ELECTRIC DISCHARGE DEVICE HAVING A THERMOSTATICALLY OPERATED SWITCH CONNECTED TO A MAIN ELECTRODE

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ELECTRIC DISCHARGE DEVICE HAVING A THERMOSTATICALLY OPERATED SWITCH CONNECTED TO A MAIN ELECTRODE

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This invention relates to electric discharge devices such as mercury lamps, and more particularly to high pressure lamps containing a halide such as iodine as well as mercury.

High pressure lamps, for example, comprise an outer transparent jacket and an inner arc tube with electron emitting electrodes between which an arc discharge is established through the vaporized, ionized mercury fill in the lamp. Recently, the addition of iodine and certain metals to the mercury has been found to improve the spectral distribution of emission in the visible range greatly. However, mercury-iodine lamps are difficult or impossible to start with a conventional ballast such as a constant wattage ballast. When an arc has been struck but the arc tube is still cold, the lamp presents a very low impedance to the ballast and the waveform of the current from the ballast is highly peaked, with relatively long periods of current flow so low that the arc temperature drops to the point where iodine apparently induces recombination of electrons and ions and extinguishes the arc between the current peaks. Striking of the arc causes the arc tube temperature, and hence pressure, to increase to the point, less than final operating pressure and impedance, where the arc cannot be reignited from extinction.

The object of this invention is to provide a way in which electric discharge devices containing mercury and iodine can be started from a conventional ballast such as a constant wattage ballast.

According to the invention an electric discharge device comprises an envelope containing a vaporizable, positively ionizable, at least two electrodes enclosed by said envelope between which an electric arc discharge is established, electric impedance means connected in series with one of said electrodes, and thermostatic switch means responsive to heat from said arc to shunt said iodization.

With the impedance in series with an external ballast, current flow is maintained sufficiently high between peaks to prevent extinction of the arc during the period that the arc tube is warming up to operating temperature and impedance.

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

FIG. 1 is an elevation of one embodiment of a high-pressure mercury lamp;
FIG. 2 is an enlarged detail in elevation, showing a modification of the lamp;
FIG. 3 is a schematic diagram of the electrical circuit of the lamp; and
FIGS. 4 to 6 are waveforms of current in the lamp.

As shown in FIGS. 1 and 2 a high pressure mercury lamp comprises an outer glass jacket 1. A quartz arc tube 3 is supported within the jacket 1 on a U-shaped conducting frame 4. Spring fingers 6 on the frame 4 engage the jacket 1 holding the frame and arc tube in position. At its lower end the frame 4 is welded to a terminal wire 7. This terminal wire 7 and a like terminal wire 8 extend through a stem press seal to a terminal base 11. Collars 12 on the frame engage shoulders at opposite ends of the arc tube 3.

At each end of the arc tube 3 main operating electrodes 14 and 16 enter through stem press seals. A starting electrode 17 enters adjacent the lower main electrode 16. The upper main electrode 14 is connected by a nickel ribbon 18 to the frame 4, thence through the frame to terminal wire 7. The starting electrode 17 is connected through a 40,000 ohm resistance R1 to the frame 4, thence to terminal wire 7.

In a conventional lamp the lower main electrode 16 would be connected directly to the terminal wire 8 in the stem press 9, and in a conventional lamp, filled with mercury and a small amount of argon, the following starting and operating sequence would occur. At first alternating current supplied from lines A and C through a ballast B to the terminal wire 7 would encounter a very high impedance between electrodes 14 and 16, but a relatively low impedance through the resistance R1 and the space between the starting electrode 17 and lower main electrode 16. A starting arc would be struck between these electrodes. Heat from the starting arc then initiates vaporization of the mercury providing a very low impedance path between the two main electrodes 14 and 16. A main arc is struck over this path, and during a starting period of time to seven minutes the temperature and pressure within the arc tube, and the impedance between the main electrodes, decrease to stabilized operating values. During the starting period and stable operation, the main arc comprises an alternating flow of electrons emitted from the main electrodes and a counter flow of mercury and other positive ions. When the main arc is first struck across the cold arc tube, the arc at low mercury pressure produces a current impedance, typically 6--8 ohms. When this low impedance is connected to the terminals of a ballast, of the so-called constant wattage type, the current waveform output from the ballast consists of narrow, widely spaced peaks as shown in FIG. 4. In a conventional mercury lamp there are sufficient free electrons remaining from the previous current peak to permit the arc to reignite on the subsequent peak, and the arc is maintained between peaks. As temperature and pressure increase, the arc impedance between the main electrodes increases to and stabilizes at an ohmic value typically about 40 ohms for a 400 watt lamp. When this impedance is connected to the terminals of the so-called constant wattage ballast, the current waveform output from the ballast is as shown in FIG. 5. As the arc tube warms up and the mercury pressure increases, its impedance gradually increases. With increasing lamp impedance the ballast current output waveform gradually changes from that of FIG. 4 to that of FIG. 5. FIG. 6 shows an intermediate waveform such as might appear when the arc impedance is about 20 ohms.

However, in a mercury-iodine lamp to which the present invention is related, during the starting period recombination of iodine with the electrons extinguishes the arc between current peaks and prevents reignition of the arc on the subsequent current peak as the arc tube pressure increases.

