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(54) **Metal halide lamp**

Metallhalogenidlampe

Lampe à halogénures métalliques

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(56) References cited:

EP-A- 0 359 200	EP-A- 0 382 516
FR-A- 2 309 974	GB-A- 2 000 637
US-A- 3 654 506	US-A- 4 968 916

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Description**TECHNICAL FIELD**

5 [0001] This invention relates to high intensity discharge (HID) lamps and more particularly to such lamps having increased efficacy.

BACKGROUND ART

10 [0002] HID lamps are among the most efficient light sources currently available. When first introduced in 1934 as mercury lamps, such lamps had an arc length of 158 mm, a bore diameter of 33 mm and a power input of 400 W, resulting in a power loading of 2 W/cm². Efficacy was about 40 lumens per watt (LPW) and the color rendering index (CRI) was less than 20.

15 [0003] With the introduction in 1939 of the quartz arc tube, bore diameter was reduced to 22 mm and the arc length to 70 mm. For a 400 W input the power loading reached 6 W/cm². An efficacy of 50 LPW was achieved and the life was increased to 6000 hours.

[0004] By the early 1960's improved quartz manufacturing techniques made possible the introduction of metal halides to augment the sparse mercury spectrum. This resulted in lamps with additives of scandium and sodium which provided for LPW of 80 and CRI of 65 for a 400 W power input. These lamps had a bore diameter of 20 mm and an arc length of 45 mm to satisfy the vaporization requirements of the metal halide additives. Power loading increased to 12 W/cm² for the 400 W input power.

[0005] GB-A 2 000 637 discloses a metal halide lamp containing a fill of mercury and argon and comprising sodium and scandium halides. The wall loading is from 10 to 35 W/cm².

25 [0006] Still more recent activity in this area has included the development of lithium iodide enhancements to the scandium-sodium chemistry (see, for example, EP-A-0 359 200). These lamps further improved the CRI to 75 at a correlated color temperature (CCT) of 3200°K with LPW of 85 and average wall loadings of 15.5 W/cm² in low wattage lamps.

30 [0007] These lamps are noted for their long life and good color rendering properties. These lamps comprise arc discharge envelopes of quartz having complex fills of metal halides, mercury and an inert gas. The arc discharge chamber is usually enclosed within an outer envelope of a hard glass such as an aluminosilicate having good UV absorbing properties. However, in an era of high energy costs, it would be advantageous to provide a metal halide HID lamp having even better and more efficient luminating qualities.

DISCLOSURE OF INVENTION

35 [0008] It is, therefore, an object of the present invention to obviate the disadvantages of the prior art.

[0009] It is another object of the invention to provide a metal halide HID lamp having a color rendering index greater than 75; an efficacy greater than 90 LPW and a CCT of between 3500 and 4040°K.

40 [0010] These objects are accomplished, in one aspect of the invention, by the provision of a metal halide HID lamp which comprises an outer glass envelope having a pair of electrical conductors extending into the interior thereof. A quartz discharge tube is disposed within the outer envelope and includes a pair of spaced electrodes which are electrically connected to the electrical conductors for creating an electrical discharge during operation of the lamp. The discharge tube has an arc chamber with the configuration of a prolate spheroid having a major cross-sectional diameter and a given arc distance as measured by the linear distance between the interior terminations of the electrodes, the ratio of the major diameter to the arc distance being less than 1 and greater than 0.9. An arc generating and sustaining medium is contained within the arc chamber and includes the halides of sodium, scandium, lithium, thulium and thallium, a fill gas selected from argon and xenon, and a given quantity of mercury to achieve a desired lamp voltage. The lamp is operated with a wall loading greater than 17 W/cm².

45 [0011] Lamps produced as above have fulfilled these design requirements and additionally have shown better lamp-to-lamp uniformity, improved color consistency, long life, reduced near UV emission, elimination of the troublesome end paint, reduced arc mantle color separation and manufacturing cost savings by reducing the amount of chemical fill necessary for the lamp dose.

BRIEF DESCRIPTION OF THE DRAWINGS

55 [0012]

Fig. 1 is a perspective view of a lamp in accordance with an aspect of the invention;

Fig. 2 is a graph of CRI vs. Life of lamps employing the chemistry of the invention and prior art lamps;

Fig. 3 is a graph of CCT vs. Life of lamps employing the chemistry of the invention and prior art lamps;

Fig. 4 is a graph of the lumen maintenance of lamps employing the chemistry of the invention and prior art lamps;

Fig. 5 is a cross-sectional view of an embodiment of an arc tube in accordance with an aspect of the invention; and

Fig. 6 is a graph of core temperatures at peak current for various prior art chemistries and the chemistry of the invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0013] For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims taken in conjunction with the above-described drawings.

[0014] Referring now to the drawings with greater particularity, there is shown in Fig. 1 a metal halide arc discharge lamp 10 including a lamp envelope 12 and an arc tube 14 mounted within the envelope by mounting frame 16. The arc tube may be positioned within a shroud 20 which can also be supported by the mounting frame 16. Electrical energy is coupled to the arc tube 14 through a base 22, a lamp stem 24 and electrical leads 26 and 28. The arc tube contains a chemical fill or dose of materials to provide light when an arc is initiated therein, as will be explained hereinafter. The shroud 20 comprises a cylindrical tube of light transmissive, heat resistant material such as quartz.

