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(54) High pressure sodium reflector lamp.

(57) A high pressure discharge lamp having a discharge device (10) within a gas filled outer envelope (1, 2). Improved means for controlling heat loss from the discharge device is comprised of a translucent sleeve (25) open at both ends (26) and having an inside diameter selected to be within a sheath around the discharge device in which the velocity of the gas fill from convection currents is reduced, resulting in reduced convective heat loss from the discharge device. The diameter of the sleeve can be selected to minimize heat loss or to obtain the same heat loss as when the discharge device is operated in an evacuated outer envelope.

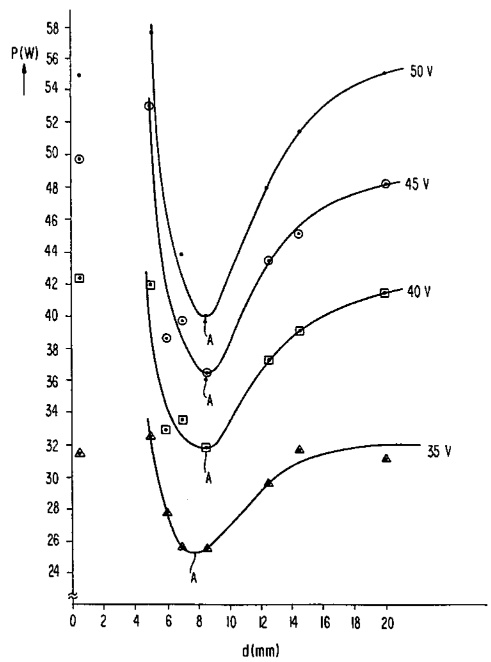

FIG.2

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BACKGROUND OF THE INVENTION

The present invention relates to high pressure discharge lamps having a discharge device within a gas filled outer envelope, and more particularly to lamp structure within the envelope for controlling heat loss from the discharge device.

High pressure sodium discharge lamps are typically comprised of a discharge device, or arc tube, mounted in an evacuated outer envelope. The discharge device generally has a ceramic discharge vessel comprised of alumina or sapphire and has conductive terminals for receiving an operating voltage. The outer envelope is evacuated in order to thermally isolate the discharge device, and to avoid reactions of any gas within the outer envelope with the discharge device. Evacuated outer envelopes of high pressure discharge lamps must be strong and able to withstand severe mechanical impacts without breaking. If the lamp outer envelope were to break, it would implode, scattering glass fragments and creating a safety hazard. It has thus been the practice to manufacture high pressure sodium lamps with evacuated outer envelopes, and to make these envelopes sufficiently strong to avoid breakage.

However, high envelope strength is not feasible in the case of many reflector lamps. Reflector lamp envelopes have a large face that merges with the envelope sidewalls at an edge portion having a small radius of curvature. The atmospheric pressure acting on the evacuated envelope causes high stress concentrations in the edge portion and makes it susceptible to breakage. Moreover, reflector lamps having blown glass envelopes cannot be strengthened by making them substantially thicker. Accordingly, to eliminate the breakage hazard, it has been necessary to introduce a fill gas in blown glass reflector envelopes with an internal pressure of about one atmosphere during lamp operation. With the inner and outer pressures acting on the envelope being approximately equal, no implosion will occur if the envelope breaks and there is less apt to be flying glass fragments.

The introduction of the fill gas into the outer envelope of a high pressure sodium discharge lamp presents the problem of excessive convective cooling from the discharge device. This reduces the efficacy of the discharge lamp. An additional disadvantage with a gas fill is that the cold spot temperature, and thus the lamp voltage, are dependent on the burning position of the lamp. When burned base up, base down, or with the discharge device in a horizontal position, the lamp voltage will be different as well as the color temperature, efficacy, and color rendering, because the convective cooling of the discharge vessel will be different in each case. Yet another disadvantage is that arc tubes designed for operation in an evacuated outer envelope will have significantly different operating characteristics when burned in a gas filled outer envelope. Thus, when designing a gas filled reflector lamp, it has been necessary to alter the power input to the arc tube or to design a completely new arc tube. For example, to compensate for thermal losses through the rare fill gas, it is known to make the arc tube physically smaller than an arc tube for the same wattage used in an evacuated HPS lamp. In U.S. Patent 4,939,408 (Gibson et al), the gas filled reflector lamp described therein has an arc tube length of 41.8 mm and an inside diameter of 4.0 mm as compared to a 48.0 mm length and 4.8 mm inside diameter for a conventional 50 watt HPS arc tube for a vacuum outer. The smaller physical size reduces the area of the discharge device through which heat can transfer to the rare fill gas so that the arc tube operates at the correct temperature even though substantial amounts of thermal energy are transferred through the rare gas. However, the above approach has the disadvantage that an arc tube must be designed and completely tested for each desired wattage arc tube despite the availability of arc tubes for evacuated outer envelopes having known operating characteristics. A different sized discharge device or arc tube also requires the switchover of assembly lines, or new assembly lines, as well increased parts handling, resulting in a more costly lamp.

