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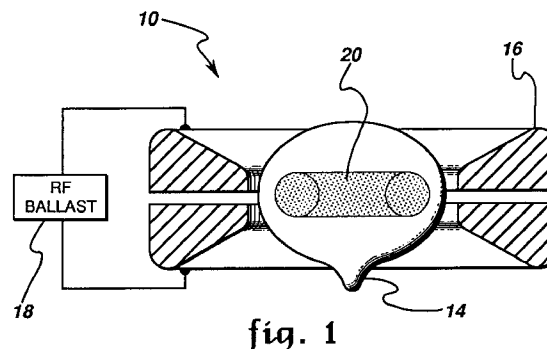
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Use of silver to control iodine level in electrodeless high intensity discharge lamps.

Silver is added to the fill of an electrodeless high intensity metal halide discharge lamp, which includes at least one metal iodide as a fill ingredient, for controlling the iodine vapor level therein. In operation, silver reacts with free iodine, forming silver iodide (AgI), which has a relatively high boiling point and a relatively low vapor pressure. The iodine level is thus controlled below an arc instability threshold to promote and maintain arc stability. In addition, silver does not attack the quartz arc tube wall because silica (SiO₂) is much more stable than silver oxide (Ag₂O). Moreover, the addition of silver to the arc tube does not accelerate the decomposition of iodides in the fill, such as sodium iodide (NaI), cerium iodide (CeI₃), lanthanum iodide (LaI₃), neodymium iodide (NdI₃), and praseodymium iodide (PrI₃), which would otherwise enhance devitrification and etching of the quartz wall. Lamp performance and life are thus substantially improved using silver as an iodine getter.



Field of the Invention

The present invention relates generally to high intensity metal halide discharge lamps and, more particularly, to the use of silver in metal halide discharge lamps for controlling the iodine level therein and thereby promoting arc stability and improving lamp performance.

Background of the Invention

In operation of a high intensity metal halide discharge lamp, visible radiation is emitted by the metal portion of the metal halide fill at relatively high pressure upon excitation typically caused by passage of current therethrough. One class of high intensity metal halide lamps comprises electrodeless lamps which generate an arc discharge by establishing a solenoidal electric field in the high-pressure gaseous lamp fill comprising the combination of one or more metal halides and an inert buffer gas. In particular, the lamp fill, or discharge plasma, is excited by radio frequency (RF) current in an excitation coil surrounding an arc tube which contains the fill. The arc tube and excitation coil assembly acts essentially as a transformer which couples RF energy to the plasma. That is, the excitation coil acts as a primary coil, and the plasma functions as a single-turn secondary. RF current in the excitation coil produces a time-varying magnetic field, in turn creating an electric field in the plasma which closes completely upon itself, i.e., a solenoidal electric field. Current flows as a result of this electric field, producing a toroidal arc discharge in the arc tube.

Typical electrodeless metal halide discharge lamps use metal halides for generating white color lamp emission for general lighting applications. Disadvantageously, however, free iodine formation and devitrification of the arc tube wall occur in electrodeless high intensity metal halide discharge lamps after exposure to the plasma arc discharge. The amount of free iodine in the arc tube increases with time. This accumulating iodine, beyond a certain threshold, causes arc instability and eventual arc extinction.

Accordingly, it is desirable to provide an iodine getter for controlling the iodine level in electrodeless high intensity metal halide discharge lamps and thereby promote arc stability. To be practicable, such an iodine getter should extend the useful life of the lamp and hence not enhance devitrification and etching of the arc tube wall.

Summary of the Invention

Silver is added to the fill of an electrodeless high intensity metal halide discharge lamp, which includes at least one metal iodide as a fill ingredient, for controlling the iodine vapor level therein. In operation, sil-

ver reacts with free iodine, forming silver iodide (AgI), which has a relatively high boiling point and a relatively low vapor pressure. The iodine level is thus controlled below an arc instability threshold to promote and maintain arc stability. In addition, silver does not attack the quartz arc tube wall because silica (SiO_2) is much more stable than silver oxide (Ag_2O).

Moreover, the addition of silver to the arc tube does not accelerate the decomposition of iodides in the fill, such as sodium iodide (NaI), cerium iodide (CeI_3), lanthanum iodide (LaI_3) and neodymium iodide (NdI_3), which would otherwise enhance devitrification and etching of the quartz wall. Lamp performance and life are thus substantially improved using silver as an iodine getter.