[0015] As noted, in this particular instance, the mounting frame 16 supports both the arc tube and the shroud within the lamp envelope 12. The mounting frame 16 includes a metal support rod 30 attached to lamp stem 24 by a strap 31. The support rod engages an inward projection 32 in the upper end of the lamp envelope 12. The support rod 30 in its central portion is parallel to a central axis of the arc tube 14 and shroud 20. The mounting means 16 further includes an upper clip 40 and a lower clip 42 which secure both arc tube 14 and shroud 20 to support rod 30. The clips 40 and 42 are attached to the support rod 30, preferably by welding.

[0016] It has been discovered that when a metal halide chemical composition comprised of the iodides of thulium, scandium, sodium and lithium is incorporated within an arc tube 14, and that arc tube is operated at power loadings heretofore found to be excessive for prior art chemistries, unexpected advantages ensue. For example, it has been found that when such a chemistry, in which the mole fractions of the iodides of Tm, Sc, Na and Li are 0.316, 0.020, 0.474 and 0.190, respectively, is dosed into a low wattage (i.e., 75 W) cylindrical arc tube which is then operated at 100 W, so that the actual wall loading is $100/75 \times 15.5 = 20.67 \text{ W/cm}^2$, the performance is unexpectedly improved while no deleterious effects owing to the elevated loading, which would have been present with prior art chemistries, are found. The CRI performance of such a lamp is shown in Fig. 2 wherein plot A is a lamp in accordance with the aspect of the invention described above, showing an initial value of 87 while maintaining a value of 84 at 10,000 hours. Plots B, C, D and E depict prior art lamps. Similarly, the CCT is remarkably stable, as shown by plot A of Fig. 3, holding the initial value of $4600^\circ\text{K} \pm 100^\circ\text{K}$ over the 10,000 hours. Plots B, C, D and E, again depict prior art lamps. The lumen maintenance, (Fig. 4) likewise, is remarkably constant following an initial drop which is believed to be caused by tungsten evaporation from the electrodes caused by operating the lamps above their rated wattage. Again, in Fig. 4, plot A represents a lamp in accordance with an aspect of the invention and plots B, C, D and E represent prior art lamps. Plots C and D illustrate lamps operated at a conventional average low wattage power loading of 15.5 W/cm^2 , while plot E represents a prior art lamp with a conventional fill operated at 33% over the design power loading. Although this latter lamp has a life of over 10,000 hours, its maintenance is not as good as lamps prepared with the improved chemistry and, thus, it is not a viable alternative absent the improved chemical fill of this invention.

[0017] All of the above to the contrary notwithstanding, it has been discovered that even further performance gains can be made with an optimized chemical dose and by increasing the power loading to even higher levels by departing from the cylindrical shape of the prior art arc tubes and shaping the arc tube to conform more closely with the configuration of the arc discharge. The arc discharge is known to take a more or less ellipsoidal shape and variations of such shapes have been previously proposed for arc tubes. See, for example, U.S. Patent No. 4,020,377, which discusses isothermal arc tubes of elliptical configuration. However, the specific configuration of arc tube 14 shown in Fig. 5 provides a definite advance in the art and is preferred. This shape is a prolate spheroid generated by rotating an ellipse with semi-axes "a" and "b", where $a > b$, about the major axis, "a". If "a" and "b" are internal dimensions, then the internal surface area is given as

$$A = 2\pi \left(b^2 + ab \frac{\text{ARCSIN } e}{e} \right)$$

where

$$e = \frac{(a^2 - b^2)^{1/2}}{a}$$

so that the average power loading is P/A , where P is the input power.

[0018] The arc tube 14 is made from quartz or other suitable translucent, high temperature material and has a cavity 44 with tungsten electrodes 46 sealed therein by means of the usual molybdenum foils 48 in a press seal 50. The arc tube cavity 44 has a major cross-sectional diameter Z and an arc distance Y , as measured by the linear distance between the interior terminations of the electrodes 46, and the ratio Z/Y is less than 1 and greater than 0.9. In a preferred form of the invention, Z equals 0.440 " (1.1176 cm); Y equals 0.472 " (1.1988 cm); and Z/Y equals 0.932. Electrode penetration is 3 mm and the electrode tips are not at the foci of the prolate spheroid arc tube 14. This arc tube has a volume of 1.167 cm³ and an internal surface area of 5.55 cm².

[0019] The permissible average power loading for this shape is higher than for conventional shapes for the prior art sodium-scandium-lithium chemistry, owing to the more uniform heat load upon the conformably tailored shape. Moreover, the permissible wall loading is unexpectedly higher for the thulium-scandium-sodium-lithium-iodides- thallium/mercury chemical dose. For example, while low wattage (i.e., 75 W) conventional cylindrical shapes containing sodium-scandium-lithium iodides are limited to 15.5 W/cm² for long life operation, and ellipsoidal shapes containing this chemistry have been successfully operated at 17.8 W/cm², ellipsoidal shapes containing thulium-scandium-sodium-lithium-iodides with thallium/mercury have shown good photometric results at wall loadings as high as 26.7 W/cm². This result occurs because of the lowering of core temperature for the latter chemistry, as shown in Fig.6. Therein, it will be seen that the core temperature for the chemistry including thallium/thulium is some 850°K cooler than that with thulium alone, and some 900°K cooler than the previous standard without either the thallium or thulium.

