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Description

The present invention relates to a gas discharge lamp of the tubular kind filled with gas or vapour at low pressure, e.g. a fluorescent lamp. Because of its construction, the inventive gas discharge lamp has properties which render it especially suited for use in low ambient temperatures. The lamp is therefore particularly suited for outdoor use in the Nordic winter climate, and also for illuminating cold storage and freeze storage facilities. Fluorescent lamps are widely used in the open, because the fluorescent lamp gives light more efficiently than an incandescent lamp. In addition to street lighting, fluorescent lamps have thus been used to illuminate road signs, as canopy lighting, e.g. in railway stations, to illuminate loading piers, loading bays, and gasoline stations, and to an increasing extent as a means of illumination in both freestanding and surface-mounted advertising signs. When fluorescent lamps, or tubes, are used to illuminate signs, and not only to illuminate such signs from within, it is desirable that the luminous flux is uniform throughout the sign, irrespective of the ambient air temperature.

The document US-A- 3 358 167 discloses a lamp having resilient annular support members attached to each end of the lamp for holding an inner and an outer tube in a spaced relationship. The members are not only mechanical distance pads but also a thermal reservoir, which provides additional insulation of the inner tube and especially its end parts, which in turn is described to give the desirable effect that mercury condenses in the cooler center portion of the tube.

Because up to 80% of the energy supplied to a fluorescent tube is converted into heat, a fluorescent tube which is mounted in known kinds of lamp casings or enclosures will, to some extent, be self-heating, since the air present in the casing is able to conduct heat away from the actual fluorescent tube only to a very limited extent. This problem applies to fluorescent tubes incorporated in advertising signs (company name signs) and road signs (traffic), such as overhead lane-destination signs of partially translucent design, and also to fluorescent tubes which are mounted in enclosed lamp fittings. With the ambient air stationary and the air temperature beneath 0°C, this self-heating effect will result in a surface temperature of +15°C on the coldest part of the fluorescent tube. At an air temperature of -20°C the self-heating effect is so small as to produce hardly any increase in luminous flux. At such low temperatures, the lamp casings or enclosures absorb all of the increase in luminous flux achieved by self-heating of the fluorescent tube. Consequently, the great majority of fluorescent lamps for outdoor use are of the kind which have reflectors fitted over the fluorescent tube, but which lack the provision of a casing. The purpose of encasing fluorescent lamps is to protect the fluorescent tubes from damage through mechanical causes, and the lighting requirement has been made secondary to the need of protecting the lamp.

Although in the case of advertising signs the need to obtain a high luminous yield is not equally as important as in the case of lamps which are intended for street lighting, the rising price of electrical energy will influence the future design of such sign illumination. The lamps used to illuminate such signs will also be required to have a higher luminous efficiency, which means that the lamps must sustain higher temperatures at the coldest point on the envelope surface of the lamp. In order to achieve optimum luminous yield, this point on the lamp envelope needs to be heated to close to 40°C.

Tunnels are another area of use in which fluorescent tubes or lamps can be subjected to the effects of low ambient temperatures. The air flow through tunnels, even when the tunnels have a length of several hundred meters, is so large that any heat which may be radiated from the surrounding rock or earth is unable to supplement heating of the surfaces of the fluorescent tube. Thus, when used for the aforesaid purpose the luminous flux will decrease exponentially with falling air temperatures. This can have a serious consequence, for instance, on a cold sunny winter's day when a car driver will see the road with an illumination strength of close to 100 000 lux. When this driver enters an illuminated tunnel, his eyes must adjust to an illuminance which is far below 100 lux. Road safety and the driver's own feeling of security are assisted by the fact that the fluorescent lamps in the tunnel maintain a practically normal luminous flux, even in very cold weather conditions.

