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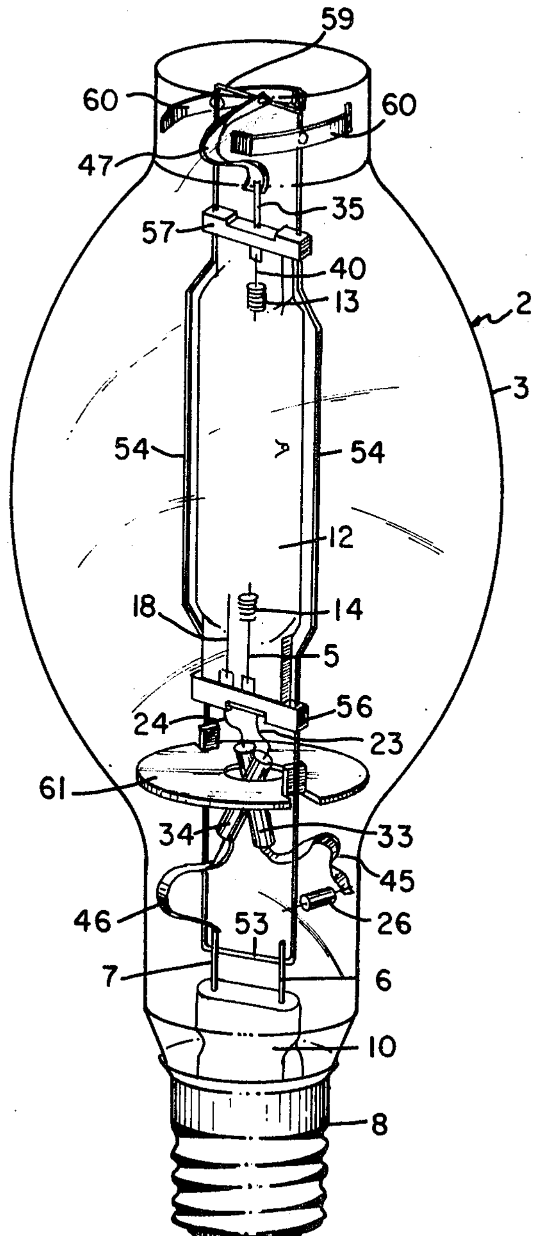

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HIGH PRESSURE VAPOR DISCHARGE LAMP WITH CESIUM IODIDE

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ABSTRACT OF THE DISCLOSURE

The addition of cesium atoms as the halide to a discharge device containing a fill of mercury, halogen and light emitting metal(s) will control the reignition voltage of such devices.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to high pressure electric discharge devices and particularly to those which contain fills of atoms of mercury, halogen and light emitting metal(s).

Description of the prior art

In high pressure electric discharge devices utilizing AC voltage, there is an interruption of current flow twice during each cycle. Before the current flow can be restarted, the voltage applied to the discharge must effect two phenomena: (1) The establishment of an electrode as a cathode which was the anode during the previous half cycle (2) re-establish a minimum conductivity to the plasma. The amount of voltage required for performance of these tasks is dependent upon the pressure and composition of the discharge.

For arc discharges operating at pressures of one to two atmosphere, thermodynamic equilibrium exists. A discharge of this nature will have a significant heat capacity. As a result, the gas temperature and the associated plasma conductivity will exhibit only relatively small fluctuations even though the applied voltage has a sinusoidal variation. At these pressures, the applied voltage need only establish an electrode as a cathode prior to the effective passage of current through the device.

By contrast, the low-pressure discharge operating on AC is characterized by large fluctuations in arc temperature and in conductivity. The fluctuations of the conductivity follow the sinusoidal fluctuation of the applied voltage and the heat capacity is inconsequential in maintaining high arc temperature and a carryover of lamp conductivity from one half cycle to the next. During the period of reversal of polarity of applied voltage, any electron-ion loss mechanism will be instrumental in reducing the plasma conductivity. Depending upon the rate of loss of conducting species, the "effective" temperature and the instantaneous lamp pressure, the reignition voltage required to establish a minimum plasma conductivity may approach and even surpass the initial breakdown voltage of the device.

