(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 470 496 A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 91112878.3

(22) Date of filing: 31.07.91

(51) Int. Cl.5: H01K 1/32, H01K 1/02, H01K 7/02

(30) Priority: 07.08.90 JP 209464/90
07.08.90 JP 209465/90

(43) Date of publication of application:
12.02.92 Bulletin 92/07

(84) Designated Contracting States:
DE GB

(71) Applicant: TOSHIBA LIGHTING & TECHNOLOGY CORPORATION
4-28, Mita 1-chome
Minato-ku Tokyo(JP)

(72) Inventor: Yuge, Yoji
2-2-53-205, Matsugaoka
Chigasaki-shi, Kanagawa-ken(JP)
Inventor: Tanaka, Sumiko
4-65-19, Kugo-cho
Yokosuka-shi, Kanagawa-ken(JP)
Inventor: Kawakatsu, Akira
1-25-3-417, Deiki
Kanazawa-ku, Yokohama-shi(JP)

(74) Representative: Henkel, Feiler, Hänzel & Partner
Möhlstrasse 37
W-8000 München 80(DE)

(54) Incandescent lamp and reflector type projection lamp.

(57) A reflector type projection lamp comprising an incandescent lamp (1) provided on the inner or outer surface of its bulb (2) with an interference layer for reflecting infrared light and transmitting visible light and a reflector (10) provided on its reflecting surface with an interference layer (15) for reflecting visible light and transmitting infrared light is characterized in that the bulb (2) of said incandescent lamp is either spherical or spheroidal. Of the light emitted from the filament (6) of the incandescent lamp, the infrared component is effectively reflected by an interference layer (9) on the bulb and returned to the filament to enhance the overall lighting efficiency of the lamp and reduce the rate of heat irradiated from the lamp into the atmosphere.

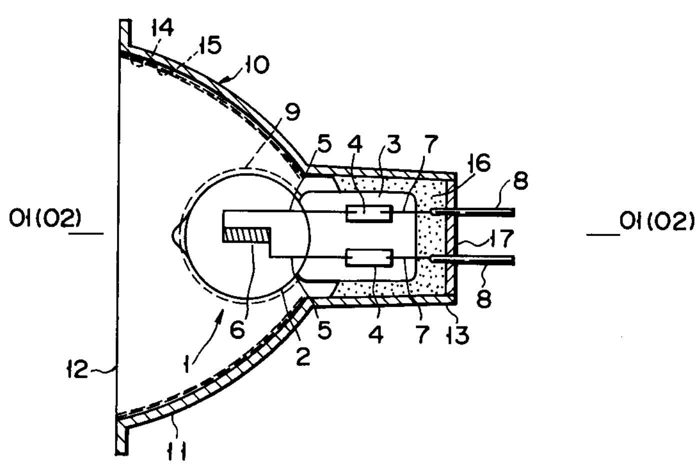


FIG. 1

EP 0 470 496 A2

This invention relates to an incandescent lamp and also to a reflector type projection lamp realized by combining an incandescent lamp and a reflector. More particularly, it relates to an incandescent lamp having an interference layer arranged on the inner or outer surface of the lamp bulb and capable of reflecting infrared light and transmitting visible light so as for the filament of the lamp to absorb the infrared light irradiated from itself and reflected by said interference layer. It also relates to a reflector type projection lamp realized by using an incandescent lamp of the above described category.

Incandescent lamps such as halogen lamps have conventionally been used for illumination of commodities as well as for other applications that require a high degree of color rendering. Such incandescent lamps are often used in combination with reflectors to form so-called reflector type projection lamps. A reflector type projection lamp is a lamp that reflects light irradiated from a filament by a reflector and sheds light just onto a limited area in front of the lamp.

Such an incandescent lamp emits not only visible light but also infrared light and therefore heat. When an incandescent lamp is used to illuminate commodities, infrared light coming from the lamp inevitably heats the commodities to deteriorate their quality.

In order to eliminate this problem, there has been proposed an incandescent lamp provided with a reflector having an interference layer so arranged on its reflecting surface that only visible light is reflected by the reflector while infrared light passes through it. An interference layer to be used for this purpose is of a known type and comprises a plurality of sub-layers, each of which interferes with light so that the interference layer as a whole reflects only visible light whose wave-length is found below a certain limit and transmits infrared light whose wavelength is above said limit. Consequently, of the light irradiated from the filament of an incandescent lamp of this type, only the visible portion is reflected by the interference layer and projected forward, whereas the infrared component is, after passing through the interference layer, either absorbed by the reflector main body or transmitted through it to proceed further backward, reducing the amount of infrared light projected forward and hence the risk of deterioration by heat of the commodities illuminated by the lamp.

A reflector type projection lamp of the type as described above, however, can only reduce the intensity of infrared light projected forward by it by approximately 80%, making itself not very potent of preserving the quality of the commodities it illuminates. Besides, the infrared light that has passed through the interference layer of the reflector is either absorbed by the reflector main body to heat it or transmitted through it to proceed further backward until it eventually hits and heats an object such as lighting equipment or wall. Therefore, if a number of such reflector type projection lamps are used simultaneously in a room, the room temperature can rise considerably by the heat emitted by them, raising significantly the cost of air conditioning for the room.

In an attempt to avoid this problem, there has been proposed a type of incandescent lamp coated on the inner or outer surface of the lamp bulb with an interference layer that reflects infrared light and transmits visible light. Consequently, of the light irradiated from the filament of an incandescent lamp of this type, the visible portion is transmitted through the interference layer, whereas the infrared component is reflected by the layer and absorbed by the filament itself to effectively reduce the intensity of infrared light irradiated from the incandescent lamp. It should be noted that the filament is not heated not only by the heat generated by its resistance under electric charge but also by the reflected infrared light to reduce the rate of power consumption and the energy emitted in the form of other than visible light and consequently enhance the efficiency of illumination. Therefore, if a number of incandescent lamps of this type are used simultaneously within a room, the rate of heat emission is very low and hence the cost of air conditioning is not significantly raised.

Now, an incandescent lamp, e.g. a halogen lamp, of this type should be so designed that infrared light emitted from the filament is reflected by the interference layer arranged on the lamp bulb and eventually gets back to the filament. For this reason, a known halogen lamp of this type has a cylindrical shape and a filament is arranged in it along the axis of the cylinder. With such an arrangement, beams of infrared light radially emitted from the filament are reflected by the interference layer on the bulb and return radially and inwardly back to the filament, where they are absorbed by the filament itself. However, some of the beams of infrared light may be emitted not perpendicularly but somewhat slantly to the axis of the filament and go out through the top and bottom of the lamp bulb after having been reflected by said interference layer. Those beams, therefore, never get back to the filament and are lost. Such loss of infrared light may be prevented to some extent by preparing a lamp bulb having a filament which is considerably long relative to the bulb diameter.

