

[54] **ARC DISCHARGE TUBE WITH
SURROUNDING STARTING COIL**

2,765,416 10/1956 Beese et al. 313/15
3,093,269 6/1963 Kuhl et al. 315/46

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[22] Filed: **Dec. 30, 1971**

[21] Appl. No.: **214,000**

[57] **ABSTRACT**

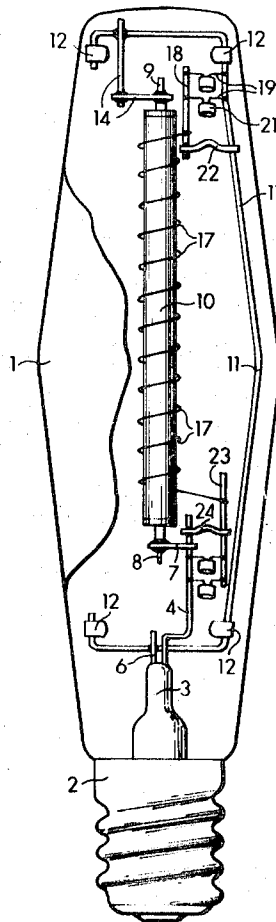
[52] U.S. Cl. **315/47, 313/15, 313/17,
313/44, 313/225, 313/229**
[51] Int. Cl. **H01J 7/24**
[58] Field of Search **315/46, 47, 48;
313/15, 17, 44**

A high pressure mercury-sodium lamp with an outer jacket and inner arc tube has several turns of tungsten resistance heating filament coiled around the arc tube. The filament is electrically connected to the leads which supply the arc tube electrodes and heats the mercury and sodium fill to arc striking temperature. At this temperature a bimetallic switch opens the filament connection.