Upon initial ignition, the pressure of the lamp containing mercury, halogen and a light emitting metal corresponds to that of the fill gas and is of the order of 20 torr. During the period of pressure build-up, which is of the order of two or three minutes, the metal iodide lamp will exhibit some characteristics of low-pressure operation. During the period of AC voltage reversal, the instantaneous power dissipated in the plasma will go to zero. The electrical conductivity will decrease and the reignition voltage will climb.

In such lamps, the peak voltage required to reignite the discharge in the period of low pressure may rise to a value higher than available from the auxiliary equipment and the lamp will extinguish.

SUMMARY OF THE INVENTION

We have discovered that reignition voltages of metal iodide lamps can be controlled by the chemical composition of the arc tube filling ingredients. We have found that free mercuric iodide in the arc tube during the warm up phase of lamp operation results in high values of reignition voltage. To prevent the formation of free mercuric iodide, it is customary to limit the quantity of the mercuric iodide added to the arc tube to an amount less than that which would stoichiometrically form the iodide at the highest oxidation state of the added multivalent light emitting metal (LEM). However, it is believed that not all of the multivalent light emitting metal reacts with iodine to form that molecular species which has the highest oxidation state. Thus, for example, when the arc is operating, free iodine can be present as follows:

$$(LEM)+zHgI_2 \rightarrow (LEM)I_2+(LEM)I_3+zHg+xI$$

(wherein x is less than $2z$). And therefore, there is in fact, an excess of mercuric iodide over that which is required to form light emitting metal iodide from all the light emitting metal which actually reacts.

Despite attempts to prevent the occurrence of mercuric iodide in an operating lamp after aging, nevertheless, such molecules can remain and in those cases, the reignition voltages are quite high. Quite unexpectedly, we have discovered that the addition of cesium iodide appears to promote the reaction between the light emitting metal and the mercuric iodide or conversely, may form an additional compound which incorporates more iodine and prevents the formation of mercuric iodide.

BRIEF DESCRIPTION OF THE DRAWING

The figure is a perspective view of a high pressure electric discharge device containing the filling of materials of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The device, such as shown in the drawing, comprises an outer vitreous envelope or jacket 2 of generally tubular form having a central bulbous portion **3**. The jacket is provided at its end with a re-entrant stem having a press seal through which extend relatively stiff lead-in wires **6** and **7** connected at their outer ends to the electrical contacts of the usual screw type base **8** and at their inner ends to the arc tube and the harness.

The arc tube is generally made of quartz although other types of glass may be used such as alumina glass or Vycor, the latter being a glass of substantially pure silica. Sealed in the arc tube **12** at the opposite ends thereof are main discharge electrodes **13** and **14** which are supported on lead-in wires **4** and **5** respectively. Each main electrode comprises a core portion which may be a prolongation of the lead-in wires **4** and **5** and may be prepared of a suitable metal such as for example molybdenum or tungsten. The prolongations of these lead-in wires **4** and **5** can be surrounded by tungsten wire helixes.

An auxiliary starting probe or electrode **18**, generally prepared of tantalum or tungsten is provided at the base end of the arc tube **12** adjacent the main electrode **14** and comprises an inwardly projecting end of another lead-in wire.

Each of the current lead-in wires described have their ends welded to intermediate foils sections of molybdenum which are hermetically sealed within the pinch sealed portions of the arc tube. The foil sections are very thin, for example approximately 8×10^{-4} inch thick, and go into tension without rupturing or scaling off when the heated arc tube cools. Relatively short molybdenum wires **23**, **24** and **25** are welded in the outer ends of the foil and serve to convey current to the various electrodes inside the arc tube **12**.