However, a long filament of an incandescent lamp means a large electric resistance of the lamp, which by turn requires a high voltage to be applied thereto for use. This problem is particularly significant with a low output incandescent lamp comprising a very thin filament, which requires a very high voltage to be applied thereto when it is used.

The aim of the present invention is, therefore, to eliminate the above problems for an incandescent lamp. A first object of the invention is to provide an incandescent lamp that emits infrared light only at a reduced level and a reflector type projection lamp realized by combining such an incandescent lamp and a reflector.

A second object of the invention is to provide an incandescent lamp that operates efficiently and emits heat due to light other than visible light only at a reduced rate and a reflector type projection lamp realized by combining such an incandescent lamp and a reflector.

A third object of the invention is to provide an incandescent lamp comprises a short and small filament and requires only a low voltage to be applied for operation and a reflector type projection lamp realized by combining such an incandescent lamp and a reflector.

The above objects of the invention are achieved primarily by providing an incandescent lamp comprising a lamp bulb and a filament contained within said bulb, said bulb having an interference layer arranged on its inner or outer surface to reflect infrared light and transmit visible light, characterized in that said bulb is either spherical or spheroidal. Therefore, of the light emitted from the filament of an incandescent lamp according to the invention, the infrared component is reflected by said interference layer and gets back to the filament to be absorbed by it. Since the bulb has a spherical or spheroidal shape, all the beams of infrared light emitted from the filament are reflected right back to the filament and never go astray out of the bulb as in the case of a known cylindrical bulb, where some the reflected beams of infrared light may never reach the filament. Thus, an incandescent lamp according to the invention effectively and efficiently reflects infrared light emitted from the filament, which by turn effectively absorbs the reflected infrared light so that the level of infrared light and, therefore, the rate of heat emitted outside the lamp are minimized, eliminating any risk of overheating nearby gadgets and any excessive charge required for the air conditioning facilities for the site where the lamp is used.

Now, for an incandescent lamp involving a spherical or spheroidal bulb, it is desirable to use a filament formed to show a corresponding shape in order to maximized the efficiency of the lamp. If, for instance, the bulb is realized in the form of a spherical ball, the lamp operates most efficiently when the filament is also spherical, although it is difficult and, therefore, not practical to manufacture such a filament.

An incandescent lamp according to the invention comprises a coil-shaped filament as in the case of a known incandescent lamp. The efficiency of operation of an incandescent lamp according to the invention is maximized when the relationship between the diameter d and the length 1 of its filament is defined by the formula below.

$1.0 < 1/d \leqq 4.2$

According to the invention, there is also provided a reflector type projection lamp realized by combining an incandescent lamp as described above with a reflector. Such a reflector type projection lamp emits forward infrared light at a minimum level and, therefore, can be effectively used for illumination of commodities without deteriorating their quality by heat.

A reflector type projection lamp according to the invention is characterized by that the reflector is realized in the form of a spheroid whose major axis has a length of a and that the relationship between a and the outer diameter D of the bulb of the incandescent lamp is expressed by the formula below.

$D/a \leqq 0.25$

With such a definition, beams of visible light reflected by the reflector are effectively prevented from being scattered by the bulb of the incandescent lamp.

A reflector type projection lamp according to the invention also comprises a light insulation layer arranged at the backside of the bulb or at the center of the reflector to block transmission of light. With such an arrangement, the reflector is protected against excessive radiation of light and resultant overheating.

Now the present invention will be described in greater detail by referring to the accompanying drawings that illustrate preferred embodiments of the invention.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is an axial sectional view of a first embodiment of the reflector type projection lamp of the present invention, utilizing an incandescent lamp according to the invention;

Fig. 2 is a graphic illustration of the relationship between the wavelength of the light emitted by the first embodiment of Fig. 1 and the relative energy output;

Fig. 3 is a lateral view of the incandescent lamp of the embodiment of Fig. 1;

Fig. 4 is a graphic illustration of the performance of the embodiment of Fig. 1 as a function of the length and the diameter of the lamp bulb;

Fig. 5 is a diagrammatic illustration of the embodiment of Fig. 1 showing the positional relationship between the reflector and the bulb;

Fig. 6 is a schematic illustration showing different illumination patterns of the embodiment of Fig. 1;

Fig. 7 is an axial sectional view of a second embodiment of the reflector type projection lamp of the present invention utilizing an incandescent lamp according to the invention;

Fig. 8 is an axial sectional view similar to Fig. 1 but showing a third embodiment of the reflector type projection lamp of the invention;

Fig. 9 is an axial sectional view similar to Fig. 1 but showing a fourth embodiment of the reflector type projection lamp of the invention;

Fig. 10 is an axial sectional view similar to Fig. 1 but showing a fifth embodiment of the reflector type projection lamp of the invention;

Fig. 11 is an axial sectional view similar to Fig. 1 but showing a sixth embodiment of the reflector type projection lamp of the invention;

Fig. 12 is a diagrammatic illustration of the embodiment of Fig. 11 showing the positional relationship between the reflector and the bulb;

Fig. 13 is a schematic illustration of the illumination pattern of the embodiment of Fig. 11;

Fig. 14 is an axial sectional view similar to Fig. 1 but showing a seventh embodiment of the reflector type projection lamp of the invention;

Fig. 15 is an axial sectional view similar to Fig. 1 but showing a eighth embodiment of the reflector type projection lamp of the invention;

Fig. 16 is an axial sectional view similar to Fig. 1 but showing a ninth embodiment of the reflector type projection lamp of the invention;

Fig. 17 is a side view of the lamp shown in Fig. 16, showing the positional relation between the center of the filament and the center of the bulb;

Fig. 18 is a graph representing the relationship between the displacement of the filament and the efficiency of the lamp; and

Fig. 19 is a graph illustrating the relationship between the displacement of the filament and the lifetime of the lamp.

Referring to Figs. 1 and 3 schematically showing a first preferred embodiment of the reflector type projection lamp of the present invention utilizing an incandescent lamp according to the invention, reference numeral 1 denotes an incandescent lamp such as a halogen lamp and reference numeral 10 denotes reflector.

Said halogen lamp 1 comprises a spherical bulb 2 having an outer diameter of 8 to 15mm and made of transparent quartz glass and is energized to operate by low voltage electricity typically between 6 and 36V. A pinch seal section 3 is formed at an end of the bulb 2, wherein a pair of laminated metal conductors 4, 4 hermetically sealed. Said laminated metal conductors 4, 4 are respectively connected with corresponding ends of a pair of internal leading-in wires 5, 5, which run into the inner space of the bulb 2 to support between their other ends a filament 6 of a tungsten coil. Said filament 6 is arranged along and exactly on the axis O_1 of the bulb 2. Said pair of laminated metal conductors 4, 4 are also connected respectively with a pair external leading-in wires 7, 7 which are by turn connected with respective feeding terminal pins 8, 8.