According to the present invention the problem of establishing stable arc conditions in mercury-iodine lamps is resolved by including with the mercury fill in the arc tube a positively ionizable, vaporizable material such as sodium or cesium, both alkaline metals, but with a substantially lower ionization potential than mercury; and further by providing in the connection between the lower main electrode 16 and wire terminal 8, a series resistance and, in parallel with the resistance, a thermostatic switch comprising normally open contacts 21 and 22, the latter contact 22 being carried on a bimetallic element 23.

While various arc tube fills may be used, the invention is of particular advantage with a fill comprising a small...
amount of rare gas such as argon, mercury, a halide such as iodine, a spectral continuum forming metal, and an alkali metal such as sodium or cesium. By spectral continuum forming metal is meant a metal which is excited by a discharge arc to emit a continuous spectral band in the visible range, or to emit an equivalent forest of closely spaced spectral lines covering substantially throughout the band. Indium, gallium and thallium emit continuous spectra. Thorium and the rare earth metals emit light distributed in a forest which, so far as physiologic response is involved, is equivalent to a continuous spectrum. The amount of mercury in the arc tube may be from 2.5 x 10⁻⁵ to 4.1 x 10⁻⁵ gram-atom per centimeter of arc length (g.a./cm.). The ratio of halide (e.g. Cl, Br, I) to mercury may range from 0.025 to 0.75, a typical ratio being 0.45. Indium, gallium and thallium are added in the amount of 1.2 x 10⁻⁵ to 1.2 x 10⁻⁶ g.a./cm.; whereas thorium and the rare earths such as yttrium and most of the metals of the lanthanide series (e.g. La, Ce, Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm, Lu) are added in the amount of 5.2 x 10⁻⁵ to 5.2 x 10⁻⁶ g.a./cm. including the thorium, if any, present in the electrodes of the arc tube. The alkali metals such as cesium and sodium are added in the amount of 0.53 x 10⁻¹ to 6.8 x 10⁻¹ g.a./cm. The filling proportions and procedure are set forth in greater detail in our copending applications Ser. Nos. 209,974 and 230,944, filed July 16, 1962 and October 11, 1962 respectively, and in the copending application of Butler et al. Ser. No. 239,272, filed November 21, 1962.

As shown in FIG. 1 the resistance is a conventional series resistor R₁. As shown in FIG. 2, the resistance comprises a tungsten filament extending through insulating sleeves 24 on a modified collar 12. The filament is incandescent and is disposed adjacent the arc tube 3 wherein it both contributes light and supplies heat to the arc tube during the starting period. Both the resistor R₂ and the filament R₀ have an ohmic value which is a substantial fraction of the stable operating impedance of the arc tube. For example, in a 400 watt lamp with an operating impedance of approximately 40 ohms, the resistance R₂ or filament R₀ may have a value of about 20 ohms.

The effect of the resistance R₂ or R₀ is to add to the arc impedance so that the minimum impedance presented to the ballast is greater than 20 ohms. The current waveform output from the ballast immediately after striking the arc is never less favorable to maintenance of the arc than that shown in FIG. 6. And with increasing arc tube pressure and impedance the waveform approaches that of FIG. 5. FIG. 6 shows that, in contrast to FIG. 4, sufficient current flows in the interval between peaks for the cold arc tube to operate and continue warm up. The bimetallic element 23 holds the contacts 21 and 22 open during initial warm up so that all arc current passes through the resistance R₂ or R₀. The bimetallic element, being adjacent the arc tube, then responds to heat from the arc tube by closing the contacts 21 and 22 thereby shutting out the resistance R₂ or R₀ and connecting the main electrode 16 directly to the terminal wire 8. Typically the bimetallic element is set to close the contacts when the arc tube is partially warmed up toward its operating temperature of 600° to 700° C. and its impedance is about 20 to 30 ohms. In this range, which is not critical, the arc tube impedance is sufficiently high to maintain a satisfactory current waveform between those of FIGS. 5 and 6 and to allow the arc tube to warm up to stable condition.

It should be understood that the present invention includes all modifications and equivalents which fall under the scope of the appended claims. For example, the present starting circuit is useful in fluorescent lamps lacking iodine, and with ballasts other than constant wattage ballasts.

We claim:

1. An alternating current electric discharge device comprising an envelope containing a vaporizable, positively ionizable material, at least two electrodes enclosed by said envelope, said electrodes and material providing an electric arc discharge path within the envelope, said each electrode a terminal exterior of the envelope for applying high voltage discharge current thereto, electric impedance means of the same order of ohmic value as the operating impedance of said arc discharge path connected between one said terminal and electrode in series with said discharge path, and thermostatic switch means in parallel with said impedance means and responsive to heat from said arc to shut said resistance out of series with said switch while said arc is discharging continuously.

2. A discharge device according to claim 1 wherein said material comprises mercury and its impedance is about 20 to 30 ohms.

3. An electric discharge device according to claim 1 wherein said material comprises iodine and a plurality of vaporizable, positively ionizable materials at least two of which have relatively high and low ionization potentials respectively.

4. An electric discharge device according to claim 3 in which the material of low ionization potential is selected from the group comprising of cesium and mercury.

5. An electric discharge device according to claim 3 wherein the material of low ionization potential is sodium.

6. An electric discharge device according to claim 1 wherein said material comprises mercury, a halide, a continuum forming metal and an alkali metal.

7. An electric discharge device according to claim 1 characterized by an outer jacket around the envelope, said terminal entering through said jacket and said impedance means being located within said outer jacket.

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