In high pressure discharge lamps having evacuated outer envelopes, it is known to surround the discharge vessel with a glass sleeve to re-radiate part of the radiation from the arc tube back onto the arc tube to increase its temperature. Such lamps are shown in GB Patent 937,938 and EP Patent 0,290,043. The latter patent discloses that the ratio of the outer radius of the arc tube to the inner radius of the sleeve should be within an optimum range of approximately 0.54 to approximately 0.68 to improve the isothermal operation of a metal-halide arc discharge device.

U.S. Patent 4,281,274 (Bechard et al) shows a metal halide lamp having an arc tube and auxiliary incandescent filaments. A nitrogen fill within the outer envelope prevents oxidation of the filaments. A glass sleeve open at both ends and surrounding the arc tube is positively biased relative to the arc tube to prevent sodium loss from the arc tube by preventing ultraviolet light from striking metal parts within the lamp and by shielding the arc tube from photoelectrons. Bechard also discusses, without explanation, that the glass sleeve reduces the difference in the arc tube operating temperature between a "high" mode of operation and a "low" mode of operation, presumably from radiation reflected back onto the arc tube, as disclosed in G.B. 937,938 and EP 0,290,043, above.

U.S. Patent 4,499,396 (Fohl et al) discloses a metal halide discharge lamp having a gas filled outer envelope which includes a tubular sleeve closed at one end to suppress convection currents around the arc tube. Fohl et al discloses that it is critical for the sleeve to be closed at one end. With a sleeve open at both ends, Fohl teaches that a "chimney effect" occurs in which there is an upward flow of gas inside the sleeve and along the arc tube wall and a downwards flow along the walls of the outer envelope in the region outside the sleeve. This gas flow transports heat from the arc tube to the outer envelope resulting in appreciable convective heat loss. Fohl et al also discloses that in a tube closed at one end, the convection suppressing effect is not as great when the arc tube is operated horizontally. Thus, with such a sleeve, the lamp voltage is also appreciably affected by burning position. A disadvantage of the closed end sleeve required by Fohl et al is the extra glass working step of closing one end of the tubular glass sleeve, which adds to the cost of the lamp. Another disadvantage is that for double-ended arc tubes, a hole must be provided in the closed end to allow one of the arc tube lead-throughs to pass through the closed end.

U.S. Patent 4,961,019 (White et al) discloses a metal halide reflector lamp having a similar sleeve closed at one end and surrounding the discharge vessel.

Accordingly, it is an object of the invention to provide a high pressure discharge lamp having a gas filled outer envelope with improved means for controlling heat loss from the discharge device.

Another object of the invention is to improve the efficacy of a gas-filled high pressure discharge lamp.

Another object of the invention is to provide a high pressure discharge lamp having improved means for minimizing the heat transfer from the discharge device.

Yet another object of the invention is to provide a gas filled high pressure sodium discharge lamp in which the heat transfer from the discharge device and its operating characteristics are substantially equal to the heat transfer and operating characteristics of an comparable discharge device burned in an evacuated substantially identical outer envelope.

Still another object of the invention is to provide a high pressure discharge lamp having a gas filled outer envelope with reduced dependence of the discharge device operating characteristics on lamp burning position.

Yet another object of the invention is to provide an improved HPS reflector lamp.

According to the invention, a high pressure discharge lamp has a discharge device, in which a discharge is maintained during lamp operation, mounted within an outer envelope having a gas fill. The lamp further comprises means for controlling heat loss from the discharge device, comprising a translucent sleeve surrounding said discharge device and having opposing open ends. The sleeve has an inner diameter selected to be within a boundary layer or a sheath surrounding the discharge device in which the velocity of the gas fill from convection is reduced, resulting in reduced heat loss from the discharge device.

The invention is based on the recognition that viscous forces cause a velocity gradient in the gas fill in a boundary layer or sheath which extends from the surface of the discharge device to the free stream velocity of the convection currents. The gradient is such that the gas velocity at the surface of the discharge device is zero, remains small adjacent the discharge device, and increases to the velocity of the convective free stream at a distance from the wall of the discharge device. It was discovered that by placing a sleeve around the discharge device having an inside diameter within this velocity gradient that convective flow between the sleeve and the discharge device, i.e. the "chimney effect", and the convective and total heat loss could be reduced as compared to a gas-filled lamp without a sleeve or with a sleeve located outside of the velocity gradient.

It was further discovered that heat loss was minimized for an optimum sleeve inner diameter spaced from the outer wall of the discharge device. At the minimum, the heat loss from the discharge device was substantially lower than for the same discharge device operated in an evacuated substantially identical outer envelope without a sleeve around the discharge device. Thus, according to another embodiment of the invention, the sleeve inner diameter is selected to be at the optimum sleeve inner diameter to minimize heat loss. In this way, a gas-filled lamp can have a greater efficacy than a conventional discharge lamp with a similar arc tube having an evacuated outer envelope without a sleeve.