The inner space of the bulb 2 is filled with a mixture of argon gas and a gaseous halogen compound such as a gaseous bromide having predetermined respective partial pressures.

The outer surface of the bulb 2 is coated with an interference layer that reflects infrared light and transmits visible light. While such an interference layer represents a known technology and hence is not shown in detail in the drawings, it has a multi-layer structure comprising typically 9 to 17 sub-layers, where sub-layers of a material having a high refractive index and those of another material having a low refractive index are arranged alternately. An interference layer having such an arrangement typically reflects infrared light and transmits visible light. Materials that can be advantageously used for the highly refractive sublayers include titanium oxide (TiO_2), tantalum oxide (Ta_2O_5) and zirconium oxide (ZrO_2), while silicon oxide (silica, SiO_2) or magnesium fluoride (MgF_2) may be preferably used for the lowly refractive sub-layers.

A halogen lamp 1 having a configuration as described above is then contained in a reflector 10.

The reflector 10 comprises a reflector main body 11 realized in the form of a paraboloid of revolution. While said reflector main body 11 may be made of glass, it is made of metal such as aluminum in this embodiment.

The front end 12 of said reflector main body 11 is circular and open and has an effective diameter of approximately 35 to 60mm. A tubular lamp base 13 is arranged at the rear end of the reflector main body 11.

Said tubular lamp base 13 is either cylindrical or prismatic, into which said pinch seal section 3 of the halogen lamp 1 is inserted from the front side.

The paraboloid of revolution of the reflector main body 11 provides a reflecting inner surface of the reflector which is coated with an infrared absorbing layer 14 and then with an interference layer 15.

Said infrared absorbing layer 14 is typically made of Cr_2O_3, SiO_x, TiO_x or $A\ell O_2$ and laid directly on the inner surface of the reflector main body 11 which is made of aluminum.

As described earlier, said interference layer 15 has a multi-layer structure comprising typically 21 sublayers, where sub-layers of a material having a high refractive index and selected from titanium oxide (TiO_2), tantalum oxide (Ta_2O_5) and zirconium oxide (ZrO_2) and those of another material having a low refractive index and selected from silicon oxide (silica, SiO_2) or magnesium fluoride (MgF_2) are arranged alternately.

A halogen lamp 1 as described earlier is then fitted into a reflector 10 having a configuration as described above to form an integral unit.

More specifically, the pinch seal section 3 of said halogen lamp 1 is bonded to the tubular lamp base 13 of the reflector 10 by means of an adhesive agent 16. To do this, the pinch seal section 3 of the lamp 1 is inserted into the tubular lamp base 13 of the reflector 10 from the front side in such a manner that the axis O_1 of the bulb of the halogen lamp 1 is aligned with the optical axis O_2 of the reflector 10 and the filament 6 is located at a given position relative to the focal point of the reflector 10 and then the space between the outer surface of said pinch seal section 3 and the inner surface of the tubular lamp base 13 is filled with the adhesive agent 16, which is thereafter dried and hardened to securely unite the lamp 1 and the reflector 10 together.

The adhesive agent 16 to be used for the purpose of the present invention is a heat-resistant inorganic adhesive agent that contains as a major ingredient an metal oxide such as alumina, silica, magnesia or zirconia.

Reference numeral 17 denotes a sealing plate that plays the role of hermetically sealing the rear opening of the tubular lamp base 13, helping the positioning of the halogen lamp 1 and preventing the adhesive agent 16 from running out.

A reflector type projection lamp according to the invention and having a configuration as described above operates in the following manner.

When the power switch for the halogen lamp 1 is turned on to energize the latter, the filament 6 glares and emits beams of light, which are transmitted through the bulb 2 and then mostly reflected by the interference layer 15 of the reflector 10 before they are projected forward through the front opening 12 of the reflector 10.

More specifically, beams of light emitted from the filament 6 pass through the bulb 1 and then hit the interference layer 9 arranged on the outer surface of the bulb 1 to reflect infrared light and transmit visible light. Of the light that gets to the interference layer 9, the infrared portion having a wavelength which is found within a range between 700 and 1.300nm is reflected by the interference layer 9 while the visible portion mostly passes through the layer 9.

The reflected beams of infrared light are returned to the filament 6 to additionally heat it so that the rate of the power consumption of the lamp 1 may be reduced by a certain degree while the efficiency of light emission of the lamp 1 may be improved.

Since the bulb 2 and the interference layer 9 arranged on the inner or outer surface of the bulb 2 are substantially spherical, all the reflected beams of infrared light are securely directed toward the center of the bulb 2, where the filament 6 is located. Consequently, the lamp 1 will present an enhanced efficiency.

Therefore, if the filament 6 is made relatively short, the beams of infrared light reflected by the interference layer 9 are securely returned to the filament so that the it can be effectively energized by lower voltage electricity.

On the other hand, of the light that has passed through the interference layer 9 and reached the reflecting surface of the reflector 10, the infrared portion, if any, having a wavelength greater than 700nm is transmitted through the interference layer 15 and absorbed the by infrared absorbing layer 14 to heat the reflector main body 11. Although the temperature of the reflector main body 11 may rise to some extent because of the heat given to it by the infrared light, the heat absorbed by the reflector main body will eventually be discharged into the atmosphere from its outer surface.

The visible portion of the light that has reached the interference layer 15 is reflected by it and then projected through the front end 12 of the reflector 10 to illuminate the surface of the object of illumination.

Thus, beams of infrared light emitted from the filament 6 are mostly blocked by the interference layer 9 arranged on the bulb 2 and the remaining beams, if any, that has passed through the interference layer 0 are sent backward into the atmosphere through the interference layer 15 on the reflector 10. Therefore, the object of illumination is totally free from infrared light emitted by the lamp 1 and hence deterioration by heat of the quality as a commodity.

It should be noted that the lighting efficiency of a halogen lamp 1 having a spherical bulb 2 and an interference layer 9 arranged on the inner or outer surface of the bulb is greater than a halogen lamp without such an interference layer by approximately 20 to 30%.

It should also be noted that the level of infrared light projected forward from the reflector 10 of a lamp having a configuration as described above is reduced by more than 10% as compared with a lamp having no interference layer on the reflector main body 11 because the infrared light emitted by the filament is mostly utilized within the lamp to heat the filament and therefore scarcely reaches the reflector 10. As a matter of course, the temperature rise of the reflector main body 11 is also minimized.

It may be more than clear now that the temperature rise of a room where such a reflector lamp is used is held to a minimum level and the cost of air conditioning for the room becomes negligible.

Now, some of the results of the experiments conducted by the inventor of the present invention for this embodiment will be described.

In an experiment where a spherical bulb having an outer diameter D of 12mm was used for a halogen lamp 1 having a rated voltage of 12V and a rated power of 35W, the lamp 1 showed a lighting efficiency of approximately 17.51m/W without an interference layer 9 and an efficiency of approximately 23.11m/W with a TiO_2-SiO_2 multi-layered interference layer 9 arranged on the outer surface of the bulb, representing an improvement of approximately 32%.