According to statistics, November is the month in which the majority of road accidents occur in the Nordic countries. These accidents occur mostly in the dark hours and to a large extent are the result of poor street lighting. When this street lighting comprises lamp fittings with low-pressure mercury vapour discharge lamps, the luminous flux from these lamps is halved at temperatures between +10°C and 0°C, when conventional fluorescent tubes with an external diameter of 38 mm are used. In recent years there has been a change from tubes of this diameter to tubes of 26 mm in diameter, these latter tubes having been given a 10% lower power output than the former. This decrease in power output has resulted in an energy saving when the tubes are in operation, although there is no appreciable reduction in the luminous flux of such tubes at ambient temperatures of 20°C. The conditions engendered when the ambient temperature falls from +20°C to 0°C in the case of a 58W tube cause a decrease in luminous flux from 4700 to 1400 lumens. In the case of a 26 mm tube, the luminous flux is reduced to a third of its original value when the ambient temperature lies within a range of

+10°C to 0°C. The matter is made more serious by the fact that the luminous flux of a 26 mm tube at +10°C is 20% lower than the luminous flux of a 38 mm tube of corresponding power.

Because the narrower tubes are being used to an ever increasing extent and now practically dominate all demand, the majority of fluorescent tube manufacturers have ceased to produce the 38 mm tube. Cathodes and other lamp components have therewith been fully adapted to tubes of 26 mm diameter.

Now that the drawbacks of the narrower tubes have been observed, it should be possible simply to restart the manufacture of components for tubes of 38 mm diameter. This is not the case, however, since the production lines would need to be adjusted to the tubes of larger diameter in several respects and at heavy costs.

One serious problem associated with the use of gas discharge lamps in low ambient temperatures concerns their ignition. The starters (or chokes) normally used are effective in short circuiting the electrodes, so that they are preheated by through surging current, whereby when the striker opens, a spark arcs from anode to cathode and a positive column is generated therebetween. In the case of low ambient temperatures, the striker will open and close a number of times before the electrodes are sufficiently warm to sustain an arc therebetween. It may often take 30 seconds for the tube to ignite, which drawback is far more manifest in 26 mm tubes than in tubes of 38 mm in diameter.

The object of the present invention is to solve the problems which are associated with the use of narrow fluorescent tubes in freezing temperatures and to provide a lamp which has high illuminance at low temperatures. This object is realized in accordance with the invention with a narrow fluorescent tube which is surrounded along the whole of its length by a fixed transparent outer tube, for instance a glass tube. Other characteristic features of the inventive solution are set forth in the following claims.

It has surprisingly been found that when the gas present in the tubular space between the fluorescent tube and the outer glass tube or envelope is demoiaturized, the lamp will ignite more readily at low ambient temperatures. This is believed to be due to the fact that in the absence of moisture, no ions carrying space charges will be located adjacent the inwardly placed fluorescent tube. In this way, the generation of a positive column between the lamp electrodes can take place undisturbed. This is achieved because as the discharge current passes through the discharge chamber, ions and electrons will diffuse in a direction towards the wall of the inner tube. Since the electrons are much lighter than the positive ions, the electrons will reach the tube wall more quickly than the latter, thereby imparting a negative charge to said wall. In this respect, if positive space charges were to be available in the space between the fluorescent tube and the outer tube, the wall charge on the discharge chamber side would be neutralized, therewith making it much more difficult to achieve a positive column between the electrodes.

It has been found that the most effective method of demoiaturizing the gas present between the two tubes is to fit siloxane seals at the ends of the tubes. Siloxane seals toughen in taking up water, wherewith alcohols are formed. The dipolarity of the water molecule makes it a far more effective charge carrier than the electrically indifferent alcohols. This effectivity eliminates the occurrence of space charges and the lamp is subsequently more readily ignited, even in extreme cold.