Additionally, there were found to be two sleeve inner diameters, larger and smaller than the optimum sleeve inner diameter, at which the lamp voltage and other operating characteristics of the discharge device, or arc tube, were similar to the lamp voltage and operating characteristics of the same arc tube operated in an evacuated substantially identical outer envelope. According to another embodiment of the invention, the sleeve has an inner diameter equal to either of these diameters. This is significant because a discharge device or arc tube designed for operation in an evacuated envelope can then be operated with the same characteristics in a gas filled envelope with a sleeve of either of these two inner diameters. This is a less costly alternative to providing an arc tube of reduced size for minimizing heat transfer.

Thus, through selection of sleeve inner diameters within the velocity gradient of the sheath or boundary layer, the heat transfer from the arc tube can be controlled to be minimized, or to equal the heat transfer of an identical arc tube operated in an evacuated outer envelope.

According to the preferred embodiment of the invention, the lamp is a high pressure sodium discharge reflector lamp having a high pressure sodium ceramic discharge device, or arc tube, within a blown glass reflector envelope.

An embodiment of a lamp according to the invention is hereafter described with reference to a drawing in which:

Figure 1 is a partial vertical section of an HPS reflector lamp with a blown glass envelope according to the invention;

Figure 2 is a graph of lamp power (P) versus sleeve inner diameter (d) for an arc tube operated at various constant voltages.

Figure 3 is a graph showing the difference in lamp power (ΔP) for a constant lamp voltage between an arc tube operated in a gas filled outer envelope without a sleeve and with a sleeve for various sleeve inner diameter (d); and

Figure 4 shows the dependence of lamp voltage (V1a) at constant wattage of 35 W versus sleeve inner diameter (d) for a gas fill of krypton, nitrogen, and argon.

Fig. 1 illustrates a high pressure sodium reflector lamp having a blown glass envelope. The envelope has a transparent or translucent front dome 2 from which light is emitted during lamp operation. A mid-section 1 converges toward a narrow neck 3 which terminates at the base end of the lamp envelope. A lamp base 4 is mounted on the base end of the envelope opposite the front dome 2.

A reflective layer 5 is disposed over at least a portion of the converging mid-section 2 of the lamp envelope. It is illustrated extending up to the edge of the dome 1 of the lamp envelope, and down onto a part of the narrow neck 3. The reflective layer 5 is typically metallic aluminum or silver which is vapor deposited on the inner surface of the envelope or chemically deposited. A high pressure sodium discharge device 10 is mounted axially symmetrically within the envelope and emits light which is incident on the reflective layer 5. The convergence of the envelope mid-section 2 having the reflective layer 5 is effective to reflect light from the light source 10 in a forward direction through the dome end of the envelope 80 as to concentrate the light and give it directivity.

The high pressure sodium discharge device 10, or arc tube, has a translucent cylindrical tubular discharge vessel or body 11 and a pair of terminals, or feed-throughs, 12, 13 each extending from a respective end of the tubular body 11. When a sufficiently high voltage is applied across the terminals 12 and 13, an electrical discharge is established between a pair of spaced internal electrodes (not shown) within the tubular body 11 and intense visible light is emitted.

The discharge device 10 is mounted within the envelope by a frame structure which also comprises conductors for applying an operating voltage to the discharge device. The base end of the envelope is closed by a stem 7 which is terminated at a pinch seal 8. A pair of rigid support conductors 14, 15 emerge from the pinch seal 8 and extend longitudinally of the envelope toward the dome end 1. The shorter conductor 14 has a free end which is connected to the terminal 13 of the discharge device by a U-shaped conductive link 22. Similarly, the free end of the longer conductor 15 is attached to the terminal 12 by the conductive link 21. A conventional getter support 40 is attached to the conductor 15. Each of the support conductors 14, 15 extend into the pinch seal 8 and are connected by respective conductive leads to the lamp base 4, in a conventional manner. Consequently, a voltage applied across the lamp base 4 is developed across the terminals 12, 13 of the high pressure sodium discharge device 10 for energizing it to emit light.

In order to avoid the danger of implosion upon breakage of the outer envelope 1, the outer envelope contains rare gas at a fill pressure of about 600 torr at room temperature. At the lamp operating temperature, the rare gas pressure is approximately one atmosphere (760 torr), in one example 700 torr, so there is no substantial pressure difference across the wall of the lamp envelope. Consequently, if the envelope is broken there will be no substantial pressure difference to accelerate glass fragments and cause flying fragments of the broken envelope. The rare fill gas within the outer envelope thus makes it safe to use thin blown glass outer envelopes, which are readily commercially available, in high pressure sodium reflector lamps.

The use of a rare fill gas in the outer envelope of a high pressure sodium lamp has certain consequences for the lamp's characteristics. These in turn dictate that the lamp incorporate certain structural features.

The rare fill gas contributes to the dissipation of heat developed in the discharge device 10 during lamp operation by causing convection currents which flow upwards along the discharge device 10 and downwards along the wall of the outer envelope. The convection currents are greatest when the lamp is burned in a base up or base down position. HPS discharge devices have minimum operating temperatures. If they do not reach a sufficient temperature during operation, their internal sodium vapor pressure will be too low and the light output will be substantially reduced.