In another experiment, a lamp having a rated voltage of 12V and a rated power of 50W was fitted into a reflector having a mirror diameter of 50mm and provided with an interference layer 15 and the light forwardly projected from the lamp was spectroscopically analyzed. Fig. 2 shows a result of the analysis in terms of the relationship between the wavelength (nm) of the light emitted by the lamp and its relative energy output (%). The solid line in the graph represents the performance of the lamp when it was used with an interference layer 9, whereas the broken line represents the performance of the lamp when it was used without an interference layer.

It may be clear from the graph that a reflector type projection lamp according to the invention scarcely projects infrared light forward or, more specifically, more than 90% of the infrared light emitted from the lamp and going forward was blocked.

The graph also shows that, when the lamp was used with an interference layer 9, it had to consume electric power only at a rate of 37W in order to bring forth the same intensity of illumination as the one obtained by the lamp without an interference layer, consuming power at a rate of 50W. This represents an improvement in the lighting efficiency of 26%, implying that the temperature rise on the reflector 10 of such a lamp should be very low.

It may be understood that a reflector 10 made of metal, or aluminum in particular, is advantageous over an reflector made of glass because it can transfer and emit heat very quickly and is highly heat resistive, making itself practically free from breakage.

Therefore, if the reflector of a reflector type projection lamp having an configuration as described above by referring to the first embodiment of the invention is made of aluminum, it may prove to be sufficiently heat-resistive and feasible for practical applications even when the mirror diameter is modified from 50mm to 35mm to make the lamp compact.

In a still another experiment, a halogen lamp 1 having a spherical bulb was tested for the efficiency with which the beams of infrared light emitted from the filament 6 were returned to it.

The ratio of the intensity of the infrared light emitted from the filament 6 of a reflector type projection lamp to that of the infrared light returned to the filament depends on the geometry of the lamp and, therefore, it is termed here as geometric coefficient. Further, it is so defined that the geometric coefficient of a lamp is equal to 1 when all the beams of infrared light emitted from the filament of the lamp are returned to it, whereas the geometric coefficient is equal to 0 when all the beams of infrared light emitted from the filament go astray without returning to it.

As shown in Fig. 3, the diameter of a spherical bulb 2 is expressed by D and the length of a coil filament 6 arranged at the center of the bulb is expressed by 1, whereas d stands for the diameter of the coil filament 6.

Since the bulb 2 is spherical, the geometric coefficient is equal to 1 if the filament is completely spherical.

However, as a spherical filament is difficult to prepare, a coil filament is a practical choice for a reflector type projection lamp. Now, if l/d = 1, it signifies that the filament is infinitely close to a sphere and hence it may be easily assumed that such a filament is effective and desirable. In practice, however, beams of light emitted from the ends of such a filament can be hardly returned to it and 1 should be made relatively large in order to obtain a large geometric coefficient.

On the other hand, it may be safely assumed that the ratio l/d has little effect on the geometric coefficient if the filament is sufficiently small relative to the bulb diameter D.

The geometric coefficient can be optimized by defining the relationship among 1, d and D by way of the following formulas.

$1.0 < l/D \leqq 4.2$ (1)

$0.05 \leqq d/D \leqq 0.15$ (2)

or $d/D < 0.05$ (3)

These formulas defining the relationship among the filament length 1, the coil diameter d and the bulb diameter D are obtained as a result of a series of experiments conducted by the inventor of the present invention. Fig. 4 shows some of the results of the experiments.

In Fig. 4, the transverse axis indicates the ratio l/d and the ordinate axis indicates the geometric coefficient. A high geometric coefficient signifies a lamp where most of the beams of infrared light emitted from the filament are effectively returned to and absorbed by it.

From Fig. 4, it may be understood that, so long as the relationship $d/D < 0.05$ is maintained, any change in the value of l/d does not affect the geometric coefficient which is close to 1, although the bulb 2 should be made rather large.

On the other hand, if the relationship $d/D > 0.15$ is chosen, the filament needs to have a considerable length because the coil diameter d is rather large, although the bulb 2 may be made small.

Assuming $0.05 \leqq d/D \leqq 0.15$, the geometric coefficient is greater with $1.0 < l/D \leqq 4.2$ than with $l/d = 1$.

Thus, a reflector type projection lamp that satisfies either the formulas (1) and (2) or the formula (3) will show an improvement in the lamp efficiency if an interference layer that reflects infrared light and transmits visible light is installed.

The inventor of the present invention also conducted experiments to determine an optimum relationship between the size of the lamp 1 and that of the reflector 10.

Since a reflector type projection lamp 1 under consideration comprises a spherical bulb 2, part of the beams of light projected toward the back of the lamp 1 and reflected by the top area of the reflector 10 will hit the back area of the bulb 2 and will be reflected backward by it to hit again the reflector and to be reflected by it and so on until they are scattered and lose parallelism so that consequently no desired beams of light may be obtained.

In order to overcome this problem, the relationship between the size of the reflector 10 and that of the bulb 2 of the lamp 1 was studied by the inventor of the present invention.

Fig. 5 diagrammatically shows the positional relationship between the reflector 10 and the lamp 1.

The reflector 10 is realized as a part of the surface of a spheroid as seen from Fig. 5. Let us assume that the major axis of the spheroid has a length of a and the focal point is located at point Fr, while the outer diameter of the spherical bulb 2 is D and the center of the bulb is at point 0.

Now, in order to avoid scattering of visible light caused by hitting the bulb after being reflected by the reflector, it was found by the inventor of the present invention that the value of D/a and the distance between 0 and Fr should satisfy the respective conditions as shown below.

$D/a \leqq 0.25$ (4)

distance between 0 and Fr $\leqq$ 2mm (5)

Differently stated, if the bulb 2 is too large relative to the reflector 10, a large portion of the light reflected by the reflector 10 hits the bulb to scatter and not to produce intended parallel beams of light. If, on the one hand, the center 0 of the bulb is moved too much to the right relative to the focal point Fr or off the major axis of spheroid either upward or downward in Fig. 5, the reflected beams of light tends to converge and are, therefore, more likely to hit the bulb. On the other hand, the center 0 of the bulb is moved left too far from the focal point Fr in Fig. 5, the light reflected by the reflector can easily hit the bulb because the distance between the reflector 10 and the bulb 2 is short. Therefore, the size of the bulb and its position relative to the reflector are vital to the efficiency of a reflector type projection lamp under consideration.

Now, some of the results of the experiments conducted by the inventor on these factors will be described.