[0020] In Table I, lamps designated K and L represent prior art lamps having the designated fills, and M and N represent lamps having the fills of the instant invention. From the table, it will be apparent that merely increasing the wall loading of the prior art lamps will not achieve the benefits of the instant invention. Additional increases in LPW were shown between lamp M and lamp N when the fill gas of 100 Torr argon was replaced with 100 Torr xenon. The preferred mercury dose is that quantity which provides the desired lamp voltage. For example, to achieve a lamp voltage of 95 volts in the arc tube described above, a mercury dose of 15 mg is required with 0.3 mg of thallium. The preferred method of dosing the thallium is as an amalgam with about 0.5 to 2 wgt. percent of the mercury; however, dosing may also be accomplished as thallium iodide.

[0021] The scandium is preferably added in the form of the iodide and as a 0.13 mg metallic chip to getter residual oxygen impurities and scavenge any excess iodine released by the metal iodide salts.

TABLE I

Wall Loading - 17.8 W/cm² Wall Loading - 26.7 W/cm² $T_h \cong 925^\circ\text{C}$ $T_c \cong 790^\circ\text{C}$ $T_h \cong 990^\circ\text{C}$ $T_c \cong 880^\circ\text{C}$

	Chemistry	LPW	CRI	CCT	LPW	CRI	CCT
	Na/Sc/Li/Tm (no paint)						
K	24:1:10:16 MR Hg & 100 Torr Ar	83	83	4350	79	92	3800
L	24:1:10:16 MR 2% Tl/Hg & 100 Torr Ar	91	81	4210	88	91	3610
M	48:1:10:16 MR 2% Tl/Hg & 100 Torr Ar	92	78	3900	94	88	3560
N	48:1:10:16 MR 2% Tl/Hg & 100 Torr Xe	98	75	4040	102	85	3670

[0022] The chemical dose described herein is more tolerant of elevated power loadings heretofore found to be detrimental to long lamp life and provides for good life expectancy, LPW greater than 90; and a CCT of between 3500 and 4040 °K.

[0023] While there have been shown and described what are at present considered the preferred embodiments of the invention, it will be apparent to those skilled in the art that various changes and modifications can be made herein without departing from the scope of the invention as defined by the appended claims.

Claims

1. A metal halide discharge lamp comprising an outer glass envelope (12) and a pair of electrical conductors (26,28) extending into the interior of the glass envelope (12), and a quartz discharge tube (14) disposed within the outer envelope (12) and including a pair of spaced electrodes (46) which are electrically connected to the electrical conductors for creating an electrical discharge during operation of the lamp, and an arc generating and sustaining medium within the arc chamber (14) comprising the halides of sodium, scandium and lithium, a fill gas selected from inert gas, and a given quantity of mercury to achieve a desired lamp voltage, characterized in that the arc chamber (14) has a configuration of a prolate spheroid having a major cross-sectional diameter (Z) and a given arc distance as measured by the linear distance between the interior terminations of the electrodes (46), the ratio of the major diameter to the arc distance being less than 1 and greater than 0,9 and wherein the medium comprises thallium and an halide of thulium and the fill gas is selected from argon and xenon so that the lamp has a color rendering index greater than 75, a lumen per watt rating greater than 90 and a correlated color temperature of between 3500 and 4040 K, and a wall loading greater than 17 W/cm².
2. The lamp of Claim 1 wherein the halides are iodides.
3. The lamp of Claim 2 wherein the sodium, scandium, lithium, thulium are present in the ratio of 48:1:10:16.
4. The lamp of Claim 3 wherein the thallium is dosed as an amalgam.
5. The lamp of claim 4 wherein the arc chamber (14) has a volume of about 1,2 cm³; an arc length of about 1,0 cm; and said fill contains 15 mg of mercury and 0,3 mg of thallium.
6. The lamp of Claim 5 wherein said fill gas is xenon at a cold fill pressure of about 100 Torr.
7. The lamp of Claim 6 wherein said lumens per watt is about 98, said correlated color temperature is about 4040°K,

said color rendering index is about 75, and said wall loading is about 17.8 W/cm².

8. The lamp of Claim 5 wherein said lumens per watt is about 102, said correlated color temperature is about 3670°K, said color rendering index is about 85, and said wall loading is about 26.7 W/cm².

9. The lamp of Claim 5 wherein said fill gas is argon at a cold fill pressure of about 100 Torr.

10. The lamp of Claim 9 wherein said lumens per watt is about 92, said correlated color temperature is about 3900°K, said color rendering index is about 78, and said wall loading is about 17.8 W/cm².

11. The lamp of Claim 9 wherein said lumens per watt is about 94, said correlated color temperature is about 3560°K, said color rendering index is about 88, and said wall loading is about 26.7 W/cm².

Patentansprüche

1. Metallhalogenidentladungslampe, die folgendes umfaßt: einen äußeren Glaskolben (12) und ein Paar sich in das Innere des Glaskolbens (12) erstreckende elektrische Leiter (26, 28) und eine innerhalb des Außenkolbens (12) angeordnete Quarzentladungsröhre (14), die ein Paar beabstandeter Elektroden (46) enthält, die mit den elektrischen Leitern elektrisch verbunden sind, um beim Betrieb der Lampe eine elektrische Entladung zu erzeugen, und ein einen Lichtbogen erzeugendes und aufrechterhaltendes Medium innerhalb der Lichtbogenkammer (14), das die Halogenide von Natrium, Scandium und Lithium, ein aus Inertgas gewähltes Füllgas und eine gegebene Menge an Quecksilber enthält, um eine gewünschte Lampenspannung zu erzielen, dadurch gekennzeichnet, daß die Lichtbogenkammer (14) eine Konfiguration eines gestreckten Sphäroiden mit einem Hauptquerschnittsdurchmesser (Z) und einer gegebenen Lichtbogenentfernung, gemessen durch die lineare Entfernung zwischen den inneren Anschlüssen der Elektroden (46), aufweist, wobei das Verhältnis des Hauptdurchmessers zu der Lichtbogenentfernung unter 1 und über 0,9 ist und wobei das Medium Thallium und ein Halogenid von Thulium umfaßt und das Füllgas aus Argon und Xenon ausgewählt ist, so daß die Lampe einen Farbwiedergabeindex von über 75, eine Nennleistung von über 90 Lumen pro Watt und eine korrelierte Farbtemperatur von zwischen 3500 und 4040 K und eine Wandbelastung von über 17 W/cm² aufweist.