Brief Description of the Drawings

The features and advantages of the present invention will become apparent from the following detailed description of the invention when read with the accompanying drawings in which:

Figure 1 is a partially schematic and partially cross sectional illustration of a typical electrodeless high intensity metal halide discharge lamp; Figure 2 graphically compares the efficacy of a group A of electrodeless high intensity metal halide discharge lamps using silver as an iodine getter with corresponding control lamps not using the getter;

Figures 3 and 4 graphically compare the iodine absorbance of groups A and B, respectively, of electrodeless high intensity metal halide discharge lamps using silver as an iodine getter with corresponding control lamps not using the getter; Figure 5 graphically compares the color temperature for silver-gettered and control lamps of group A; and

Figure 6 graphically compares color rendition index values for silver-gettered and control lamps of group A.

Detailed Description of the Invention

Figure 1 illustrates a typical electrodeless high intensity metal halide discharge lamp 10. As shown, lamp 10 includes an arc tube 14 formed of a high temperature glass, such as fused silica. By way of example, arc tube 14 is shown as having a substantially ellipsoid shape. However, arc tubes of other shapes may be desirable, depending upon the application. For example, arc tube 14 may be spherical or may have the shape of a short cylinder, or "pillbox", having rounded edges, if desired.

Arc tube 14 contains a metal halide fill, including at least one metal iodide, in which a solenoidal arc discharge is excited during lamp operation. A suitable fill comprises at least one rare earth metal halide (e.g.,

cerium iodide (CeI_3), lanthanum iodide (LaI_3), neodymium iodide (NdI_3), praseodymium iodide (PrI_3) and at least one alkali metal halide (e.g., sodium iodide (NaI), cesium iodide (CsI) and lithium iodide (LiI)). One exemplary fill comprises sodium iodide, cerium iodide and xenon combined in weight proportions to generate visible radiation exhibiting high efficacy and good color rendering capability at white color temperatures. Such a fill is described in commonly assigned U.S. Pat. No. 4,810,938 of P.D. Johnson, J.T. Dakin and J.M. Anderson, issued on Mar. 7, 1989 and incorporated by reference herein. Another exemplary fill comprises a combination of lanthanum iodide, sodium iodide, cerium iodide, and xenon, as described in commonly assigned U.S. Pat. No. 4,972,120 of H.L. Witting, issued Nov. 20, 1990 and incorporated by reference herein.

Electrical power is applied to lamp 10 by an excitation coil 16 disposed about arc tube 14 which is driven by an RF signal via a ballast 18. A suitable excitation coil 16 may comprise, for example, a two-turn coil having a configuration such as that described in commonly assigned U.S. Pat. No. 5,039,903 of G.A. Farrall, issued Aug. 13, 1991 and incorporated by reference herein. Such a coil configuration results in very high efficiency and causes only minimal blockage of light from the lamp. The overall shape of the excitation coil of the Farrall patent is generally that of a surface formed by rotating a bilaterally symmetrical trapezoid about a coil center line situated in the same plane as the trapezoid, but which line does not intersect the trapezoid. However, other suitable coil configurations may be used, such as that described in commonly assigned U.S. Pat. No. 4,812,702 of J.M. Anderson, issued Mar. 14, 1989 and incorporated by reference herein. In particular, the Anderson patent describes a coil having six turns which are arranged to have a substantially V-shaped cross section on each side of a coil center line. Still another suitable excitation coil may be of solenoidal shape, for example.

In operation, RF current in coil 16 results in a time-varying magnetic field which produces within arc tube 14 an electric field that completely closes upon itself. Current flows through the fill within arc tube 14 as a result of this solenoidal electric field, producing a toroidal arc discharge 20 in arc tube 14. The operation of an exemplary electrodeless high intensity discharge lamp is described in Johnson et al. U.S. Pat. No. 4,810,938, cited hereinabove.

In accordance with the present invention, silver is added to the metal iodide fill of an electrodeless high intensity discharge lamp in order to control the level of iodine vapor therein, thereby promoting arc stability. In operation, silver reacts with free iodine that has been released due to metal loss in the arc tube wall, forming silver iodide (AgI).