The lamp according to the invention has means for controlling heat loss from the discharge device consisting of a cylindrical translucent vitreous sleeve 25 of quartz glass surrounding and aligned with the discharge device 10 and having open ends 26. The quartz sleeve is laterally positioned by straps 27 circumferentially surrounding the sleeve and welded to the support 15. This sleeve is prevented from sliding within the straps 27 by the conductive links 21 and 22 which butt against the opposite ends 26 of the quartz sleeve.

The invention is based on the recognition that during lamp operation the convection currents cause a velocity gradient in the fill gas around the surface of the discharge device, or arc tube, 10. At the wall 11 of the discharge device, the velocity of the gas is zero. The gas velocity remains small adjacent the wall 11 and increases to the velocity of the convective free steam at a distance from the wall. By selection of sleeve inner diameters to be within this gradient, the heat transfer from the discharge device can be controlled. For a discussion of a boundary layer or sheath around an arc tube, see Campbell, R.J. and Kroontje, W., Evaporation Studies of the Sintered Aluminum Oxide Discharge Tubes Used In High Pressure Sodium (HPS) Lamps; Journal of IES, July 1980 and Elenbaas, W., Light Sources, Philips Technical Library, Crane, Russack & Co., New York, NY (1972).

In order to establish the effectiveness of the quartz glass sleeve 33 at controlling heat transfer from the arc tube, a high pressure sodium reflector lamp was used in which open-ended quartz sleeves of various inner diameters could be supported surrounding and aligned with the arc tube. The lamp had a saturated high pressure sodium discharge device, or arc tube, of the 50 watt size having a length of 37 mm, an inside diameter of 2.5 mm, and an outside diameter of 4.5 mm. The outer envelope was sealable and for each sleeve had a nitrogen fill with a cold fill pressure of about 600 torr and a pressure during lamp operation of about 700 torr. The lamps had sleeves of quartz glass having a length of 40 mm with an inside diameter of 5, 6, 7, 8.5, 12.5, 14.5 and 20 mm, and wall thickness of 1 mm. The discharge device was operated at the constant voltages of 35, 40, 45, and 50 volts. Constant voltage operation corresponds to constant temperature of the arc tube for saturated HPS lamps. Thus, the arc tube had the highest temperature when operated at 50 volts.

Figure 2 shows that the power consumed by the arc tube was at a minimum with optimum sleeve inner diameters of between about 8 and 8.5 mm. Since the lamp volts and therefore the lamp temperature are constant for each curve, the minimum for each curve (denoted "A" in Figure 2) indicates that the least amount of heat was transferred from the arc tube. Figure 2 further shows that the optimum diameter for minimum heat transfer was substantially independent of arc tube temperature (voltage), with only a slight shift towards larger diameters for higher temperature (voltage) operation.

The increased heat loss for sleeve inner diameters smaller than the optimum diameter (between 5 and 8.5 mm) is believed to be based on the following. At the optimum inner diameter the gas between the arc tube and the sleeve is believed to be substantially stagnant. Convection occurs substantially only on the outside of the sleeve and heat transfer from the arc tube to the sleeve is predominately by conduction and radiation. The gas between the sleeve and the arc tube insulates the arc tube from the convective cooling of the outside surface of the sleeve. At the optimum sleeve inner diameter this insulative effect and the radiation reflected back to the arc tube from the sleeve results in minimized heat transfer. As the sleeve inner diameter is reduced, the thickness of the stagnant insulative gas layer is reduced, resulting in higher temperatures of the quartz sleeve and increased heat loss from the sleeve by convection over the outside surface of the sleeve. The arc tube heat loss from conduction to the sleeve and convective cooling from the sleeve increases faster than the heat gain caused by the increased radiation reflected to the arc tube as the sleeve diameter gets smaller. As the inner diameter of the sleeve approaches the outer diameter of the arc tube, the temperature of the sleeve increases and the arc tube-sleeve is cooled by convection as if the arc tube had an outside diameter equal to the sleeve.

For sleeve inner diameters larger than the optimum diameter, it is believed that convection between the arc tube and sleeve increases. The increased convective cooling and decreased radiation reflected back to the arc tube results in increased heat transfer from the arc tube.

