operation an arc discharge is sustained between electrodes at each end of the arc tube by a predetermined voltage supplied, usually from line terminals, to lamp terminals connected to the electrodes. For mercury lamps at low temperatures and mercury-iodine lamps the supply or line voltage is inadequate to ignite an arc discharge between the electrodes. For example, 175 watt and 400 watt mercury-iodine lamps, which will maintain an arc discharge at 240 volts AC at operating temperature, require substantially twice that voltage to strike the arc.

It is an object of the present invention to provide a starting circuit for connection between the supply terminals and the lamp terminals which will provide a starting voltage substantially double the instantaneous voltage at the supply terminals, which after starting the discharge will apply only the supply voltage, and which will not draw appreciable current after starting.

The present invention involves a starting circuit for an alternating current electrical discharge device comprising an envelope containing a fill of a vaporizable, positively ionizable material and an inert gas, and having electrodes at respective ends of the envelope between which an arc discharge is maintained by a predetermined alternating current voltage supplied to respective electrodes, said circuit comprising alternating current supply terminals, lamp terminals adjacent said lamp for connection to said electrodes, an inductance connected between one supply terminal and one lamp terminal, and a connection between the other supply and lamp terminal, and two-directional voltage breakdown valve means and a capacitance connected in series between said lamp terminals, said valve means having a breakdown voltage less than that of said alternating current, such that after the capacitance is charged through said breakdown means to said predetermined voltage a substantially greater voltage is applied by said inductance and capacitance to said lamp terminals thereby to ignite said lamp to operate at an applied voltage less than said predetermined voltage, whereupon said valve means ceases to charge said capacitance during lamp operation, characterized in that the values of the capacitor and inductance are chosen such

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that the charging time constant of the capacitor is less than the interval between the times at which the supply voltage reaches breakdown and maximum value.

For the purpose of illustration typical embodiments of the invention are shown in the accompanying drawing in which:

FIGS. 1 to 3 are schematic diagrams of three forms of starting circuit; and

FIGS. 4 and 5 are graphs of voltages in the circuit of FIG. 1.

One starting circuit according to the invention is shown in FIG. 1 in which a conventional mercury or mercury-iodine lamp comprises an outer jacket J and an inner arc tube T enclosing electrodes e. Carried outside the jacket J are lamp terminals *tl*. Operating voltage for the lamp is supplied from alternating current supply terminals *ts* through a ballast B comprising a current-limiting choke L, and usually a power factor correcting capacitor C1. The ballast B corrects and limits the line voltage at ballast terminals *tb*. After the arc is ignited the voltage at the ballast and lamp terminals drops below that of the supply terminals. For example, in a 400 watt high pressure mercury lamp designed for operation on a 240 volt RMS AC line, the peak voltage applied to the lamp terminals is 304 volts at 10 percent below nominal line voltage, which is adequate for reliable starting of mercury vapor lamps at ordinary temperatures but not for reliable starting of all mercury-iodine lamps. Moreover, such voltages as are supplied by a ballast choke are inadequate to start mercury-iodine lamps or mercury lamps at low temperatures.

As shown in FIG. 1 a branch starting circuit is connected across the lamp terminals *tl*. The branch circuit comprises a two-directional voltage breakdown valve D and a capacitor C2 in series therewith. The voltage breakdown valve D is of the type which blocks current of either polarity until a predetermined threshold voltage is applied, whereupon the valve conducts in either direction with a relatively low voltage drop. One example of such a valve is the silicon symmetrical switch type PD 135 manufactured by Hunt Electronics, Incorporated. An equivalent valve means is two avalanche diodes connected in series, opposed in polarity. Both these devices have the property of remaining in a non-conducting state until the threshold or breakover voltage is exceeded, and then conducting currents of several amperes at a negligibly low voltage drop, typically 1 volt, after breakdown. When alternating current is applied, the device conducts and as the alternating current falls below threshold voltage, the device extinguishes and recovers non-conducting state. Then when the reverse voltage exceeds threshold value, the device conducts in the opposite polarity.

The above described starting circuit operates as follows, and with reference to FIGS. 4 and 5. As the instantaneous voltage across the unignited lamp terminals *tl* increases, the valve D does not conduct until the instantaneous voltage exceeds its threshold voltage, typically about 230 volts for a line designed for 240 volt supply. At the time *t1* when the supply voltage *Vs* (FIG. 4) increases to the threshold voltage *V1* the valve D abruptly becomes fully conducting and the voltage across it drops to 1 volt. At this instant the capacitor C2 is uncharged and the voltage across it is zero. Thus the potential *V1* (FIG. 5) across the valve D and capacitor C2 series and across the lamp terminals *tl* drops nearly to zero. The entire instantaneous line voltage appears across the inductive choke L and a current flows into the capacitor, charging it. As is well known, the charging current reaches a maximum when the potential across the capacitor C2 equals the instantaneous line voltage; but since the current through the inductive choke L cannot drop to zero instantly it continues to flow into the capacitor, driven by the collapsing lines

of magnetic flux in the choke. The current does not drop to zero until a time t_2 when the additional charge driven into the capacitor is such that the potential across it is approximately double that of the voltage at the ballast terminals tb . Since the potential across the valve D is negligible at this time, the net voltage across the lamp terminals V1 is also approximately double the instantaneous supplied voltage. The time constant, or time to charge the capacitor to its maximum potential depends on the values of the choke L and capacitor C2. The values of the capacitor and inductance may be chosen so that the charging time (t_1 to t_2) is slightly less than the time interval (t_1 to t_3) between the time at which the threshold voltage is reached and the time when the supply voltage V_s reaches maximum.