Under lamp operating conditions, some of the sil-

ver iodide vaporizes and some remains in the liquid phase. The vapor pressure of the silver iodide is determined by its liquid temperature which, in turn, is controlled by the power applied to the system. The iodine that is bound to silver in the liquid phase is not released to the vapor phase because silver iodide has a relatively high boiling point (1506°C) and a relatively low vapor pressure. Hence, the total iodine concentration in the vapor phase is regulated by the liquid temperature only, and an excessive iodine buildup is avoided. Hence, with the iodine vapor pressure controlled below an arc instability threshold, arc stability is promoted and maintained.

The quantity of silver employed as an iodine getter according to the present invention in order to control iodine vapor pressure below an arc instability threshold is dependent upon such factors as type and quantity of fill ingredients, size and shape of the arc tube, excitation power and operating temperature. An exemplary quantity is in the range, for example, from approximately 0.4 to 4 milligrams.

Advantageously, silver does not attack (or reduce) the quartz arc tube wall because silica (SiO_2) is much more stable than silver oxide (Ag_2O).

Moreover, silver is less stable than the iodides of the lamp fill such as, for example, sodium iodide (NaI), cerium iodide (CeI_3), lanthanum iodide (LaI_3), neodymium iodide (NdI_3), and praseodymium iodide (PrI_3), so that the addition of silver to the arc tube does not accelerate the decomposition of the iodides of the fill which would otherwise enhance devitrification and etching of the quartz wall. Lamp performance and life are thus substantially improved using silver as an iodine getter.

Example

The performance of two groups A and B of lamps were compared, each group consisting of lamps which did employ silver as an iodine getter and corresponding control lamps which did not employ an iodine getter. The lamps of groups A and B are ellipsoid with dimensions 19mm x 26mm. Each lamp of group A (and its corresponding control group) contained 8 mg of a fill mixture comprising sodium iodide (NaI) and neodymium iodide (NdI_3) in a 5:1 molar ratio. Each lamp of group B (and its corresponding control group) contained 10 mg of a fill mixture comprising sodium iodide (NaI) and neodymium iodide (NdI_3) in a 7:1 molar ratio. The lamps of group A were dosed with 1 mg of silver, and the lamps of group B were dosed with 0.49 mg of silver. The lamps of group A were operated with excitation coils of 31 mm inner diameter (I.D.), and the lamps of group B were operated with excitation coils of 34 mm I.D., each group being tested at a power level of 300 coil Watts. Each lamp of groups A and B had a quartz outer jacket filled with nitrogen gas surrounding the arc tube, the group A

jackets having an outer diameter (O.D.) of 30 mm and the group B jackets having an O.D. of 33 mm.

Photometric data were taken for the lamps of group A at burn times of 100, 500, 1000 and 2000 hours. The graph of Figure 2 compares the efficacy of the lamps of group A using silver as an iodine getter and the corresponding control lamps. Lamp efficacy was higher for the lamps of group A using silver as an iodine getter than for the control lamps. In addition, the lumen loss over the first 2000 hours of operation was much lower for the lamps of group A (2.5%) than for the control lamps (15%).

Free iodine formed in the arc tubes was measured by absorption spectroscopy at a wavelength of 515 nm. The results for group A and B and their corresponding control groups are illustrated graphically in Figures 3 and 4, respectively. Iodine accumulated rapidly in the ungettered control lamps. Advantageously, however, the level of free iodine in the lamps using silver as an iodine getter was very low. As illustrated in Figure 3, arc instability was observed in a lamp of control group B at 2642 hours at an iodine absorbance of 0.36, equivalent to 0.56 mg of I_2 formed in the lamp. At the same burn time, the arc was stable and the iodine absorbance was near zero in a corresponding silver-gettered lamp.

Advantageously, the addition of silver as a fill ingredient also improved the color temperature and color consistency of the lamps of groups A and B. Figure 5 shows color temperature as a function of lamp operating time for group A silver-gettered lamps and group A control lamps. The color temperature increased by 400°C in the control lamps at 2000 hours, while a constant color temperature was observed in the silver-gettered lamps.

Figure 6 compares the color rendition index (CRI) values measured for the silver-gettered and control lamps of group A. The CRI values measured at 100 hours were very similar in both the silver-gettered and control lamps. As lamp operation time increased, the CRI value of the control lamps increased, while the CRI of the silver-gettered lamps remained almost constant. Hence, color consistency is improved with the addition of silver to the fill.