2. Lampe nach Anspruch 1, bei der es sich bei den Halogeniden um Iodide handelt.

3. Lampe nach Anspruch 2, bei der Natrium, Scandium, Lithium, Thulium im Verhältnis von 48:1:10:16 vorliegen.

4. Lampe nach Anspruch 3, bei der das Thallium in Form eines Amalgams dosiert ist.

5. Lampe nach Anspruch 4, bei der die Lichtbogenkammer (14) ein Volumen von etwa 1,2 cm³ und eine Lichtbogenlänge von etwa 1,0 cm aufweist und die Füllung 15 mg Quecksilber und 0,3 mg Thallium enthält.

6. Lampe nach Anspruch 5, bei der das Füllgas Xenon einen Kaltfülldruck von etwa 100 Torr aufweist.

7. Lampe nach Anspruch 6, bei der der Lichtstrom pro Watt etwa 98 beträgt, die korrelierte Farbtemperatur etwa 4040 K beträgt, der Farbwiedergabeindex etwa 75 beträgt und die Wandbelastung etwa 17,8 W/cm² beträgt.

8. Lampe nach Anspruch 5, bei der der Lichtstrom pro Watt etwa 102 beträgt, die korrelierte Farbtemperatur etwa 3670 K beträgt, der Farbwiedergabeindex etwa 85 beträgt und die Wandbelastung etwa 26,7 W/cm² beträgt.

9. Lampe nach Anspruch 5, bei der das Füllgas Argon einen Kaltfülldruck von etwa 100 Torr aufweist.

10. Lampe nach Anspruch 9, bei der der Lichtstrom pro Watt etwa 92 beträgt, die korrelierte Farbtemperatur etwa 3900 K beträgt, der Farbwiedergabeindex etwa 78 beträgt und die Wandbelastung etwa 17,8 W/cm² beträgt.

11. Lampe nach Anspruch 9, bei der der Lichtstrom pro Watt etwa 94 beträgt, die korrelierte Farbtemperatur etwa 3560 K beträgt, der Farbwiedergabeindex etwa 88 beträgt und die Wandbelastung etwa 26,7 W/cm² beträgt.

Revendications

1. Lampe à décharge à halogénures métalliques comprenant une enveloppe (12) extérieure en verre et une paire de conducteurs (26, 28) électriques s'étendant à l'intérieur de l'enveloppe (12) en verre, et un tube (14) de décharge en quartz disposé dans l'enveloppe (12) extérieure et comprenant une paire d'électrodes (46) à distance l'une de l'autre qui sont reliées électriquement aux conducteurs électriques pour créer une décharge électrique pendant le fonctionnement de la lampe et un milieu engendrant un arc et le maintenant dans la chambre (14) à arc électrique qui comprend les halogénures de sodium, de scandium et de lithium, un gaz de remplissage choisi parmi un gaz inerte et une quantité donnée de mercure pour obtenir la tension souhaitée de la lampe, caractérisée en ce que la chambre (14) à arc électrique a la configuration d'un sphéroïde de révolution aplatie ayant un grand diamètre (Z) de section transversale et une distance d'arc donnée telle que mesurée par la distance linéaire entre les extrémités intérieures des électrodes (46), le rapport du grand diamètre à la distance d'arc étant inférieur à 1 et supérieur à 0,9, et le milieu comprend du thallium et un halogénure de thulium et le gaz de remplissage est choisi parmi l'argon et le xénon de sorte que la lampe a un indice de rendu des couleurs supérieur à 75, un rendement en lumen par watt supérieur à 90 et une température corrélée de couleur comprise entre 3500 et 4040 K, et une charge de paroi supérieure à 17 W/cm².
2. Lampe suivant la revendication 1, dans laquelle les halogénures sont des iodures.
3. Lampe suivant la revendication 2, dans laquelle le sodium, le scandium, le lithium et le thulium sont présents dans le rapport de 48:1:10:16.
4. Lampe suivant la revendication 3, dans laquelle le thallium est apporté sous la forme d'un amalgame.
5. Lampe suivant la revendication 4, dans laquelle la chambre (14) à arc électrique a un volume de 1,2 cm³ environ, une longueur d'arc de 1,0 cm environ, et le gaz de remplissage contient 15 mg de mercure et 0,3 mg de thallium.
6. Lampe suivant la revendication 5, dans laquelle le gaz de remplissage est du xénon à une pression de remplissage à froid de 100 Torr environ.
7. Lampe suivant la revendication 6, dans laquelle le flux en lumen par watt est de 98 environ, la température corrélée de couleur est de 4040°K, l'indice de rendu des couleurs est de 75 environ, et la charge de paroi est de 17,8 W/cm² environ.
8. Lampe suivant la revendication 5, dans laquelle le rendement en lumen par watt est de 102 environ, la température corrélée de couleur est de 3670°K environ, l'indice de rendu des couleurs est de 85 environ et la charge de paroi est de 26,7 W/cm² environ.
9. Lampe suivant la revendication 5, dans laquelle le gaz de remplissage est de l'argon sous une pression de remplissage à froid de 100 Torr environ.
10. Lampe suivant la revendication 9, dans laquelle le rendement en lumen par watt est de 92 environ, la température corrélée de couleur est de 3900°K environ, l'indice de rendu des couleurs est de 78 environ et la charge de paroi est de 17,8 W/cm² environ.
11. Lampe suivant la revendication 9, dans laquelle le flux en lumen par watt est de 94 environ, la température corrélée de couleur est de 3560°K environ, l'indice de rendu des couleurs est de 88 environ et la charge de paroi est de 26,7 W/cm² environ.