The provision of the quartz sleeve with the optimum inner diameter yielded greater lamp efficacy than the same arc tube operated in a vacuum envelope without a quartz sleeve. In Figure 3, point B denotes a lamp having the same arc tube and gas filled outer envelope as the lamp of Figure 1 but without a quartz sleeve. Figure 3 shows that at constant temperature (voltage) operation, a lamp having a sleeve with the optimum inner diameter surrounding the arc tube (Point "E") consumed thirteen less watts to operate at the same temperature and voltage as compared to the gas filled lamp of Point B without a quartz sleeve. Figure

3 also shows that the arc tube with the optimum quartz sleeve of about 8.5 mm inner diameter consumed S less watts than the same arc tube in a evacuated identical outer envelope without a quartz sleeve. (Point "C")

It was also discovered that there existed two sleeve inner diameters at which the heat transfer could be controlled to be equal to the heat transfer of the same arc tube operated in a substantially identical evacuated envelope. As shown in Figure 3, with a quartz sleeve having an inner diameter of about 6.4 mm (Point "F") or about 11.2 (Point "G") mm the arc tube would have the same lamp wattage and voltage as if operated in an evacuated identical envelope. (Line "D") The diameters denoted by points "F" and "G" correspond to a ratio d/D of 0.7 and 0.4 where d is the outside diameter of the arc tube and D is the inner diameter of the sleeve. For sleeve diameters between these points the heat transfer from the arc tube is less than for an evacuated outer envelope without a sleeve (Point "C"). Thus, for ratios d/D between about 0.4 and 0.7 improved efficiency over an evacuated outer envelope are obtained.

Thus, a discharge device operated in a gas filled outer envelope can have similar operating characteristics as when operated in an evacuated outer envelope, or it can be operated more efficiently.

Figure 4 shows the dependence of the gas fill on the heat transfer for various sleeve inner diameters for the 50 watt size arc tube burned at a constant power input. The points indicated with "X" are measured without sleeve. For a krypton fill, the arc tube achieved the highest temperature, indicating the least heat transfer from the arc tube. Heat transfer for argon krypton fill with up to 50 % nitrogen provides a practicable lamp from a heat transfer and arcing standpoint.

An additional advantage of the double open-ended sleeve according to the invention is the reduced dependence of the consumed lamp power at constant voltage on burning position. Table II shows the change in lamp current and power for a 50 watt arc tube burned on a 35W HPS ballast with a 120V primary for the positions base up, base down, and horizontal. This table compares lamps without a sleeve to those with an 8.5mm quartz sleeve (the optimum inner diameter) for a 100% krypton gas fill in the outer envelope with a cold fill pressure of 600 torr.

TABLE II

	No Sleeve			Sleeve		
	Volts	Watts	Amps	Volts	Watts	Amps
Base Up	45.1	38.19	1.036	45.03	33.78	0.916
Horizontal	44.9	39.90	1.091	44.96	33.69	0.920
Base Down	45.0	41.27	1.133	45.15	34.70	0.948

With no quartz sleeve, there was an increase of 8.06% in Watts consumed between the base up and base down positions. This increase was significantly reduced to 2.72% for the sleeve at the optimum inner diameter.

While these have been shown what are presently considered to be the preferred embodiments of the invention, it will be apparent to those of ordinary skill in the art that various changes and modifications can be made without departing from the scope of the invention as defined by the appended claims.

Claims

1. In a high pressure discharge lamp comprising an outer envelope, a discharge device in which a discharge is maintained during lamp operation, mounting means for mounting said discharge device within said outer envelope and for defining a conductive path to said discharge device for applying a voltage thereacross to energize said discharge device to emit light, and a gas fill within said outer envelope subject to convection currents during lamp operation, the lamp comprising means for controlling heat loss from said discharge device, said means comprising a translucent sleeve surrounding said discharge device characterized in that the sleeve has open ends, said sleeve having an inner diameter selected for suppressing convection currents between said discharge device and said sleeve and reducing convective heat loss from said discharge device.

2. In a high pressure discharge lamp according to claim 1, wherein said sleeve has an inner diameter selected such that heat transfer from said discharge device is minimized.

3. In a high pressure discharge lamp according to claim 1, wherein said sleeve has an inner diameter selected such that the heat transfer from said discharge device is substantially equal to the heat transfer from an identical discharge device operated in an evacuated substantially identical outer envelope.

4. In a high pressure discharge lamp according to claims 1 to 3, wherein the ratio d/D is between about 0.4 and 0.7, d being the outside diameter of the arc tube and D being the inner diameter of the sleeve.

5. In a high pressure discharge lamp according to claims 1 to 4, wherein said outer envelope is a blown glass reflector envelope having a reflective surface for giving directivity to light emitted from said discharge device and said gas has a pressure of about one atmosphere during lamp operation.