Fig. 6 shows different illumination patterns obtained by shifting the position of the bulb relative to the reflector of the first embodiment of the invention as illustrated in Figs. 1. Here, the lamp was directed downward and the illuminance of the lamp was measured on a plane located 1m below the lamp. Of the six different illumination patterns, those that are marked by either o or ⓞ are acceptable ones, whereas those that are marked by either △ or x should be avoided.

Table 1 below shows a result of an experiment conducted by placing the center O of the bulb exactly on the focal point Fr of the reflector and varying the value of D/a.

It is obvious from Table 1, the illumination pattern is acceptable as long as the condition D/a ≦ 0.25 is met and any scattering of light attributable to the bulb does not practically occur where the condition D/a ≦ 0.20 is satisfied. It may be needless to say that the smaller the

Table 1

D/a	illumination pattern
0.15	ⓞ
0.20	ⓞ
0.25	o
0.30	△
0.35	x

value of D is, the better is the performance of the lamp in terms of scattering of light.

Table 2 below shows the result of an experiment where the condition D/a = 0.25 was constantly maintained, while the center 0 of the bulb was shifted relative to the focal point Fr.

In Table 2, negative values indicates that the center C of the bulb was displaced to the left of the focal point Fr, whereas positive values signifies that the center C of the bulb was moved to the right of the focal point Fr. 0 signifying that the two points agree with each other in

Table 2

distance between O and Fr (mm)	:	illumination pattern
-0.2 or less	:	Δ or x
-0.2	:	o
-0.1	:	◎
±0	:	◎
+1.0	:	◎
+2.0	:	o
+2.0 or more	:	Δ or x

It is seen from Table 2 above that the illumination pattern will be acceptable if the distance between O and F is found within ±2.0. A small value is desirable for D/a.

These facts verify that a reflector type projection lamp under consideration will be satisfactory if the conditions expressed by the formulas (4) and (5) above are met.

It should be stressed that the present invention is not limited to the above described embodiment. While a coil filament 6 is arranged in such a manner that its axis lies on the axis O_1 of a bulb that contains it in the first embodiment of Fig. 1, there may be alternatively arranged a coil filament 6a in a bulb that crosses the axis O_1 of the bulb as in the case of a second embodiment illustrated in Fig. 7.

Still alternatively, as seen from a third embodiment illustrated in Fig. 8, a reflector type projection lamp according to the invention may be provided with a light transmitting front cover 20 arranged on the front end 12 of the reflector 10. With such an arrangement, debris of glass may be prevented from flying away by the cover 20 if the bulb 2 of the lamp 1 is broken to pieces by accident.

While such a cover 20 arranged at the front end 12 of a reflector 10 may contribute to the temperature rise of the reflector main body 11 when the lamp is energized, such a factor will be negligible in practical applications if an interference layer for reflecting infrared light and transmitting visible light is arranged on the outer or inner surface of the bulb in order to reduced the thermal load applied to the reflector main body made of aluminum, as in the case of the present invention.

A reflector main body 11 made of aluminum provides an advantage that an electric lamp 1 may be fitted to the reflector 10 by mechanical means such as pinch bands or screws without using adhesive which is required if the main body 11 is made of a plastic material.

The bulb of an electric lamp 1 to be used for the purpose of the present invention may not necessarily be spherical and it may be spheroidal as in the case of a fourth and a fifth embodiments of the invention illustrated respectively in Figs. 9 and 10, where reference numerals 120 and 130 denotes the respective spheroidal bulbs.

When a spheroidal bulb 120 or 130 is used, the axis of the coil filament 6 is arranged along the major axis of the filament 6, which is found between the first and second focal points F_1 and F_2 of the spheroidal bulb.

With such an arrangement, infrared light reflected by an interference layer arranged on the outer or inner surface of the bulb 120 or 130 to reflect infrared light and transmit visible light is securely returned to the filament 6 to enhance the efficiency of the lamp.

A spherical bulb 2 of an incandescent lamp according to the invention may advantageously have a wall thickness at the bulb top area, which is found opposite to the pinch seal section 3, approximately 1.2 to 1.8 times greater than that of the bulb side area. Such an arrangement provides a well balanced thermal distribution over the entire area of the bulb surface so that generation of thermal strain and stress on the bulb surface and hence the risk of breakage of the bulb may be minimized.

Fig. 11 shows a sixth embodiment of the invention having a configuration similar to that of the first embodiment of the reflector type projection lamp as illustrated in Fig. 1.

Since the bulb 2 of the incandescent lamp 1 of this embodiment is provided with a metal reflector 20 at the rear area, beams of (both infrared and visible) beams of light emitted from the filament 6 and directed backward are reflected by this metal reflector 20 and do not go backward any further. This means that no light reaches the rear portion of the reflector 10 and hence no repeated reflection of light takes place between the rear portion of the reflector 10 and the rear surface of the bulb 2 as indicated by A in Fig. 12. Consequently, there does not occur any scattering of light beams projected forward from the reflector 10 and the lamp produces only desired parallel beams of light.

Fig. 13 shows the result of an experiment conducted to measure the distribution of intensity of illuminance, using the sixth embodiment as described above. Here, the lamp was directed downward and the illuminance of the lamp was measured on a plane located lm below the lamp.

The solid line in the graph of Fig. 13 shows the distribution of illuminance when a metal reflector 20 was arranged at the rear area of the bulb 2, whereas the broken line indicates the distribution of illuminance when such a metal reflector was not used.

The graph clearly shows the effect of the use of such a reflector.

It should be noted that the mode of covering the rear portion of an incandescent lamp to block light according to the invention is not limited to that of the six embodiment as described above or a reflector 20.

In other words, any screen 20 may be used so long as it effectively prevents light irradiated by the filament 6 from passing through it and reaching the rear area of the reflector 10 and candidates for such a screen 20 may include, beside a reflector of light, a light reflecting and scattering film made of alumina powder, a light scattering and transmitting film prepared by means of the technique of frosting and a black coating layer made of cobalt oxide, nickel oxide or a similar material that absorbs light.

The bulb of an incandescent lamp provided with a screen 20 may not necessarily be spherical as in the case of the above described embodiment and it may be spheroidal as bulb 120 of a seventh embodiment illustrated in Fig. 14 or bulb 130 of an eighth embodiment of Fig. 15.

When a spheroidal bulb such as the bulb 120 or the bulb 130 is used, the axis of the coil filament 6 is arranged along the major axis of the filament 6, which is found between the first and second focal points F_1 and F_2 of the spheroidal bulb.

With such an arrangement, infrared light reflected by an interference layer arranged on the outer or inner surface of the bulb 120 or 130 to reflect infrared light and transmit visible light is securely returned to the filament 6 to enhance the efficiency of the lamp.

It may be understood that both spherical bulbs 120 and 130 having a screen 20 arranged at the rear portion are free from scattering of beams of light.

Note that both the seventh and eighth embodiments are respectively similar to the fourth and fifth embodiments illustrated in Figs. 9 and 10 and described earlier except that they are provided with a screen 20.