For the lamps of groups A and B, it was also observed that the additions of silver to the lamps did not enhance deterioration of the arc tube walls.

While the preferred embodiments of the present invention have been shown and described herein, it will be obvious that such embodiments are provided by way of example only. Numerous variations, changes and substitutions will occur to those of skill in the art without departing from the invention herein. Accordingly, it is intended that the invention be limited only by the spirit and scope of the appended claims.

Claims

1. An electrodeless high intensity discharge lamp, comprising:
 - a light-transmissive arc tube for containing a plasma arc discharge;
 - a fill disposed in said arc tube, said fill including at least one metal iodide;
 - an excitation coil situated about said arc tube for exciting said arc discharge in said fill; and
 - an iodine getter comprising silver added to said fill in a predetermined quantity for controlling the iodine vapor level during lamp operation to promote arc stability.
2. The electrodeless high intensity discharge lamp of claim 1 wherein said at least one metal iodide is selected from a group of rare earth metal iodides consisting of: cerium iodide (CeI_3), lanthanum iodide (LaI_3), neodymium iodide (NdI_3), praseodymium iodide (PrI_3), and any combination thereof.
3. The electrodeless high intensity discharge lamp of claim 1 wherein said at least one metal iodide is selected from a group of alkali metal iodides consisting of: sodium iodide (NaI), cesium iodide (CsI) and lithium iodide (LiI), and any combination thereof.
4. The electrodeless high intensity discharge lamp of claim 1 wherein said fill comprises at least one rare earth metal halide and at least one alkali metal halide.
5. The electrodeless high intensity discharge lamp of claim 4 wherein said at least one rare earth metal halide comprises neodymium iodide (NdI_3) and said at least one alkali metal iodide comprises sodium iodide (NaI).
6. The electrodeless high intensity discharge lamp of claim 1 wherein said predetermined quantity is in a range from approximately 0.4 to 4 milligrams.