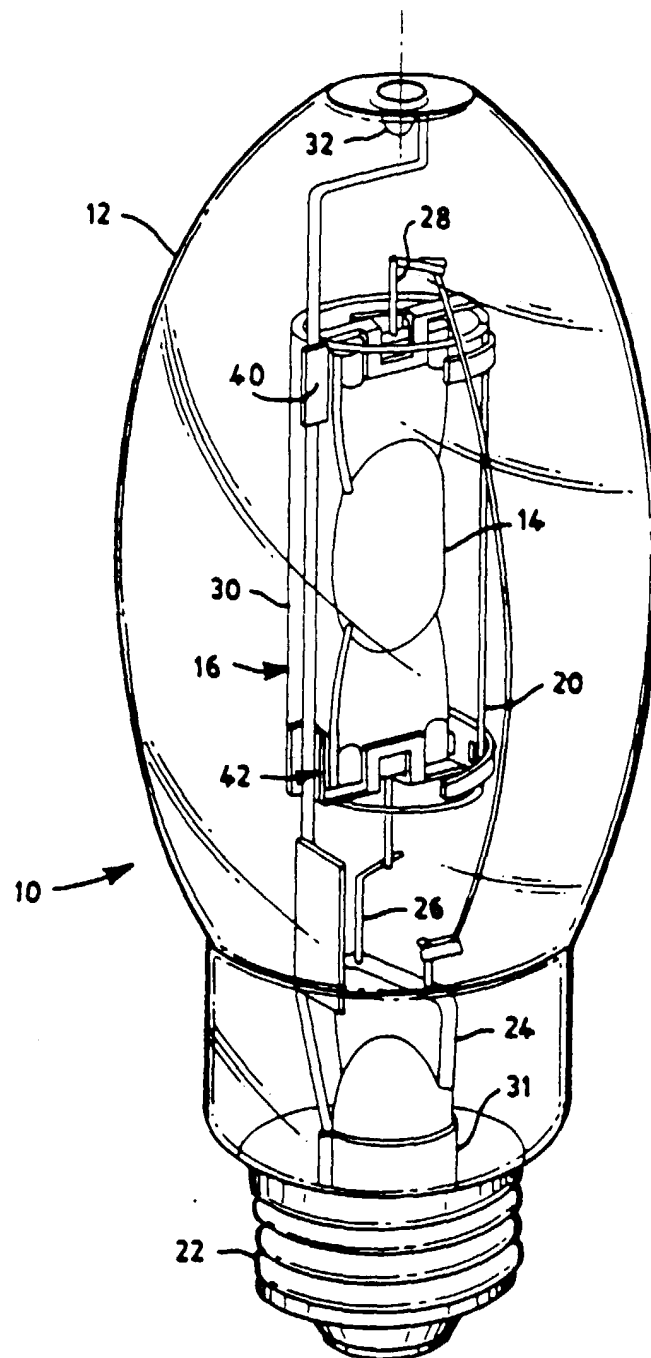


FIG. 1

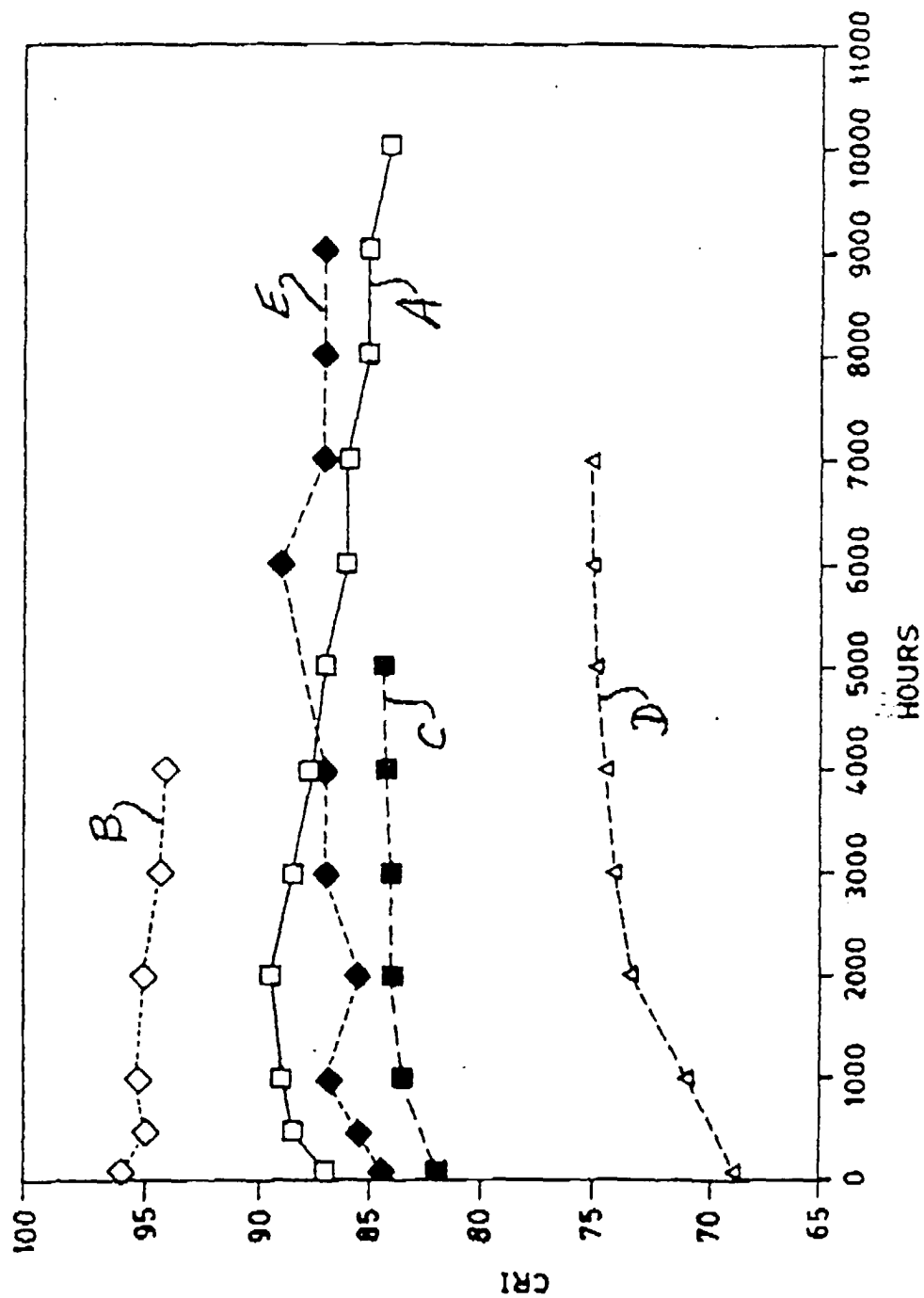