[56] **References Cited
UNITED STATES PATENTS**

2,581,959 1/1952 Koehler 313/15

18 Claims, 3 Drawing Figures



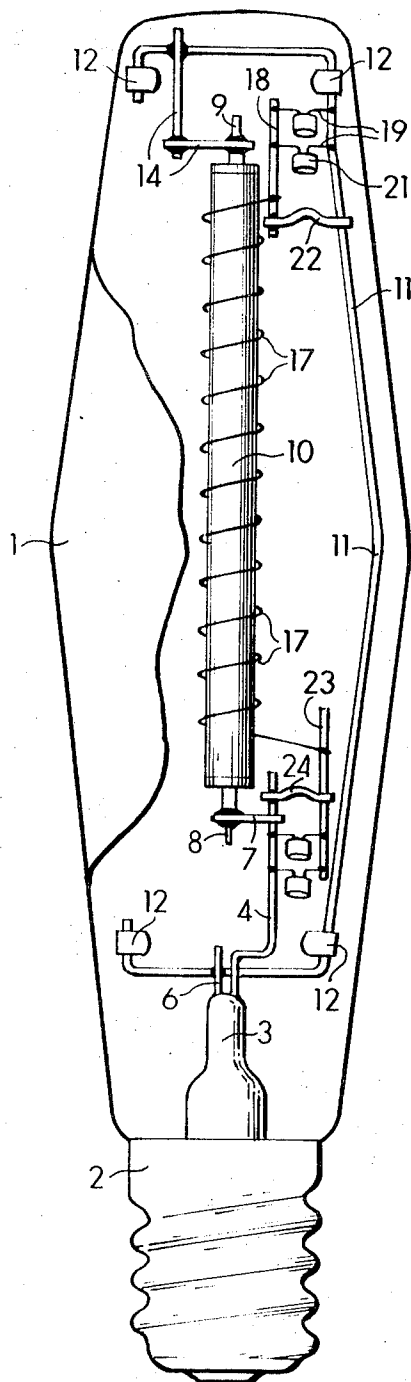


FIG. 1

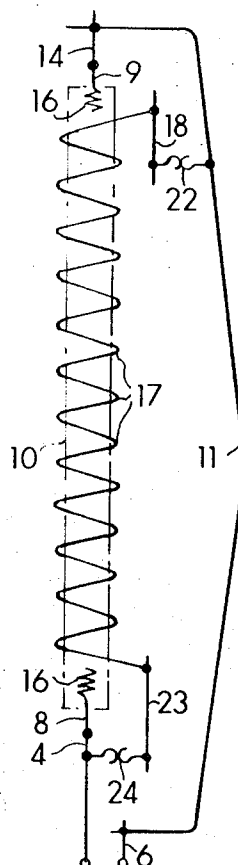


FIG. 2

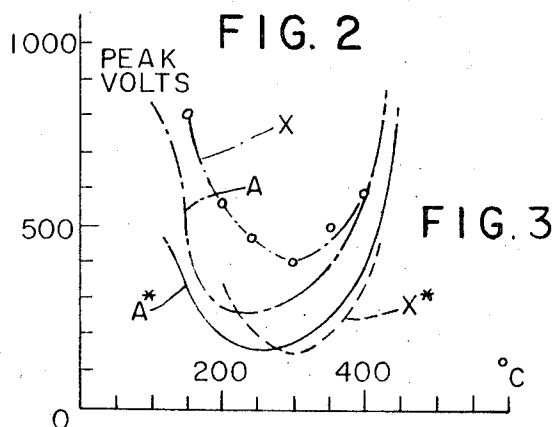


FIG. 3

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ARC DISCHARGE TUBE WITH SURROUNDING STARTING COIL

BACKGROUND OF THE INVENTION

Among the many forms of devices having a fill of vaporizable, ionizable material supporting an arc discharge, high pressure mercury lamps for example, can achieve improved light emission by addition to the mercury fill of metals such as the alkali metals, e. g. sodium and cesium, and other metals described in U.S. Pat. No. 3,262,012. Despite their improved color, light output and life, high pressure sodium (HPS) lamps are difficult or impossible to start with commonly available ballasts for the earlier high pressure (HP) mercury lamps lacking alkali metal fills. HPS lamps for example, have hitherto required a kilovolt pulse (2500 volts minimum) for ignition as compared with the two or three hundred volt, peak needed to start arc discharge in an HP mercury lamp. Also for HPS lamps a 60 hertz, 250 volt RMS, 4 ampere supply is simultaneously supplied to change the low current starting discharge to a high current operating discharge. Consequently HPS lamps cannot be used in the several million HP mercury sockets in existence, but must be used with a special, much more expensive high voltage ballast. During a relatively long starting period of several minutes little or no light is emitted.

Accordingly, the main object of the present invention is to provide a way of starting arc discharge tubes such as HPS lamps which substantially reduces the starting voltage requirements, increases the speed and reliability of starting, and allows use of lamps with earlier available, inexpensive ballasts, in particular the existing sockets already ballasted for HP (as compared to HPS) lamps of comparable wattage even at low temperatures and with below normal supply voltages. A further object is to provide illumination prior to the starting of the main arc discharge.

STATEMENT OF INVENTION

According to the invention a high pressure arc discharge lamp comprises an outer jacket, an inner arc tube having spaced arc discharge electrodes and a fill of alkali metal and rare gas, and electrical heating means connected to at least one of said electrodes and effective to raise the temperature of the arc tube to at least approximately 150° centigrade, thereby substantially reducing the voltage required to start an arc between the electrodes.

DRAWINGS

For the purpose of illustration a typical embodiment of the invention is shown in the accompanying drawing in which:

FIG. 1 is an elevation, partly broken away, of a high pressure mercury-sodium lamp;

FIG. 2 is a schematic diagram of the electrical circuit in the lamp of FIG. 1; and

FIG. 3 is a graph of starting voltages versus controlled arc tube temperature for prior lamps and lamps according to the present invention.

DESCRIPTION

The high pressure mercury-sodium (HPS) lamp in FIGS. 1 and 2 comprises a conventional outer glass jacket 1 extending from a base 2. A stem 3 supports lead wires 4 and 6, the first of which 4 is connected to

a strap 7 welded to the lower terminal 8 of an arc tube 10. The other lead wire 6 is connected by a weld to a C-shaped frame 11 extending to the top of the outer jacket 1. Straps 14 are connected by welds between the top of the frame and the upper terminal 9 of the arc tube. The lower and upper terminals 8 and 9 are connected to electrodes 16 within the arc tube as shown in FIG. 2. Spring fingers 12 engage the jacket 1 positioning the frame 11 and arc tube 10.