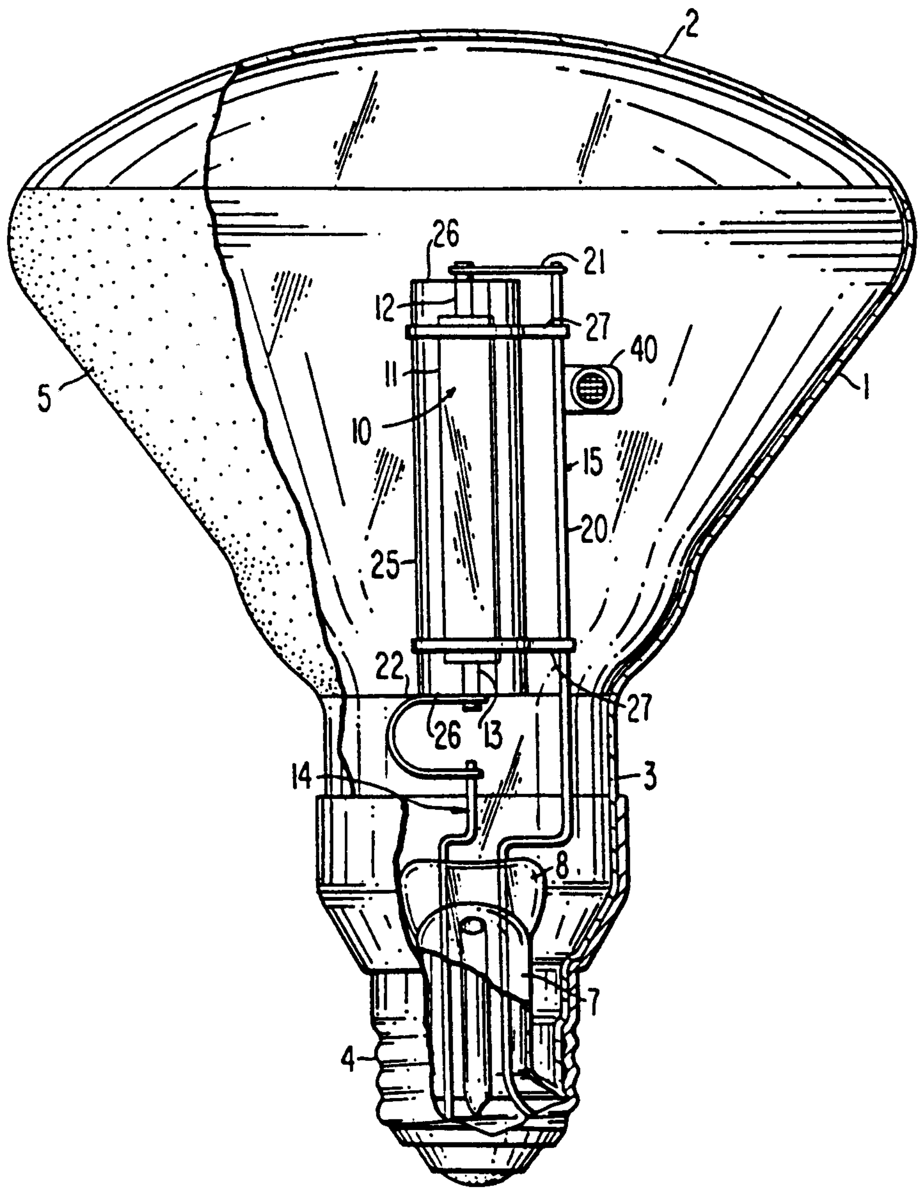
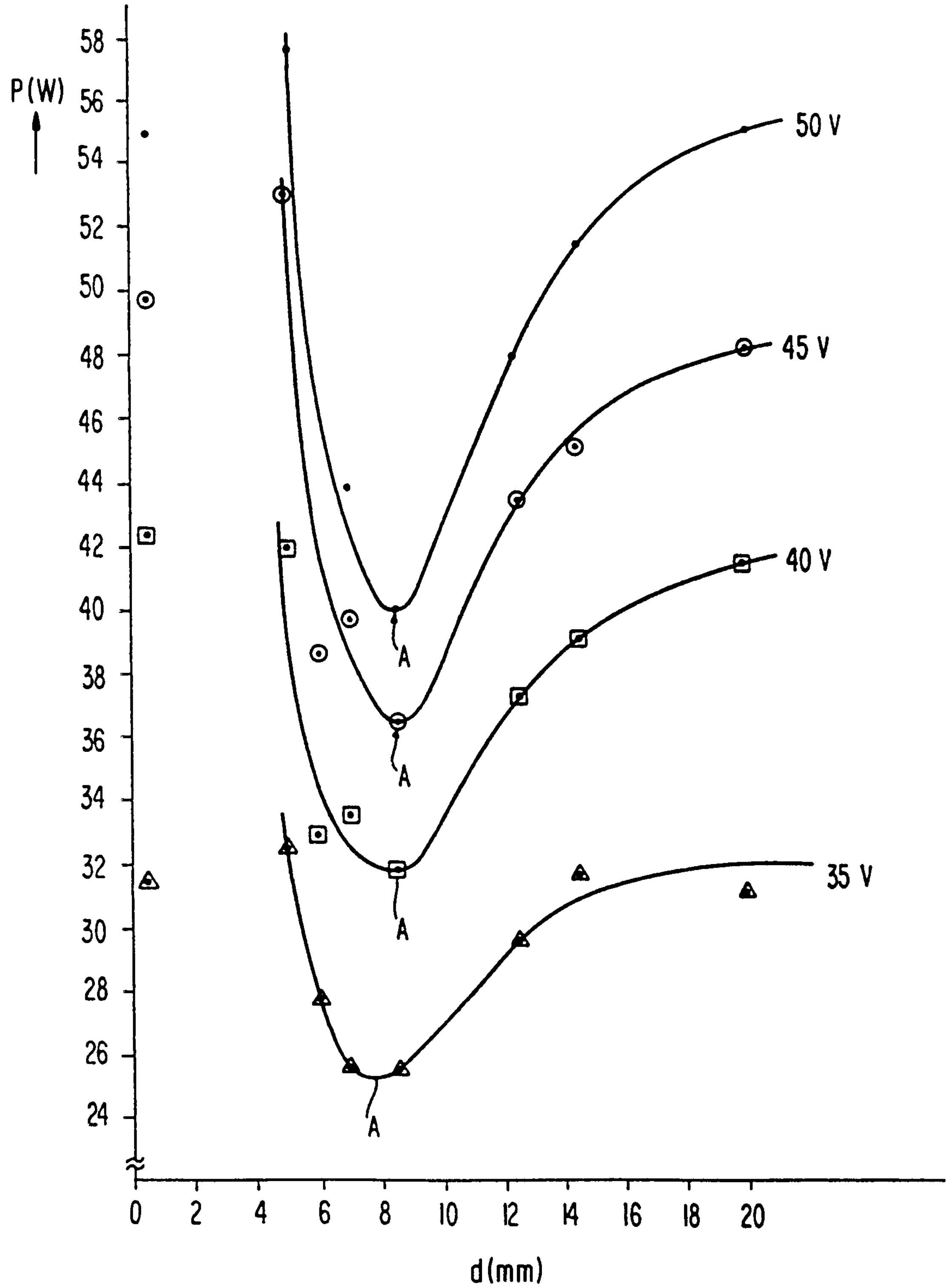