Metals strips **45** and **46** are welded onto the lead-in wires **23** and **24** respectively. A resistor **26** is welded to foil strip **45** which in turn is welded to the arc tube harness. The resistor may have a value of for example 40,000 ohms and serves to limit current to auxiliary electrode **18** during normal starting of the lamp. Metal foil strip **46** is welded at one end to a piece of molybdenum foil sealed in the arc tube **12** which in turn is welded to main electrodes **13** and **14**. Metal foil strip **47** is welded to one end of lead-in **35** and at the other end to the harness. The pinched or flattened end portions of the arc tube **12** form a seal which can be of any desired width and can be made by flattening or compressing end ends of the arc tube **12** while they are heated.

A U-shaped internal wire supporting assembly or arc tube harness serves to maintain the position of the arc tube **12** substantially coaxially within the envelope **2**. To support the arc tube **12** within the envelope stiff lead-in wire **6** is welded to the base **53** of the harness. Because stiff lead-in wires **6** and **7** are connected to opposite sides of a power line, they must be insulated from each other, together with all members associated with each of them. Clamps **56** and **57** hold the arc tube **12** at the end portions and are fixedly attached to legs **54** of the harness. A rod **57** bridges the free ends of the U-shaped support wire **54** and is fixedly attached thereto for imparting stability to the structure. The free ends of the U-shaped wire **54** are also provided with a pair of metal springs **60**, frictionally engaging the upper tubular portion of the lamp envelope **2**. A heat shield **61** is disposed beneath the arc tube **12** and above the resistor **26** to protect the resistor from an excessive heat generated during lamp operation.

The following 45 mm. arc length lamps described in Table I were prepared and contained fills which included 46 mg. of mercury, 7.5 mg. of mercuric iodide, the specified amounts of light emitting metal and the specified amounts of alkali halide. In the table, the operating and reignition voltages are recorded when the various alkali metals are used in arc tubes containing the various light emitting metals.

LEM (wt.)	Alk	Alkali metal iodide weight, (mgs.)	Starting voltage	Reignition voltage
Sc (1.0 mg.)	Na	19.5	250	100
Sc (1.0 mg.)	Na	6.5	260	145
Sc (1.0 mg.)	Na	3.3	270	200
Sc (1.0 mg.)	Cs	11.4	260	25
Sc (1.0 mg.)	Cs	5.7	330	20
Sc (1.0 mg.)	Cs	2.3	260	35
Nb (2.0 mgs.)	Na	19.5	300	160
Nb (2.0 mgs.)	Na	6.5	280	230
Nb (2.0 mgs.)	Na	3.3	290	200
Nb (2.0 mgs.)	Cs	11.4	250	70
Nb (2.0 mgs.)	Cs	5.7	260	100
Sm (3.3 mgs.)	Cs	19	240	35
Sm (3.3 mgs.)	Cs	6.0	240	40
Sm (3.3 mgs.)	Li	17.0	------	240
Sm (3.3 mgs.)	Li	11.0	150	300
Sm (3.3 mgs.)	Na	19.5	100	300
Sm (3.3 mgs.)	Na	6.5	140	300
Dy (3.5 mgs.)	Li	28.5	300	150
Dy (3.5 mgs.)	Li	11.0	270	160
Dy (3.5 mgs.)	Na	19.5	300	40
Dy (3.5 mgs.)	Na	6.5	300	40
Dy (3.5 mgs.)	Na	3.3	270	120
Dy (3.5 mgs.)	Cs	11	240	35
Dy (3.5 mgs.)	Cs	6	230	35
Dy (3.5 mgs.)	Cs	2.5	280	40
V (1.1 mg.)	Na	19.5	290	170
V (1.1 mg.)	Na	6.5	280	150
V (1.1 mg.)	Na	3.3	260	170
V (1.1 mg.)	Cs	11.4	240	30
V (1.1 mg.)	Cs	5.7	240	30
Lu (3.8 mgs.)	Li	28	270	100
Lu (3.8 mgs.)	Li	11	280	120
Lu (3.8 mgs.)	Na	19.5	260	100
Lu (3.8 mgs.)	Na	3.3	300	140
Lu (3.8 mgs.)	Cs	11	218	40
Lu (3.8 mgs.)	Cs	6	270	80
Th (5.0 mgs.)	Li	28.5	270	200
Th (5.0 mgs.)	Li	17.5	280	190
Th (5.0 mgs.)	Li	11.4	290	200
Th (5.0 mgs.)	Na	19.5	280	135
Th (5.0 mgs.)	Na	6.5	270	140
Th (5.0 mgs.)	Na	3.3	270	210
Th (5.0 mgs.)	Cs	11.4	240	20
Th (5.0 mgs.)	Cs	5.7	230	20
Th (5.0 mgs.)	Cs	2.3	230	20