In accordance with the invention, there is provided a gas-discharge lamp which comprises an inner fluorescent tube that is surrounded or enveloped by a glass tube or envelope, which may be transparent or opalescent. The ends of this outer tube or envelope are fixed to the cathode-containing ends of the glass tube of the discharge lamp, such as to leave a tubular space of constant width between the outer tube and the inner tube. This fixation of the outer glass tube may be effected with the aid of seals located at the ends of the lamp, between the two glass tubes. These seals may have the form of polymer sealing rings, or may otherwise comprise age-resistant gas-impermeable material.

Irrespective of how the outer glass tube or envelope surrounding the tube is fixed thereto, an advantage is afforded when the space between the tube and envelope is filled with a pure gas, so that no light losses will occur. The gas most preferred in this respect is dry, dust-free air, although in particular cases the gas may comprise a noble gas or a mixture of such gases.

The gas in the aforesaid space may be kept at atmospheric pressure, although in combination with the tube wall, which is normally less than 2 mm thick, and in order to increase the heat insulating ability, the gas is preferably held at a pressure beneath atmospheric. The insulating ability is also dependent on the width of the space, which width may be from 2-10 mm, depending on the intended lamp application. When the fluorescent tube has an external diameter of 26 mm and is surrounded by a glass envelope whose outer diameter is 38 mm, the tubular space will have a width of 5 mm. In the case of very narrow tubes and tubular spaces in excess of 10 mm, an exchange of heat-transporting air may take place between the outer surfaces of the inwardly located fluorescent tube and the inner surface of the tubular envelope. This will increase convection and part of the advantage afforded by the invention will be lost. An excessively narrow tubular space will not give the desired effect, unless the space is completely evacuated. An optimum space width has therefore been judged to be from 4 to 8 mm.

In order to utilize the light emitted to a maximum, the light may be directed positively from the lamp fitting, normally downwards. Since the invention is also intended for use in conjunction with very simple lamp fittings, the inner surface of the tubular envelope or outer glass tube may be coated with a light and heat reflective material, through an angle of arc of up to 180°C. In addition to increasing the light strength in the visible wave-lengths, this embodiment affords the further advantage of reflecting heat rays back to the discharge chamber of the lamp. The resultant increase in the temperature of the discharge chamber corresponds to an increase in illumination strength of more than 20% when the ambient temperature is beneath +10°C. Together with the light reflection, an increase in illuminating power of between 50 and 60% can be achieved. Fluorescent tubes of this construction can also be turned through 180°C in reflector-fitted lamp fittings, resulting in a type of top-reflection. This gives a very soft light and promotes self-heating of the lamp.

The inventive lamp is believed to afford a good solution to the illuminating requirements expressed by those who work on oil rigs in arctic climates. In addition to giving a much higher light yield than hitherto known discharge lamps at the low temperatures which prevail during the six dark months of the year, the outer envelope of the inventive lamp will also afford protection against mechanical damage.

Should the tubular envelope or glass outer tube break, the inner, fluorescent tube is likely to remain intact and the lamp will continue to give-out light, without risk of sparking between the cathodes igniting gas located around the oil platform or rig. The inventive lamp thus provides in this instance a safety lamp which will reduce explosion hazards on oil platforms and rigs.

The invention is illustrated in the accompanying drawings; in which

Figure 1 is a partly cut-away view of an inventive fluorescent tube; and

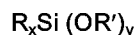
Figures 2, 3 and 4 are graphs which show the ratio of ambient temperature, in °C, illuminance strength in lumens (Lm) in respect of fluorescent tubes of 18/20W, 36/40W, 58/65W respectively.

The inventive lamp illustrated in Figure 1 is a preferred embodiment of the invention, namely a double-walled fluorescent lamp 1. The lamp comprises a fluorescent tube 2 which has a diameter of 26 mm and which is fitted at both ends with lamp bases 3 having connector pins 4. The tube 2 also has cathodes placed on a terminal foot 5 in the usual manner, the cathodes in this case being surrounded by electrode screens 6. The electrical contact pins extend through the foot, or base, 5 to the cathode current distributor 7.