FIG.1


P(W)
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45 V
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d(mm)

FIG.2

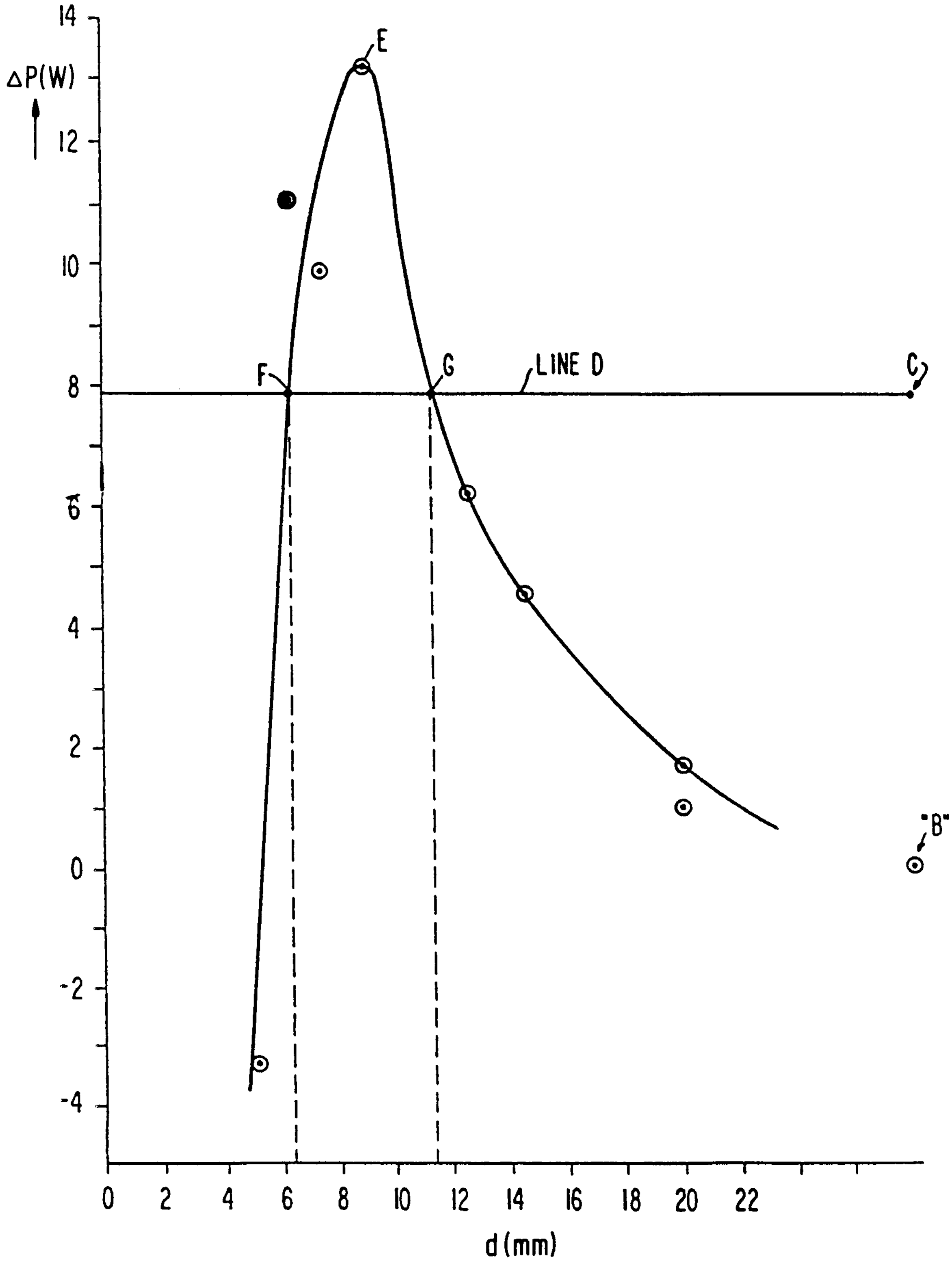

FIG.3

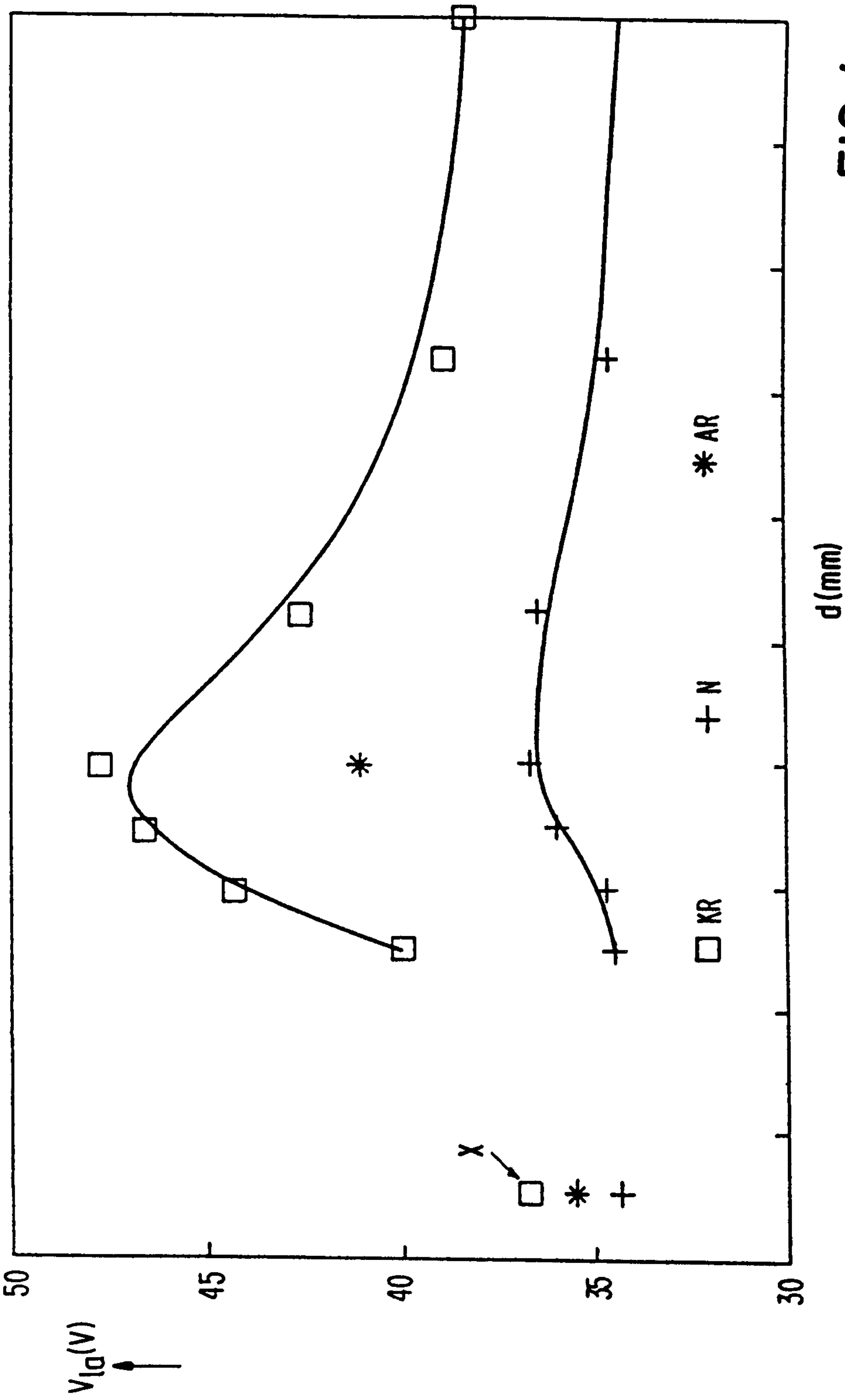

FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91203353.7

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.5)
D,Y	EP - A - 0 290 043 (GTE) * Page 4, lines 9-37 * --	1,2,4, 5	H 01 J 61/52
D,Y	US - A - 4 499 396 (FOHL) * Column 4, lines 3-10 * --	1,2,4, 5	
P,X	US - A - 5 043 623 (SCHOLZ) * Column 4, lines 8-23 * --	1	
A	DE - A - 2 840 771 (PATENT TREUHAND) * Page 2, lines 56-60 * ----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H 01 J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	28-02-1992	SCHLECHTER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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