FIG. 2

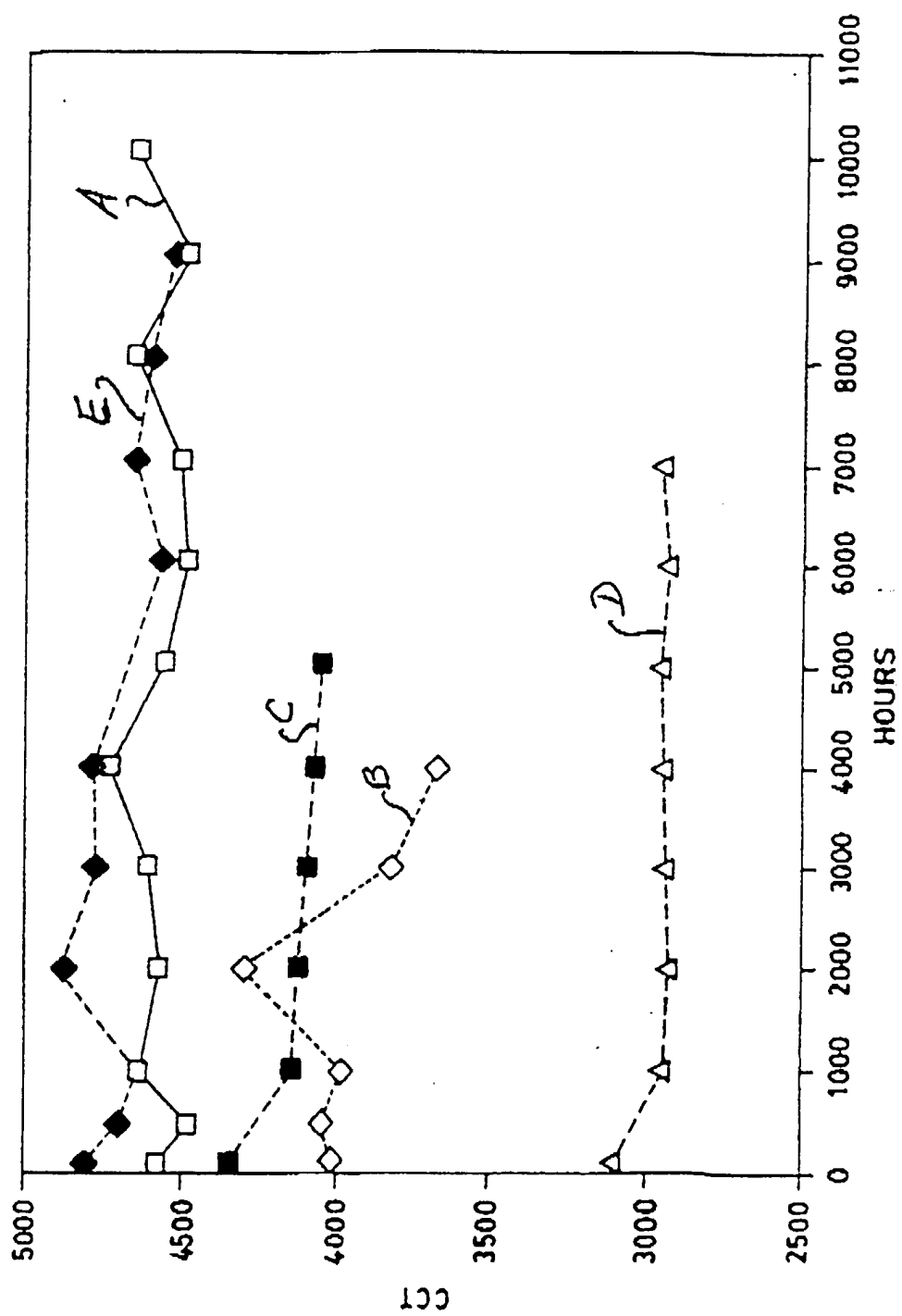


FIG. 3