The fluorescent tube 2 of the illustrated embodiment is surrounded by a tubular glass envelope 8 which is transparent and has an outer diameter of 38 mm and the ends of which are drawn or necked slightly inwards. The ends of the tubular envelope 8 are inserted into ring-shaped grooves in polymer rings 9 which are press-fitted onto the bases 3. When the tubular envelope is fitted with the aid of polymer rings 9 in a chamber which is under a partial vacuum and to which only dry, filtered air is introduced, the air present in a tubular space 10 between the fluorescent tube 2 and the tubular envelope 8 will be free from dust. Furthermore, the application of atmospheric pressure will assist in holding the polymer rings 9 tightly and sealingly between the envelopes 8 and respective lamp bases 3.

For the purpose of achieving a completely dry atmosphere in the tubular space 10, seals 11 consisting of some form of siloxane are provided on the side of the polymer rings 9 that faces towards the discharge chamber. For instance siloxane compound can be placed in the grooves in the rings 9 into which respective ends of the outer tube 8 are fitted, and a bead of siloxane compound can be provided on the fluorescent tube 2 in immediate contact with the polymer rings 9.

In practice, 1.5 g of polydimethylsiloxane compound is disposed on each end of the lamp. The active substance in the siloxane compound comprises trimethyl siloxane monomers and an addition of a catalyzing and stabilizing substance. The monomer can be expressed as:



where

R = methyl group

OR' = methoxy group

x = 1; 2

y = 2; 3.

As with all alkoxysilanes, the trimethylsiloxane is hydrolyzed in the presence of water and hardens to form polysiloxanes, which are characterized by high molecular weights (= high degree of polymerization).

During the process of polymerization, 2 moles of siloxane monomers (~180g) consume 1 mole of water (18g), releasing 2 moles of methanol (64g). Since the sealing compound consumes water as it hardens, a process which continues for up to 24 hours, it is able to lower considerably the humidity of a closed space, such as the sealed space between the fluorescent tube 2 and the outer tube 8. In practice, all of the water vapour present will react with the siloxane monomers during the process of polymerization. Values relating to a 58W lamp comprising a fluorescent tube 26 mm in diameter and an outer glass tube 38 mm in diameter, corresponding to an inner diameter of 36 mm, since the wall thickness is 1 mm, are given below by way of an example.

Volume of the tubular space

721 cm³

Maximum amount of water enclosed in manu-
 5 facture (air +30°C, 80% relative humidity,
 atmospheric pressure)

24.3 mg/l

= 17.5 mg H₂O.

10 This corresponds to 0.001 mole of water. 2 x 1.5 g of siloxane incorporating 60% active substance will be 1.8 g, corresponding to 0.020 mole. Thus, there is a 20-fold certainty that all water present in the tubular space 10 will be chemically bound.

15 In order to establish the readiness of the novel lamp to ignite, comparison tests were carried out between conventional 26 mm fluorescent tubes of 18W, 36W and 58W powers and lamps provided with an outer tube 8 and designated 18W Terno, 36W Terno and 58W Terno respectively. The lamps were kept in a chest freezer, in which the tests were subsequently carried out. The temperature was maintained at -30°C with each test series. No metal surfaces were present in the proximity of the lamps. The tests were carried out with the aid of starters that had been early used to effect 8500 ignitions and 2000 ignitions respectively, and also with the
 20 aid of new starters. In the case of the 18W lamps, ignition was only a few seconds longer than the time taken to ignite the 18W Terno lamps. The differences became more pronounced, however, when using the oldest starters.

The ignition time for the 36W Terno lamps was under 5 seconds, whereas the 36W lamps took between 8 and 20 seconds to ignite, the longest ignition times being experienced with the eldest starters.