A typical arc tube 10 for a 400 watt HPS lamp is manufactured of polycrystalline, high density, high purity alumina tubing resistant to sodium attack such as is described in U.S. Pat. No. 3,026,210 to Coble. The tube has a length of 4½ inches with an outer diameter of 0.350 inches and a wall thickness of 0.030 inches. The arc tube has a gas fill of argon at 23 torr, or xenon at 13 torr and a chemical fill of 20 milligrams of mercury and 50 milligrams of mercury-sodium amalgam, approximately one part sodium to three parts mercury by weight. Other of the previously referenced vaporizable, ionizable fill materials may be used. Previous HPS lamps have required a minimum pulse of 2500 volts to strike an arc between the electrodes 16 of a cold HPS arc tube at room temperature. The high voltage ballast weighs and costs substantially more than a conventional high pressure mercury lamp ballast.

According to one embodiment of the present invention a conductor 17 of ohmic heating material is preferably in coiled form around and supported in contact with the arc tube 10 throughout a major portion, or preferably as shown, throughout substantially the entire length of the arc discharge space between the electrodes 16. Typically the conductor is a tungsten filament, 12.31 milligrams per 200 millimeters, rated for 120 volt, 100 watt alternating current at up to 3000°K. The turns of the coil may be spaced approximately ¼ to ½ inch apart, the end turns being about ¼ inch from the end caps of the arc tube. The upper turn of the filament coil 17 is welded to a wire rod 18 which is insulatively supported on the frame 11 by wires 19 separately imbedded in glass cylinders 21. The electrical gap between the rod 18 and the frame 11 is completed at cold lamp temperature by a bimetallic, thermostatic switch leaf 22 welded to the rod 18 and contacting the frame 11. Similarly the lower turn of the coil 17 is welded to a rod 23 insulatively supported on one lead wire 4 and connected through a thermostatic switch 24 to the lead wire 4. One or both of the thermostatic switches may be replaced by a permanent connection, although with a loss of efficiency if both switches are omitted. The thermostatic switches open the filament circuit after arc ignition and during normal lamp warm up and operation. While a thermally responsive mechanical switch is shown, other switches such as switches responsive to arc starting temperature or arc operating voltage or current including solid state and gaseous discharge switches may be used.

When installed with a conventional 120 VAC, 400 watt, 60 hertz mercury ballast having a choke supplying an output of 240 volt, a current of about 0.5 amperes flows through the filament. The filament incandesces emitting a useful amount of light, and raises the vapor pressure of both the sodium and mercury components of fill toward vaporized and ionized arc striking state. The lamp starts in about 100 seconds and thereafter runs up to full operating state in much less time than previously required. This is a remarkable reduction

from the previously required starting pulse in the order of two to three thousand volts. Moreover the present lamp will start within a somewhat longer period (e.g. 3 minutes), upon application of voltages as low as a 160 volt RMS sine wave. In each of the above cases the arc strikes across the lamp electrodes at a voltage lower than that at which a cold lamp will ignite, and ignition occurs independently of ambient temperature.

In FIG. 3 are four curves plotting data of peak lamp starting voltage as a function of the temperature of four 400 watt, high pressure lamps with arc tube fills of alkali metal and rare gas. In each case the arc tube was encapsulated in an envelope or outer jacket containing helium for good heat transfer. The encapsulated lamp was heated in a furnace to successive temperature levels at each of which temperature was equilibrated. An increasing voltage was then applied until an arc was struck at which point peak starting voltage was measured.

Curves A and X are plots for HPS arc tubes filled with argon at 23 torr (A) and xenon at 13 torr (X) respectively, both arc tubes lacking the conductor 17 of FIGS. 1 and 2. Curves A* and X* are of the same tubes provided with the conductor 17 as described hereinbefore except that the conductor 17 was unconnected at one end, as by insulatively spacing the contacts of bimetallic switch 22, the other end being permanently connected to one electrode only, for the purpose of establishing the potential of that electrode substantially along the entire surface of the arc tube. The arc tubes of plots A* and X* were not heated by the conductors 17 but rather by the heating elements of the furnace external of the jacket 1.