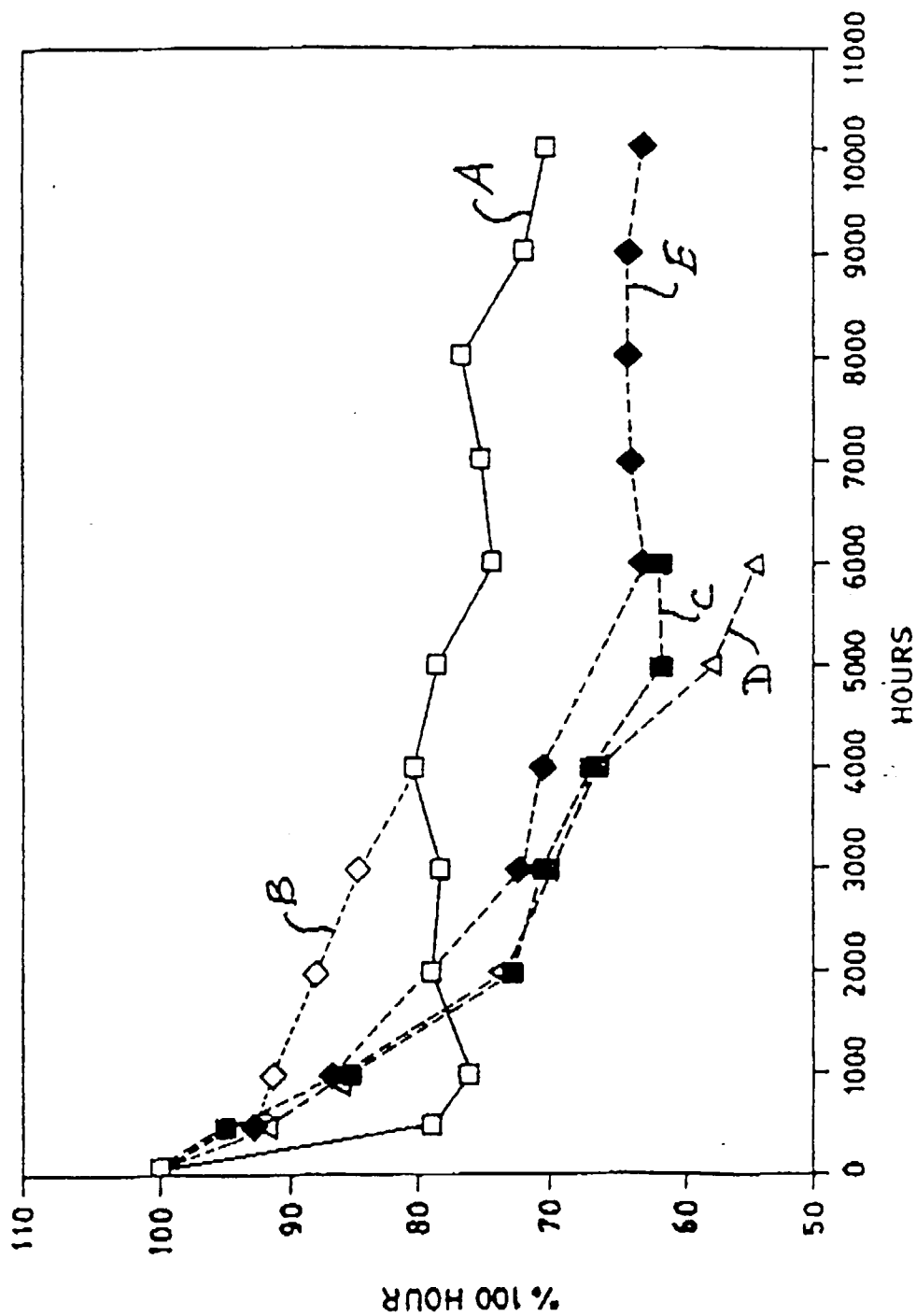


FIG. 4

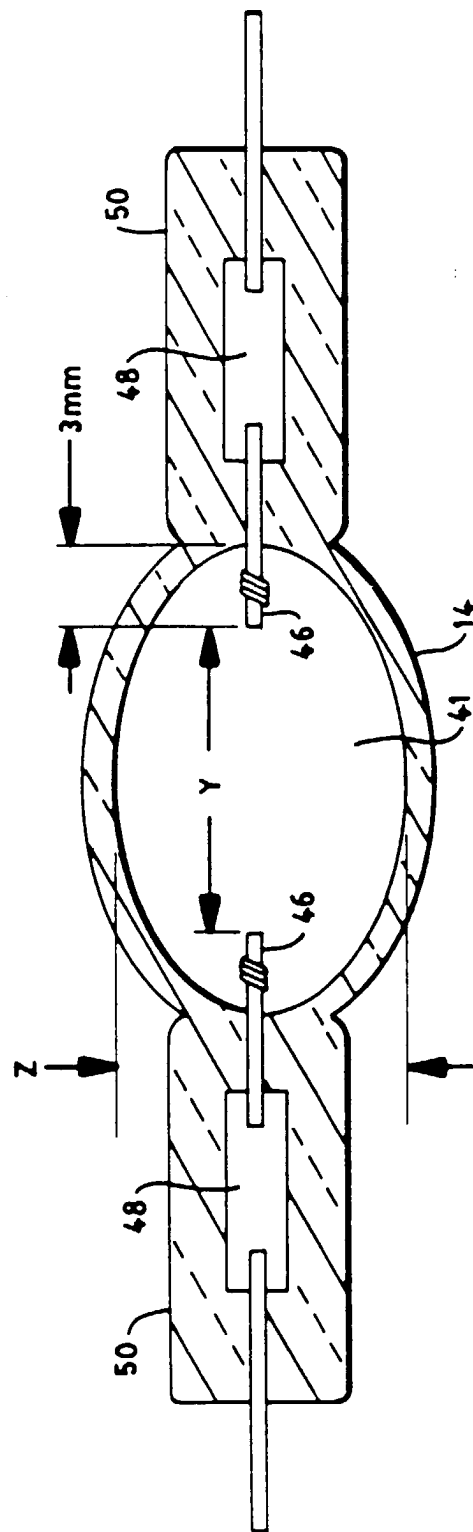