25 The 58W lamps could not be ignited with the oldest starters at the aforesaid test temperature. When using the starters which had been used 2000 times previously, only some of the lamps would ignite, and then only after an average time lapse of 25 seconds. When using a new starter, one lamp ignited after 8 seconds and all lamps ignited during the tests with new starters were seen to ignite in 15 seconds or less. In the case of the 58W Terno lamps, ignitions were observed within 8 seconds, except in the case of those lamps with which
 30 old starters were used.

A subsequent series of tests were carried out at a Finnish materials testing establishment, where ignition tests could be carried out in a refrigeration chamber at -40°C. New starters were used in these tests and all of the tested lamps, known as Luma Terno 36W/CW-LL, ignited within a time lapse of 5 seconds.

35 Figures 2, 3 and 4 show the average luminance of the lamps tested, at different temperatures. Previously documented values for 20W, 40W and 65W lamps have also been shown, for comparison purposes.

For advertising purposes, or for the purpose of otherwise meeting particular desiderata with regard to a given wave-length composition of the light emitted, the inner surfaces of the outer glass tube or envelope of the inventive lamp may be coated with substances which will filter out undesired light. This technique enables critical ultraviolet lines to be further reduced with the aid of light-absorbing or fluorescent substances. The fol-
 40 lowing substances have been found suitable in this respect.

When a reddish-pink hue or colour is desired, there is used a mixture of inorganic oxides designated (Fe₂O₃ + SiO₂ + Al₂O₃). For a green hue (CuNiZn)₄(TiAl)O₄ is used, while Na(SiAl)O₂S is used for a shimmering blue light.

45 The substances are applied to the inner surface of the outer tube 8 in the form of a suspension having a dry solids content of between 0.3 and 0.5mg/cm². These dyestuffs or pigmenting substances are burned onto the glass. Alternatively, organic dyestuffs may be used. When using organic dyestuff, however, burning, or stoving, cannot be effected at temperatures which lie above 500°C. In all events, a binder must be added when burning, baking, organic dyestuffs. One suitable binder in this regard is ammonium polymethyl acrylate.

50 Claims

1. A low-pressure gas discharge lamp of tubular form for use in low ambient temperatures, comprising an inner fluorescent tube and an outer glass tube which surrounds the inner tube such as to define a tubular
 55 space therebetween, and which outer-tube extends beyond the electrodes of the lamp and the ends of which tube are joined to the ends of said inner fluorescent tube, wherein the ends of the outer glass tube (8) are accommodated in circular grooves located in polymer rings (9) on the inner fluorescent tube (2), **characterized in that** a siloxane compound is provided in the grooves and between the polymer rings (9) and

the inner tube (2) for hermetically joining said inner and outer tubes and for achieving a dry atmosphere in the tubular space (10) between the tubes by hydrolizing the siloxanes as they harden to form polysiloxanes.

- 5 2. A lamp according to claim 1, **characterized in that** the tubular space (10) defined between the inner fluorescent tube (2) and the outer glass tube (8) is filled with dry, dust-free air.
3. A lamp according to claims 1 or 2, **characterized in that** the tubular space (10) defined between the inner fluorescent tube (2) and the outer glass tube (8) contains one or more noble gases.
- 10 4. A lamp according to claim 3, **characterized in that** the inner surface of the outer glass tube (8) is also coated with a layer of fluorescent substance.
5. A lamp according to any one of the preceding claims, **characterized in that** the inner surface of the outer glass tube (8) is coated with a coherent layer of reflective material through an angle of arc of up to 180°C.
- 15 6. A lamp according to any of the preceding claims, **characterized in that** the whole of the inner surface of the outer glass tube (8) or part of said surface is coated with one or more substances which will change the colour of the light radiating through the inner fluorescent tube (2).