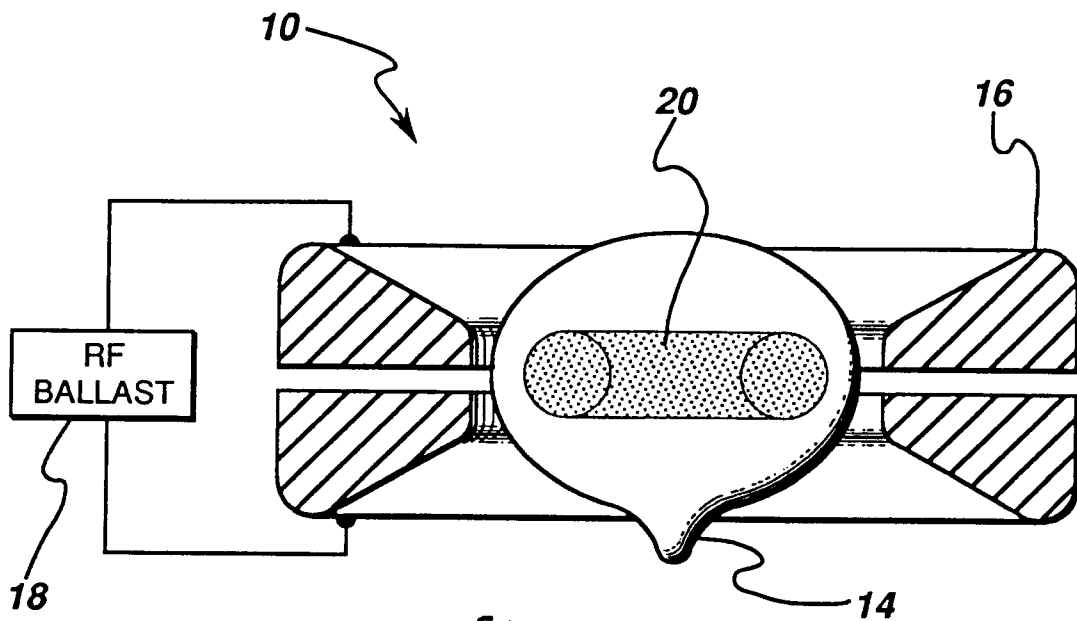


fig. 1

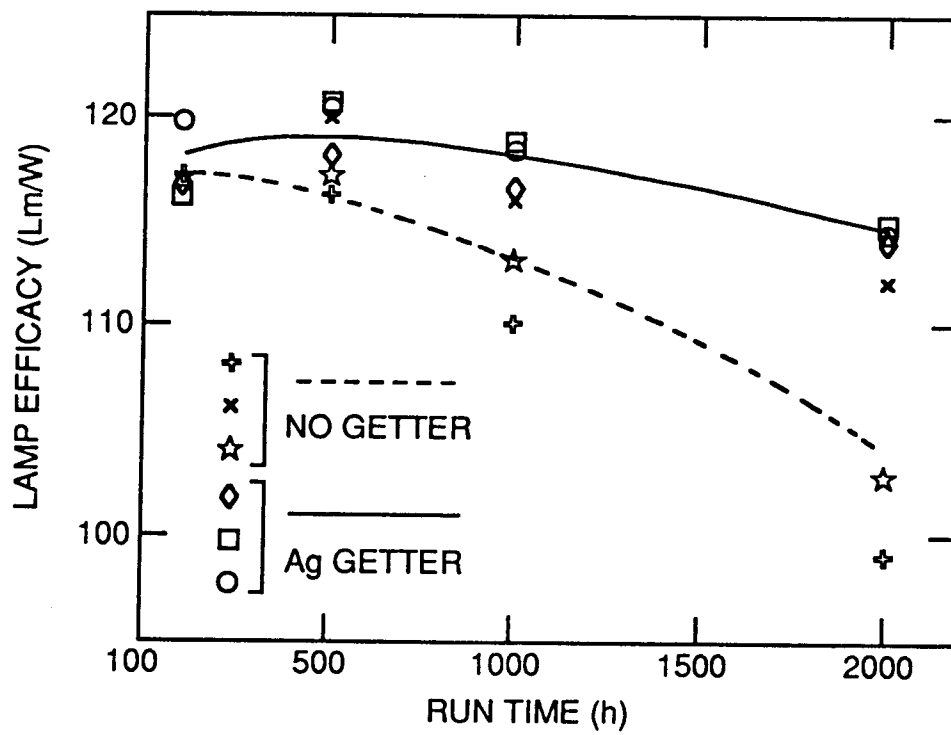


fig. 2

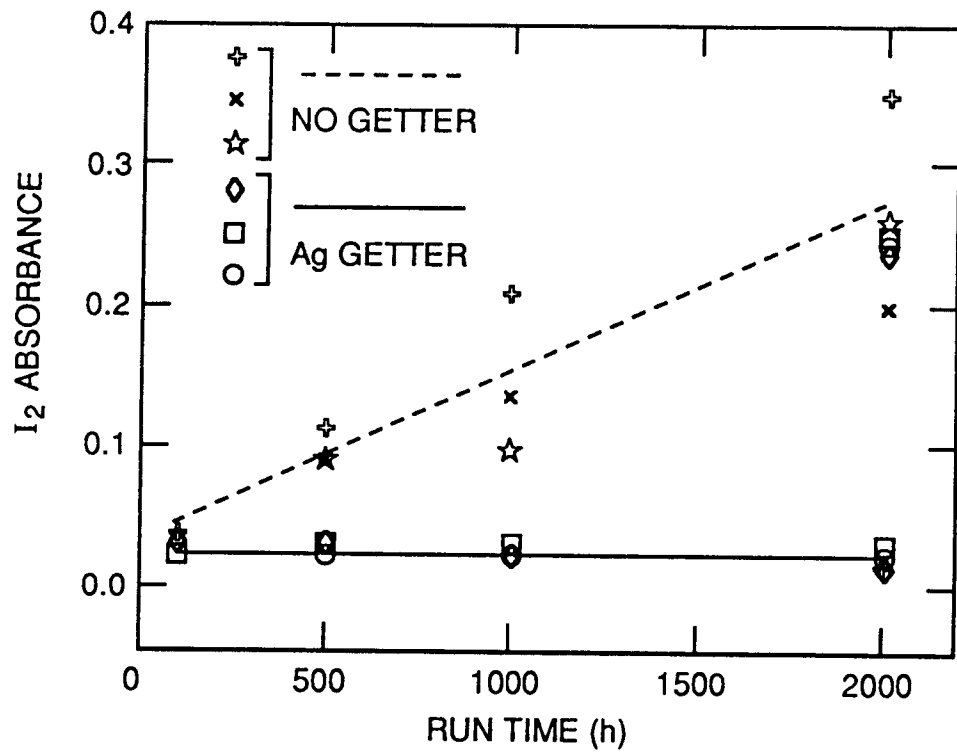


fig. 3

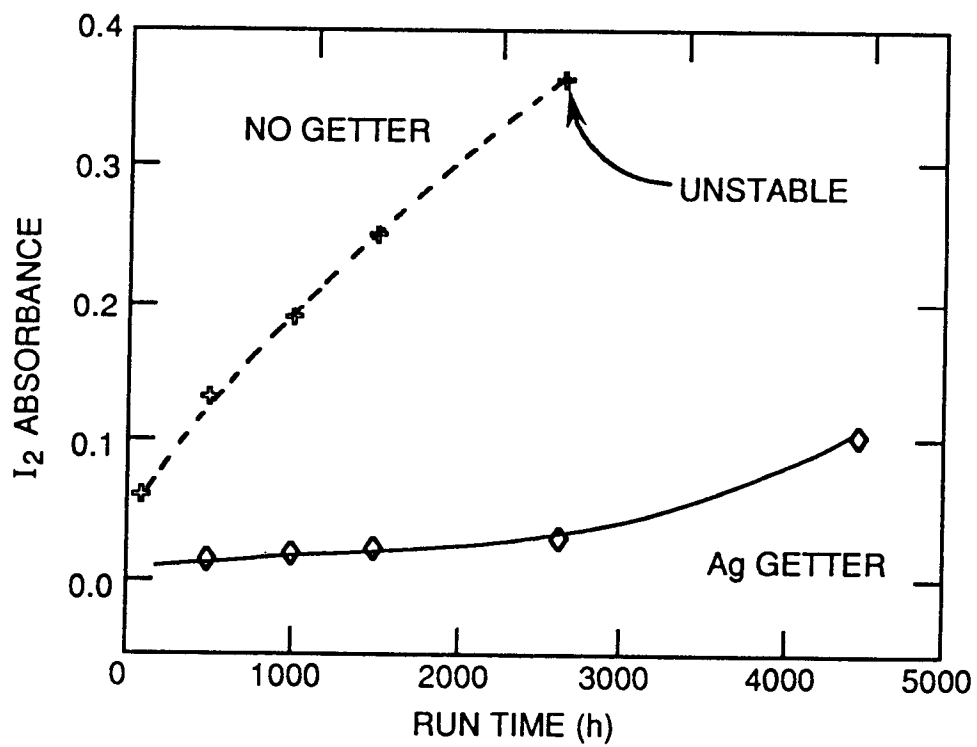


fig. 4

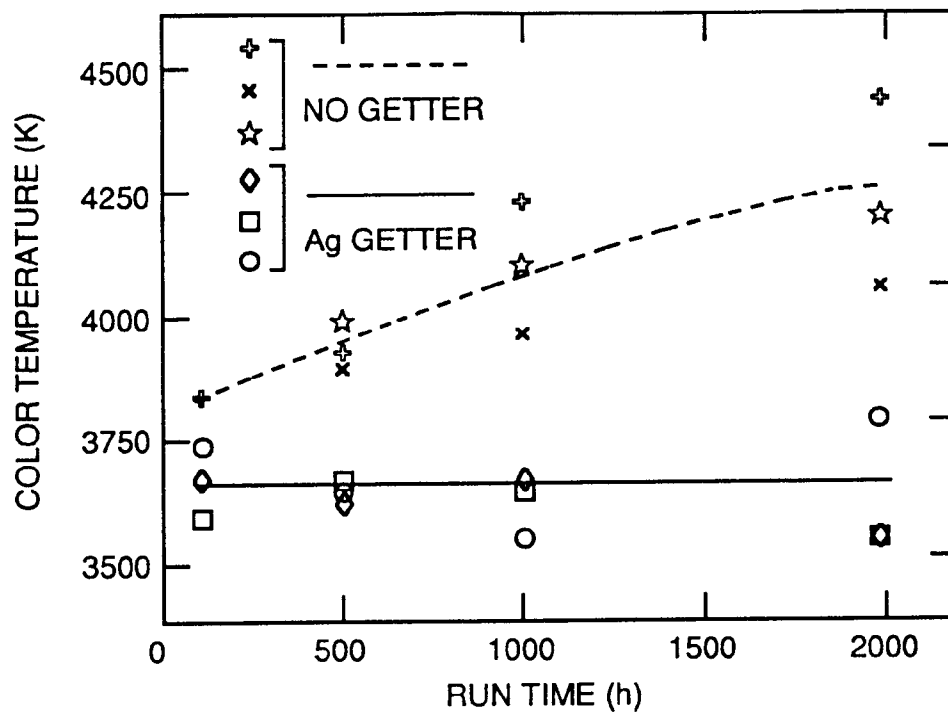


fig. 5

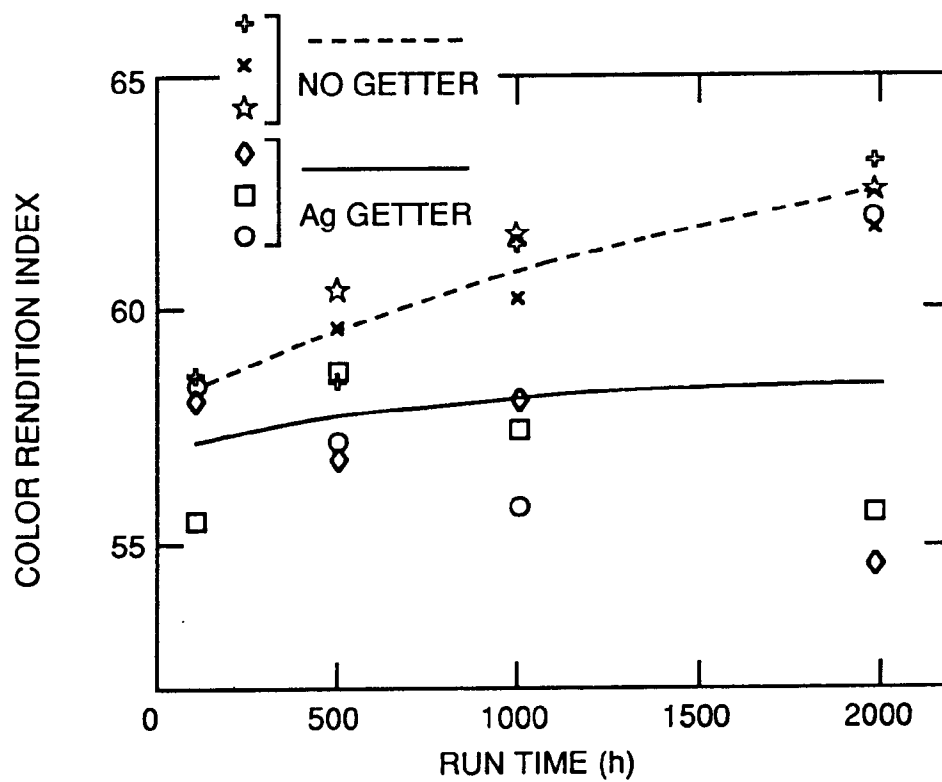


fig. 6



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 94 30 6479

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