A screen 20 arranged on the bulb 2 of an incandescent lamp 1 according to the invention in order to block light from passing may be replaced by a means for preventing reflection of light arranged on the reflector 10.

A ninth embodiment illustrated in Fig. 16 comprises such an alternative means. The reflector 10 of this embodiment is provided with a light absorbing or scattering film 30 at the top in order to prevent reflection of light from taking place there.

The area covered by a light absorbing or scattering film 30 is defined by a contour line passing through point P in Fig. 12.

With an arrangement as described above, light emitted backward from the filament 6 passes through the rear portion of the bulb 2 and reaches the rear area of the reflector 10, where it is absorbed or scattered by the light absorbing or scattering film 30 and would never goes back to the rear portion of the bulb 2. Consequently, there does not occur any scattering of light beams projected forward from the reflector 10 and the lamp produces only desired parallel beams of light.

The ninth embodiment of the invention as illustrated in Fig. 16 has a configuration similar to that of the first embodiment of the reflector type projection lamp as illustrated in Fig. 1 except that it has a light absorbing or scattering film arranged on the reflector 10.

While a coil filament 6 is arranged in this embodiments in such a manner that its axis lies on the axis O_1 of a bulb that contains it, there may be alternatively arranged a coil filament in a bulb that crosses the axis O_1 of the bulb.

Still alternatively, a reflector type projection lamp according to the invention may be provided with a light transmitting front cover 20 arranged on the front end 12 of the reflector 10. With such an arrangement, debris of glass may be prevented from flying away by the cover 20 if the bulb 2 of the lamp 1 is broken to pieces by accident.

In practice, it is unavoidable that the filament 6 is fixed slightly off the desired position. The bulb 2 of the incandescent lamp 1 is spherical or has an elliptical vertical cross section, and has a focal point within it. Hence, the actual position of the filament 6 determines the paths of the infrared rays which are radiated from the filament 6, are reflected from the interference layer 9 formed on the inner surface of the bulb 2, and travel toward the filament 6.

If the filament 6 is fixed, with its center P displaced from the center of the bulb 2 by distance f as is shown in Fig. 17, less infrared rays than otherwise will reach the filament 6, or the distribution of these infrared rays will not be uniform. Consequently, the efficiency and/or lifetime of the incandescent lamp decrease due to the non-uniform temperature distribution in the filament 6.

In practice, it is very difficult to reduce the displacement f of the filament 6 to nil. Hence, it is necessary to reduce the displacement f as much as possible.

Fig. 18 represents the relationship between the displacement f and the efficiency of the lamp. More precisely, this figure shows the results of the experiment wherein three incandescent lamps whose bulbs and filaments have different diameters are tested to determine how the lamp efficiency is influenced by f/(D-d), where D and d are the diameter of the bulb 2 and that of the filament 6, respectively. As is evident from Fig. 18, the lamp can have a high efficiency if:

$$f/(D-d) \leqq 0.3$$

Thus, in order to give the lamp 1 sufficient efficiency, it is necessary to reduce the displacement f to such value that f/(D-d) is equal to or less than 0.3.

Fig. 19 illustrates the relationship between the displacement of the filament and the lifetime of the incandescent lamp. Obviously, the greater the displacement f, the longer the lifetime of the lamp. This is because the amount of the infrared rays reaching the filament decreases as the displacement f become greater. Hence, in order to improve the lamp lifetime only, it is an necessary to reduce the displacement f to nil.

A lamp to be used for the purpose of the present invention is not necessarily a halogen lamp and it may be any incandescent lamp.

A reflector to be used for the purpose of the present invention is not necessarily a reflector provided with an interference layer 14 and an infrared light absorbing layer 15 on its light reflecting surface. If the reflector main body 11 is made of glass, for instance, it may be provided only with an interference layer on its light reflecting layer.

The sealing structure at the end of a reflector to be used for the purpose of the present invention may not necessarily be realized in the form of a pinch seal section. Alternatively, it may be realized in the form of a stem seal section. Such a sealing structure may be secured to the reflector 10 by any appropriate means other than adhesive 16.

Claims

1. An incandescent lamp comprising a lamp bulb and a filament contained within said bulb, said bulb having an interference layer arranged on its inner or outer surface to reflect infrared light and transmit visible light, characterized in that said bulb (2) is either spherical or spheroidal.

2. An incandescent lamp according to claim 1, characterized in that said incandescent lamp (1) is a halogen lamp airtightly containing halogen gas or a halogen compound in the bulb (2).

3. An incandescent lamp comprising a lamp bulb and a coil-shaped filament, said bulb having an interference layer arranged on its inner or outer surface to reflect infrared light and transmit visible light, characterized in that said bulb (2) is spherical and the relationship between the diameter d and the length 1 of said filament (6) is defined by formula

   $$1.0 < 1/d \leqq 4.2.$$

4. An incandescent lamp according to claim 3, characterized in that said incandescent lamp (1) is a halogen lamp airtightly containing halogen gas or a halogen compound in the bulb (2).

5. An incandescent lamp according to claim 3, characterized in that the relationship between the diameter D of the bulb (2) and the diameter d of the filament (6) is expressed by formula

$$0.05 \leqq d/D \leqq 0.15.$$

6. An incandescent lamp according to claim 1, characterized in that the relation of $f/(D-d) \leqq 0.3$ holds true, where f is displacement of the center of said filament (6) from the center of said bulb (2), and D is the diameter of said bulb (2), and d is the diameter of said filament.

7. A reflector type projection lamp comprising an incandescent lamp having a bulb and a filament contained in said bulb, said bulb being provided on its inner or outer surface with an interference layer for reflecting infrared light and transmitting visible light, and a reflector integrally assembled with said incandescent lamp and provided on its reflecting surface with an interference layer for reflecting visible light and transmitting infrared light, characterized in that said bulb (1) is either spherical or spheroidal.

8. A reflector type projection lamp according to claim 7, characterized in that said incandescent lamp (1) is a halogen lamp airtightly containing halogen gas or a halogen compound in the bulb (2).

9. A reflector type projection lamp according to claim 7, characterized in that said bulb (2) is spherical and the relationship between its diameter d and the length 1 of said filament (6) is defined by formula

$$1.0 < 1/d \leqq 4.2.$$

10. A reflector type projection lamp comprising an incandescent lamp having a bulb and a filament contained in said bulb, said bulb being provided on its inner or outer surface with an interference layer for reflecting infrared light and transmitting visible light, and a reflector integrally assembled with said incandescent lamp and provided on its reflecting surface with an interference layer for reflecting visible light and transmitting infrared light, characterized in that said bulb (2) is either spherical or spheroidal with diameter D and the reflecting surface of said reflector (10) is spheroidal with length a of the major axis, the relationship between the diameter D of the bulb (2) and the major axis a of the reflector (10) being defined by formula

$$D/a \leqq 0.25.$$

11. A reflector type projection lamp according to claim 10, characterized in that said incandescent lamp (1) is a halogen lamp airtightly containing halogen gas or a halogen compound in the bulb (2).