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Patentansprüche

- 25 1. Niederdruckgasentladungslampe in Röhrenform zum Einsatz bei niedrigen Umgebungstemperaturen, welche eine innere Leuchtstoffröhre und eine äußere Glasröhre aufweist, welche die innere Röhre derart umgibt, daß ein rohrförmiger Zwischenraum dazwischen gebildet wird, wobei die äußere Röhre sich über die Elektroden der Lampe hinaus erstreckt und die Enden der Röhre mit den Enden der inneren Leuchtstoffröhre verbunden sind, und wobei die Enden der äußeren Glasröhre (8) in kreisförmigen Ausnehmungen aufgenommen sind, welche in Polymerringen (9) auf der inneren Leuchtstoffröhre (2) vorgesehen sind, **dadurch gekennzeichnet**, daß eine Siloxanverbindung in den Ausnehmungen und zwischen den Polymerringen (9) und der inneren Röhre (2) zur Herstellung einer hermetischen Verbindung zwischen der inneren und der äußeren Röhre und zur Erzielung einer trockenen Atmosphäre in dem rohrförmigen Raum (10) zwischen den Röhren vorgesehen ist, wobei sich die Siloxane beim Härten hydrolisieren und Polysiloxane bilden.
- 30 2. Lampe nach Anspruch 1, **dadurch gekennzeichnet**, daß der rohrförmige Raum (10), welcher zwischen der inneren Leuchtstoffröhre (2) und der äußeren Glasröhre (8) gebildet wird, mit trockener, staubfreier Luft gefüllt ist.
- 35 3. Lampe nach Anspruch 1 oder 2, **dadurch gekennzeichnet**, daß der rohrförmige Raum (10), welcher zwischen der inneren Leuchtstoffröhre (2) und der äußeren Glasröhre (8) gebildet wird, ein oder mehrere Edelgase enthält.
- 40 4. Lampe nach Anspruch 3, **dadurch gekennzeichnet**, daß die innere Fläche der äußeren Glasröhre (8) ebenfalls mit einer Schicht aus einer fluoreszierenden Substanz überzogen ist.
- 45 5. Lampe nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet**, daß die innere Fläche der äußeren Glasröhre (8) mit einer kohärenten Schicht aus reflektierendem Material über einen Winkelbogen von bis zu 180° überzogen ist.
- 50 6. Lampe nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet**, daß die gesamte innere Fläche der äußeren Glasröhre (8) oder ein Teil der Fläche mit einer oder mehreren Substanzen überzogen ist, welche die Farbe des durch die innere Leuchtstoffröhre (2) abgegebenen Lichts verändern.

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Revendications

1. Lampe à décharge dans un gaz basse pression, de forme tubulaire, destinée à être utilisée à des températures ambiantes basses, comprenant un tube intérieur fluorescent et un tube extérieur en verre qui

- entoure le tube intérieur, en définissant ainsi une zone tubulaire entre eux, le tube extérieur s'étendant au-delà des électrodes de la lampe et les extrémités de ce tube extérieur étant reliées aux extrémités du tube intérieur fluorescent, dans laquelle les extrémités du tube (8) extérieur en verre sont reçues dans des rainures circulaires formées dans des anneaux (9) en polymère sur le tube (2) intérieur fluorescent, caractérisée en ce que un siloxane est prévu dans les rainures et entre les anneaux (9) en polymère et le tube (2) intérieur afin de joindre de manière étanche les tubes intérieur et extérieur et afin d'obtenir une atmosphère sèche dans la zone (10) tubulaire entre les tubes par hydrolyse des siloxanes tandis qu'ils durcissent en des polysiloxanes.
2. Lampe selon la revendication 1, caractérisée en ce que la zone (10) tubulaire qui est définie entre le tube (2) intérieur fluorescent et le tube (8) extérieur en verre est rempli d'air sec, exempt de poussière.
 3. Lampe selon la revendication 1 ou 2, caractérisée en ce que la zone (10) tubulaire qui est définie entre le tube (2) intérieur fluorescent et le tube (8) extérieur en verre contient un ou plusieurs gaz rares.
 4. Lampe selon la revendication 3, caractérisée en ce que la surface intérieure du tube (8) extérieur en verre est également revêtue d'une couche d'une substance fluorescente.
 5. Lampe selon l'une quelconque des revendications précédentes, caractérisée en ce que la surface intérieure du tube (8) extérieur en verre est revêtue d'une couche cohérente d'un matériau réfléchissant sur un angle d'arc allant jusqu'à 180°.
 6. Lampe selon l'une quelconque des revendications précédentes, caractérisée en ce que la totalité de la surface intérieure du tube (8) extérieur en verre ou une partie de cette surface est revêtue d'une ou de plusieurs substances qui auront pour effet de changer la couleur de la lumière rayonnant à travers le tube (2) intérieur fluorescent.