Thus, from the foregoing table, it is apparent that cesium iodide materially reduces the reignition voltages and within the alkali metal series of potassium, lithium and sodium, only cesium uniformly produces such reductions.

The arc tube **12** is provided with a filling of atoms of mercury, halogen, LEM and cesium. Generally mercury atoms are present in quantities between about 1.9×10^{-4} to 1.5×10^{-7} grams atoms per centimeter of arc tube length. The quantity of mercury which is added, either as the element or as the corresponding halide is that which will be completely vaporized at normal operating temperatures of the arc tube and will permit the formation of a restricted arc between the electrodes. The halogen added either as the element or as a compound of mercury, light emitting metal or cesium, is contained within the arc tube in a ratio between about 0.002 to 0.85 atom per atom of mercury. The cesium as the iodide is added in quantities of 8.5×10^{-8} to 3×10^{-7} gram atoms per cm. of arc length and within such ranges, the reduction of the reignition voltage described herein will be attained.

The quantity of cesium iodide which is added is sufficient to reduce the reignition voltage, but insufficient to cool the arc temperature to a point where the emission lines of the light emitting metal are substantially weakened in the lamp's spectrum. The light emitting metal can be those conventionally used in high pressure electric discharge devices containing fills of mercury and halogen such as, for example, thorium, scandium, vanadium, yttrium, praseodymium, gadolinium, terbium, dysprosium, erbium, thallium, indium, gallium, bismuth, cadmium and/or sodium. These metals can be included in quantities between about 1.2×10^{-7} to 1.2×10^{-5} gm. atoms per centimeter of arc length.

It is apparent that modifications and changes can be made within the spirit and scope of the present invention, but it is our intention only to be limited by the scope of the appended claims.

As our invention, we claim:

1. A high pressure electric discharge lamp comprising an arc tube having sealed ends and electrodes disposed therein; said arc tube containing a fill of atoms of mercury, halogen, light emitting metal together with cesium iodide, said cesium iodide being present in quantities of 8.5×10^{-8} to 3×10^{-7} moles/cm. arc length to reduce the reignition voltage, but insufficient to cool the arc temperature to a point where the emission lines of the light emitting metal are substantially weakened in the lamp spectrum.

2. The lamp according to claim **1** wherein there are 0.002 to 0.85 atom of halogen per atom of mercury and the mercury content is that which will be completely vaporized at normal operating temperatures of the arc tube and will permit the formation of a restricted arc between the electrodes.

3. The lamp according to claim **1** wherein the light emitting metal is a member selected from the group consisting of thorium, scandium, vanadium, yttrium, praseo-

dymium, gadolinium, terbium, dysprosium, erbium, thallium, indium, gallium, bismuth, cadmium and/or sodium.

4. The lamp according to claim **1** wherein the light emitting metal is between about 1.2×10^{-7} to 1.2×10^{-5} gm. atoms/cm. of arc length.

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