12. A reflector type projection lamp according to claim 10, characterized in that said bulb (2) is spherical and the relationship between the diameter d and the length 1 of said filament (6) is defined by formula

$$1.0 < 1/d \leqq 4.2.$$

13. A reflector type projection lamp comprising an incandescent lamp having a bulb and a filament contained in said bulb, said bulb being provided on its inner or outer surface with an interference layer for reflecting infrared light and transmitting visible light, and a reflector integrally assembled with said incandescent lamp and provided on its reflecting surface with an interference layer for reflecting visible light and transmitting infrared light, characterized in that said bulb (2) is either spherical or spheroidal and the bulb (2) of said incandescent lamp (1) is provided on its surface with a screen for blocking passage of light at a rear portion opposite to the center area of said reflector (10).

14. A reflector type projection lamp according to claim 13, characterized in that said incandescent lamp (1) is a halogen lamp airtightly containing halogen gas or a halogen compound in the bulb (2).

15. A reflector type projection lamp comprising an incandescent lamp having a bulb and a filament contained in said bulb, said bulb being provided on its inner or outer surface with an interference layer for reflecting infrared light and transmitting visible light, and a reflector integrally assembled with said incandescent lamp and provided on its reflecting surface with an interference layer for reflecting visible light and transmitting infrared light, characterized in that said bulb (2) is either spherical or spheroidal

and said reflector (10) is provided with a screen for blocking passage of light at its center area opposite to the rear portion of the bulb (2) of said incandescent lamp (1).

16. A reflector type projection lamp according to claim 15, characterized in that said incandescent lamp (1) is a halogen lamp airtightly containing halogen gas or a halogen compound in the bulb (2).