Fig. 1

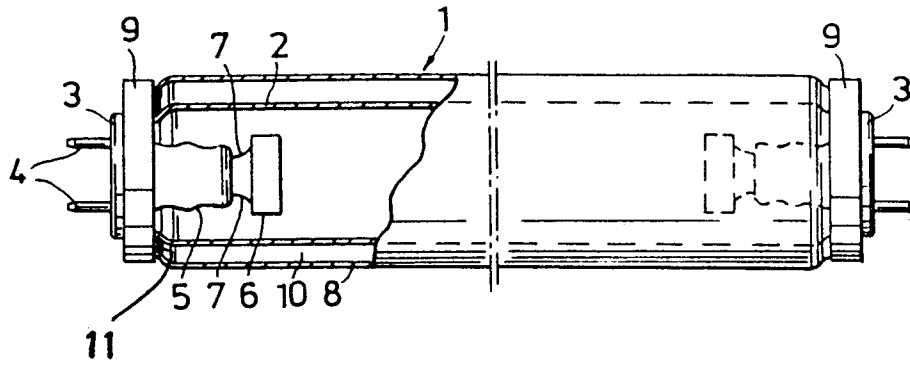


Fig. 2

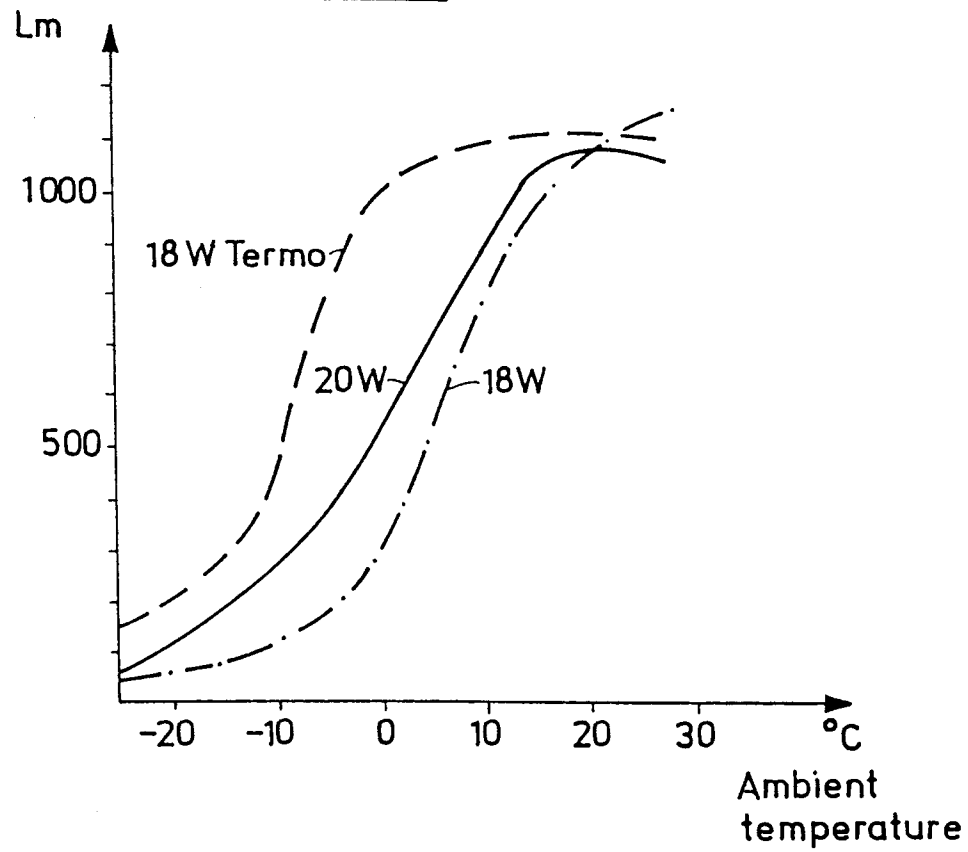