By way of example, with a choke suitable for 240 volt operation of a 400 watt lamp the capacitor C2 may have a value between 1 and 4 microfarads, preferably about 2 microfarads, for 0.2 henry chokes suitable for 200 volt operation of 175 watt lamps; or for 120 volt leakage-reactance 175 watt ballast a value of 1 microfarad is suitable.

At the time t_2 when the capacitor C2 is charged to double the instantaneous line voltage, and the charging current from the choke is zero, the capacitor C2 would normally discharge back through the choke L except for the presence of the bi-directional valve D. Instead the valve D recovers its blocking characteristic and absorbs the difference between the capacitor voltage and the supply voltage. The voltage across the lamp then drops to the instantaneous supply voltage. After the time t_3 at which maximum instantaneous supply voltage is reached and begins to decrease, the breakover voltage of the valve D is again exceeded, the valve begins conducting in the opposite direction and the capacitor starts to discharge back into the line through the inductor L. The potential across the lamp then jumps from the instantaneous line voltage to the capacitor voltage, which is nearly double the line voltage. The capacitor then discharges in the manner substantially analogous to its charging. On the second half cycle of the supply voltage V_s the voltage V1 applied to the line terminals tl is substantially the reverse of the above described cycle.

From the foregoing description it will be seen that periodically the voltage across the lamp terminals tl will be in excess of twice the line voltage at the peak voltages shown in FIG. 5. Because the valve D is not exactly symmetrical, the peak voltages may advance or retard slightly with each half cycle of the supply voltage. But sooner or later one of them will coincide with the maximum supply voltage giving them a peak voltage over double that of the supply voltage, and well above the peak voltage required to start mercury-iodine lamps or high pressure mercury lamps at low temperatures.

For example, in the circuit described a peak voltage of approximately 600 volts is applied to 175 and 400 watt, 240 volt, mercury-iodine lamps whose starting voltage requirement is 525 volts.

Once a good 175 or 400 watt lamp has started, at no time does the instantaneous voltage across the lamp exceed 230 volts. The valve D therefore does not begin conducting in either direction or charge the capacitor C2 until the lamp is extinguished and the line voltage re-applied.

Under conditions in which the line voltage accidentally fails, extinguishing the lamp, and then is restored in less than the ten or fifteen minutes required to cool the lamp, a high potential would be applied to the capacitor C2 at a time when it is heated by the lamp above its maximum temperature rating. To insure that the starting circuit is inoperative under such conditions a thermostatic switch X is shown in FIG. 2 connected in series with the valve D and capacitor C2 closely adjacent the capacitor C2. This switch X is set to open at a temperature elevated above ambient but less than the rated temperature of the

capacitor, for example 85° C. At this temperature the capacitance is disconnected from its series branch circuit. The circuit of FIG. 2 also includes a resistance R1, for example 10 ohms, for limiting the surge current through the valve D, at the instant of lamp ignition, to within its rated amperage.

FIG. 3 shows a circuit for starting 1000 watt lamps from a 480 volt line on a standard mercury lamp choke. The same circuit should also work on a leakage-reactance type auto transformer ballast designed for lower line voltages but having 460 to 480 volts open circuit voltage. It consists of the same basic elements as before, except that two breakdown devices D1 and D2 in series are required. 1.0 megohm resistances R2 and R3 are included to insure equal division of voltage between the two devices.

Potential applications of such devices include conversion of many existing choke-type mercury lamp ballasts to operate mercury-iodine lamps reliably, permitting upgrading of existing lighting installations; use of low-open-circuit-voltage choke or leakage reactance ballasts together with such a starter, at a substantial cost savings, in installations where the high line current at starting of such ballasts is not a disadvantage.

While certain desirable embodiments of the invention have herein been illustrated and described, it is to be understood that these are mainly by way of example, and the invention is broadly inclusive of any and all modifications falling within the scope of the appended claims.

I claim:

1. A starting circuit for an alternating current double jacketed high pressure mercury lamp comprising an envelope containing a fill of vaporizable, positively ionizable material and an inert gas, and having electrodes at respective ends of the envelope between which an arc discharge is maintained by a predetermined alternating current voltage supplied to respective electrodes, said circuit comprising:

alternating current supply terminals,

lamp terminals adjacent said lamp for connection to said electrodes,

an inductance connected between one supply terminal and one lamp terminal,

a connection between the other supply and lamp terminals, and

two-directional, solid state voltage breakdown valve means and a capacitance connected in series between said lamp terminals, said valve having a breakdown voltage less than that of the half cycle peak of said alternating current,

such that after the capacitance is charged through said breakdown means to said predetermined voltage a substantially greater voltage is applied by said inductance and capacitance to said lamp terminals thereby to ignite said lamp to operate at an applied voltage less than said predetermined voltage, whereupon said valve means ceases to charge said capacitance during lamp operation,

characterized in that, in its conducting state said valve means has a negligible voltage drop, and in that the values of the capacitor and inductance are chosen such that the charging time constant of the capacitor is less than the interval between the times at which the supply voltage reaches breakdown and maximum value, whereby resonance of said circuit is prevented and the voltage applied to the lamp abruptly jumps to lamp starting voltage, and

further characterized by a normally closed thermostatic switch adjacent said capacitor is connected between said lamp terminals in series with said inductance and capacitor, said switch being set to open as the circuit temperature elevates substantially toward operating temperature, thereby to disconnect said capacitance from said series and protect the capacitance from high starting potentials at elevated

temperatures after starting and extinction of the lamp.

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