All four curves show a similar decrease of peak starting voltage to a minimum and then an increase as furnace temperature is increased. All curves thus demonstrate the discovery that with alkali metal-rare gas filled arc tubes the peak starting voltage is markedly reduced at temperatures over 150°C. This reduction at increased temperature is not shown by the earlier high pressure mercury lamps HP (as compared with the present HPS lamps), HP lamp starting voltage being reduced by cooling at least to room temperature if necessary, rather than heating. Curves A and X show a reduction from the previously required HPS lamp starting voltage of 2500 volts minimum to a peak starting voltage of approximately 275 volts for the HPS-argon lamp of curve A, and approximately 400 volts for the HPS-xenon lamp X. From curves A and X it can be seen that the decline of starting voltage becomes substantial at about 150°C and remains substantial up to about 400°C.

Comparison of curves A and X with curves A* and X* shows a still further starting voltage reduction in the lamps of curves A* and X* which are provided with the coiled conductor 17. Comparing curve A with curve A* there is a further reduction of starting voltage from the minimum of approximately 275 volts on curve A to the minimum of approximately 160 volts on curve A*. More strikingly the minimum of the xenon lamp curves is reduced from approximately 400 to 160 peak starting volts, a reduction of more than 50 percent.

This further marked starting voltage reduction is believed to result from capacitive coupling between the coiled conductor 17 and the fill in the arc discharge space which is also a conductor. In any case FIG. 3 shows the reduction in starting voltage to be attribut-

able to the presence of the two forms of conductor in close electrical coupling relation.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents falling within the scope of the appended claims.

We claim:

1. A high pressure arc discharge lamp comprising: an outer jacket,

an inner arc tube having spaced arc discharge electrodes and a fill including alkali metal and rare gas, and

electrical heating means connected to at least one of said electrodes and effective to raise the temperature of the arc tube to at least approximately 150° centigrade, thereby substantially reducing the voltage required to start an arc between the electrodes, said electrical heating means being disconnected upon starting of an arc between said electrodes.

2. A high pressure arc discharge lamp according to claim 1 wherein the electrical heating means is effective to heat the arc tube to within the range of 150° to 400° centigrade.

3. A high pressure arc discharge lamp according to claim 1 wherein the alkali metal is selected from the group consisting of sodium and cesium.

4. A high pressure arc discharge lamp according to claim 1 wherein the rare gas is selected from the group consisting of argon and xenon.

5. A lamp according to claim 1 wherein the fill includes mercury.

6. A high pressure arc discharge lamp according to claim 3 wherein the rare gas is selected from the group consisting of argon and xenon.

7. A high pressure arc discharge lamp according to claim 1 wherein the heating means is a substantial light emitter, whereby the lamp provides illumination prior to full operation of the arc.

8. A high pressure arc discharge lamp according to claim 1 wherein the heating means is connected to an electrode by switching means responsive to arc starting condition to disconnect the heating means.

9. A high pressure arc discharge lamp according to claim 8 wherein the switching means is a thermal responsive device.

10. A high pressure arc discharge lamp according to claim 9 wherein the thermal device opens at a temperature between 150° and 400° centigrade.

11. A high pressure arc discharge lamp according to claim 1 wherein the heating means comprises an electrical conductor extending along a major portion of the length of the arc discharge space and in capacitive coupling relation thereto, and characterized by connections for applying voltage to the electrodes including a connection to the conductor.

12. A high pressure arc discharge lamp according to claim 11 wherein the conductor extends substantially the length of the arc discharge space.

13. The method of starting a high pressure arc discharge lamp with an arc tube having spaced electrodes and fill including alkali metal and rare gas, which comprises applying a starting voltage to the electrodes and heating the arc tube to at least 150° centigrade by means of an electrical heater and electrically disconnecting the heater upon starting the lamp.

14. The method according to claim 13 wherein the fill includes mercury.

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15. The method according to claim 13 wherein the alkali metal is selected from the group consisting of sodium and cesium.

16. The method according to claim 13 wherein the rare gas is selected from the group consisting of argon and xenon.

17. The method according to claim 16 wherein the

arc tube is heated to within the range of 150° to 400° centigrade.

18. The method according to claim 17 wherein a voltage of less than approximately 400 volts peak is applied to the electrodes.

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