Fig. 3

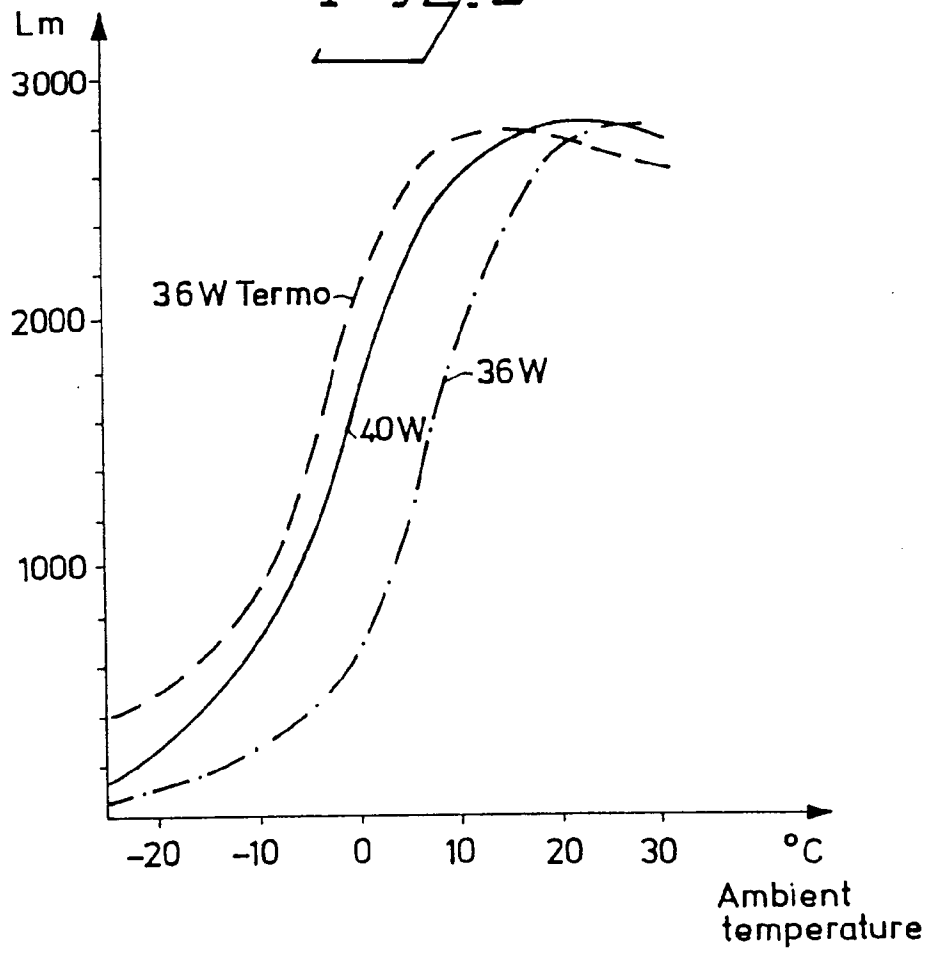


Fig. 4