D,Y	EP-A-0 397 421 (GENERAL ELECTRIC COMPANY) * abstract * * column 3, line 45 - line 46 * ---	1-6	H01J61/26 H01J61/82 H01J65/04
D,Y	US-A-4 810 938 (JOHNSON ET AL.) * abstract * * column 2, line 66 - line 68 * ---	1-6	
Y	GB-A-2 062 956 (GENERAL ELECTRIC COMPANY) * abstract * * paragraph 1 * * page 1, line 64 - page 2, line 7 * * page 4, line 10 - line 11 * ---	1-6	
Y	PATENT ABSTRACTS OF JAPAN vol. 8, no. 95 (E-242) (1532) 2 May 1984 & JP-A-59 014 246 (TOKYO SHIBAURA DENKI K.K.) 25 January 1984 * abstract * ---	1-6	
Y	DE-A-38 38 322 (KABUSHIKI KAISHA TOSHIBA) * abstract; figure 2 * * page 3, line 24 - line 26 * * page 3, line 36 - line 38 * * page 3, line 45 * ---	1,6	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H01J
Y	EP-A-0 453 893 (PATENT-TREUHAND-GESELLSCHAFT FUR ELEKTRISCHE GLUHLAMPEN MBH) * abstract * -----	1,4,5	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 2 December 1994	Examiner Martín Vicente, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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