FIG. 5

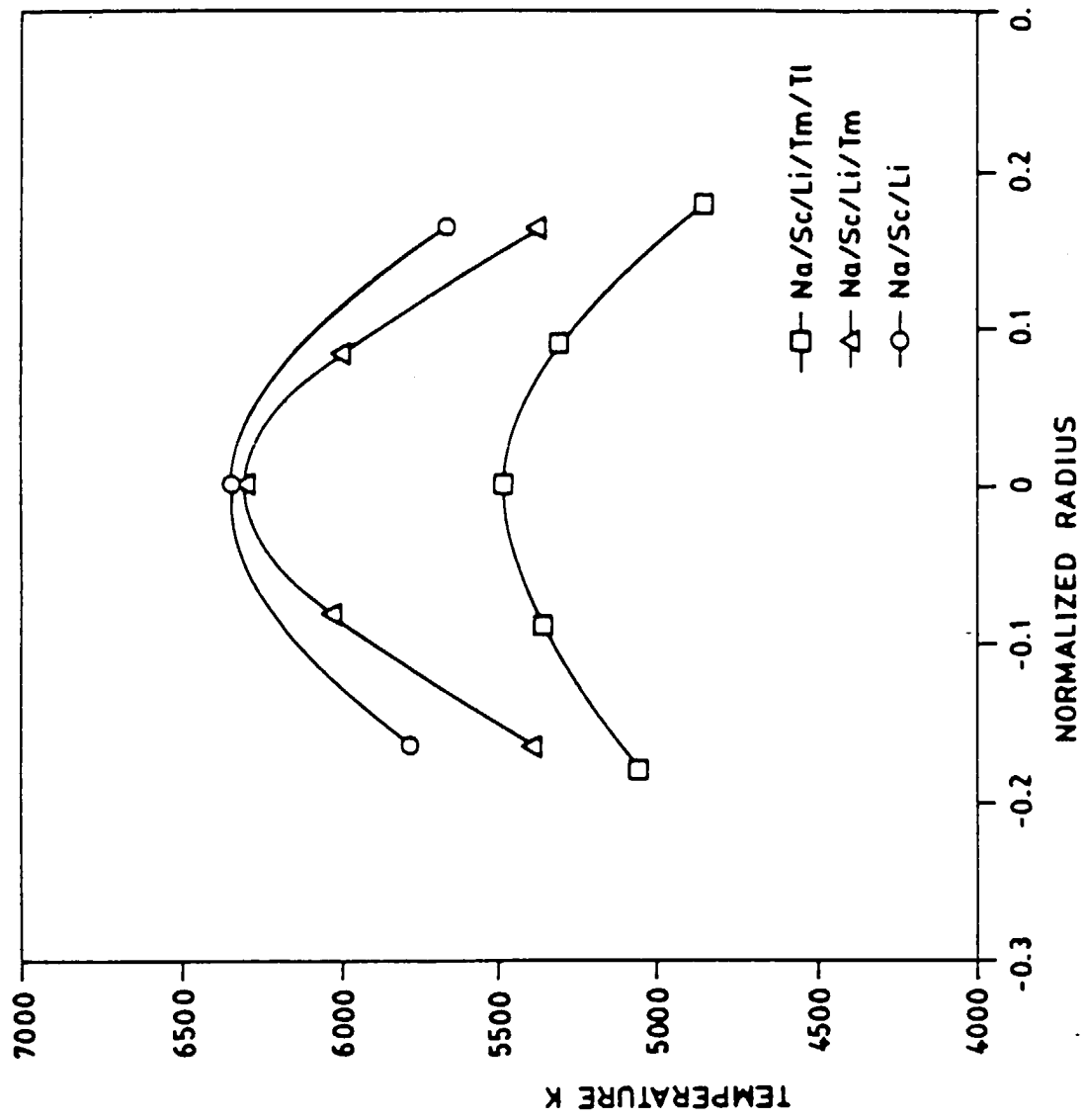


FIG. 6