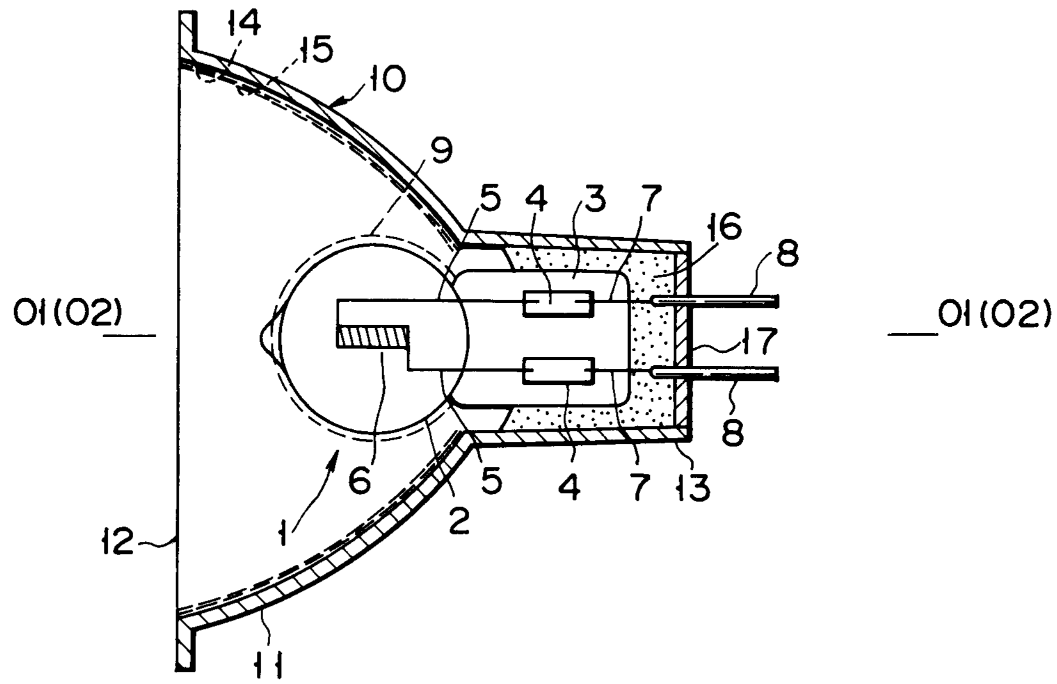

14
15
10
9
5
4
3
7
16
8
O1(O2)
O1(O2)
17
8
6
5
4
7
13
1
2
12
11

FIG. 1

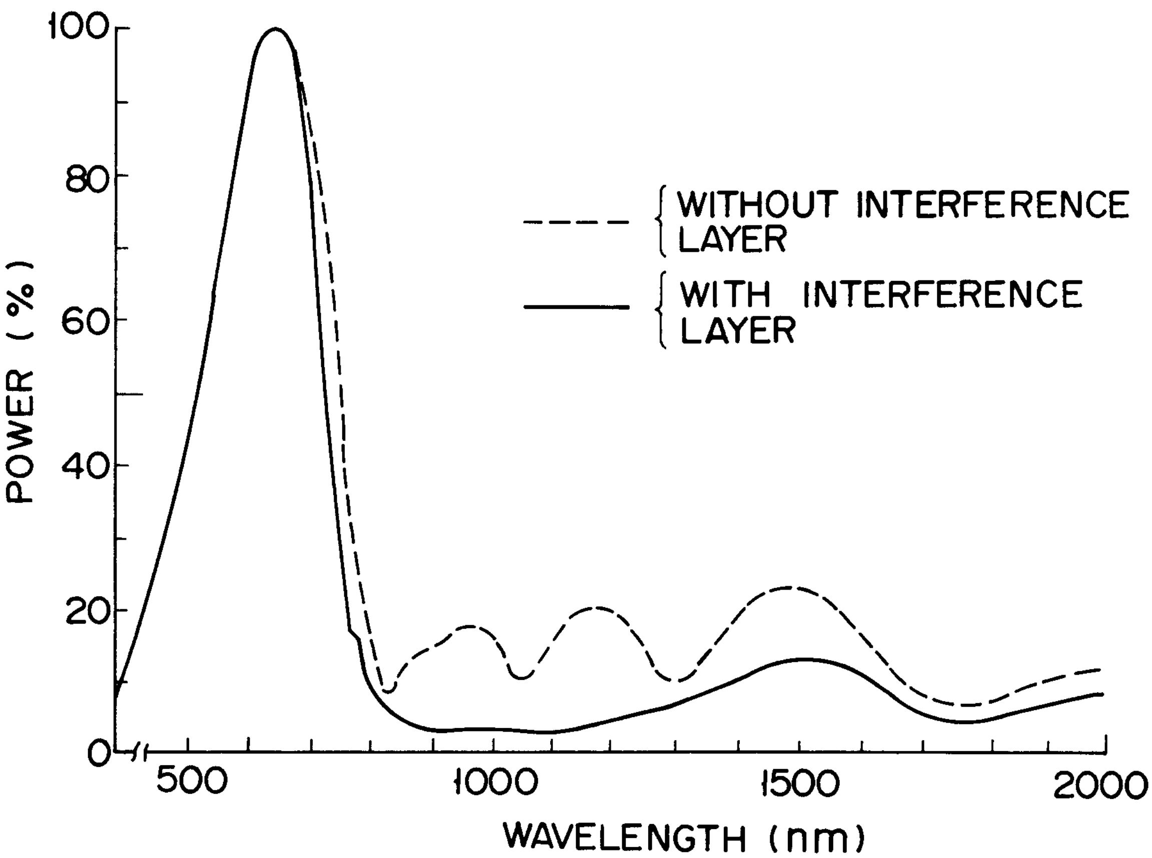
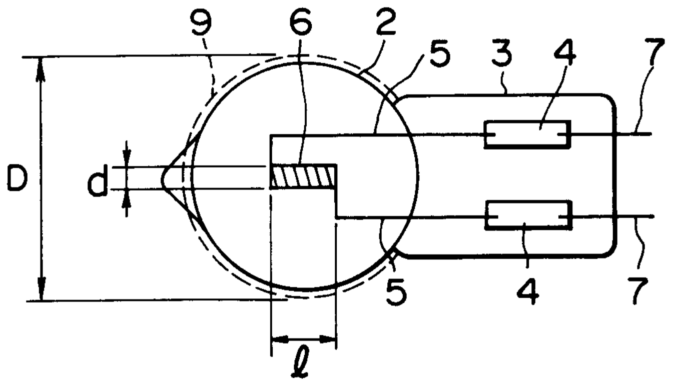
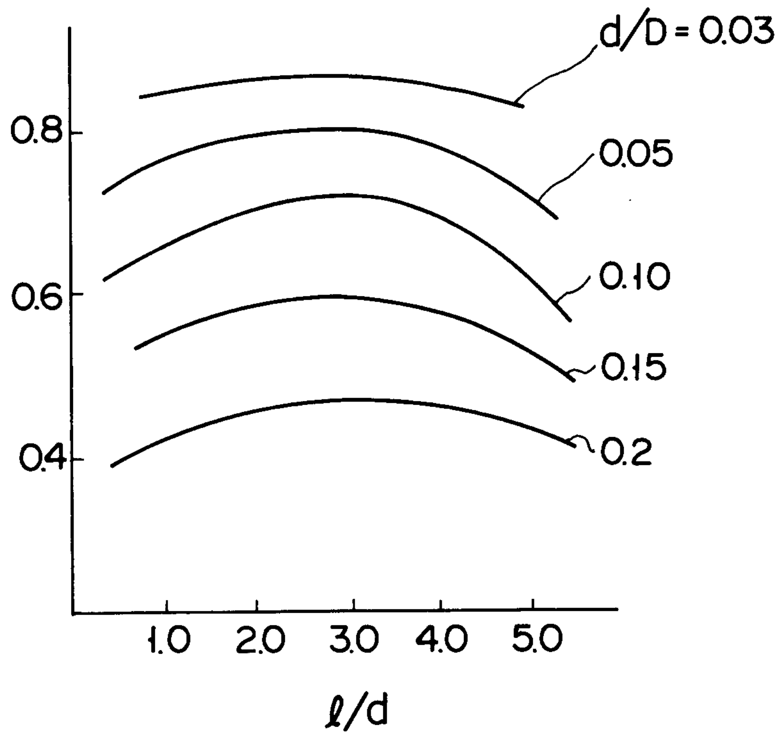

100
80
60
40
20
0
POWER (%)
WITHOUT INTERFERENCE LAYER
WITH INTERFERENCE LAYER
500
1000
1500
2000
WAVELENGTH (nm)

FIG. 2



F I G. 3



F I G. 4

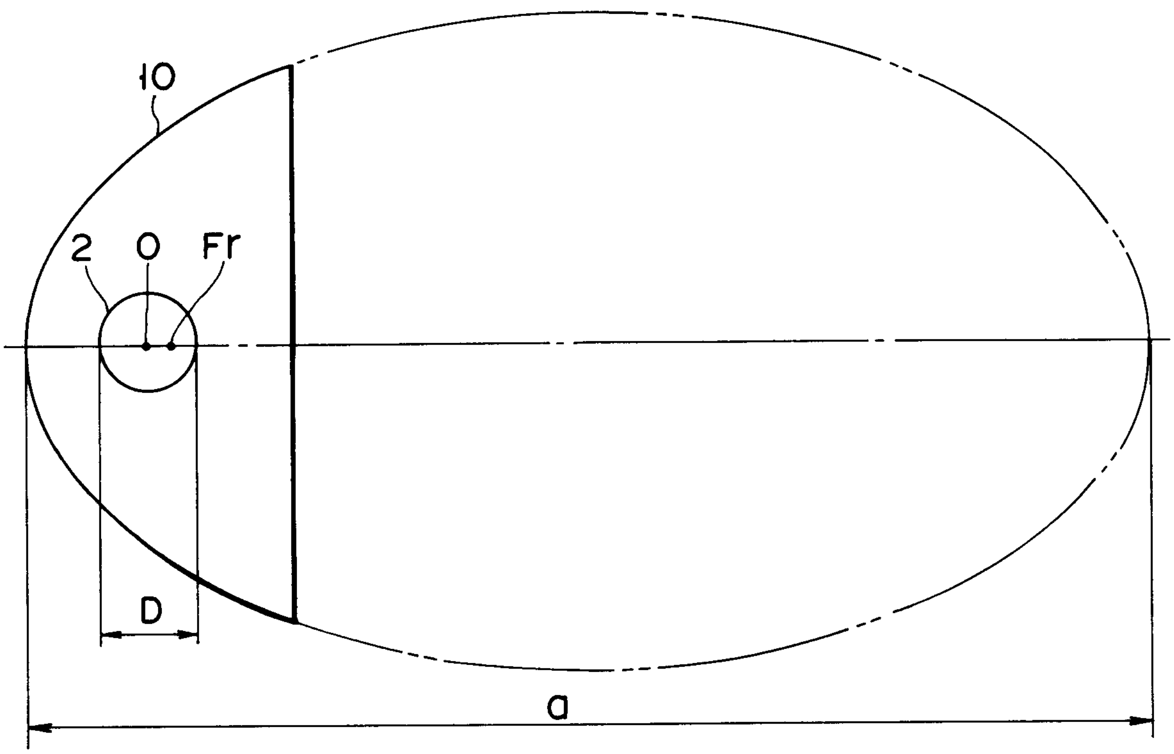


FIG. 5

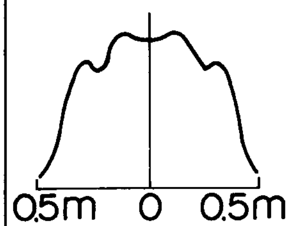
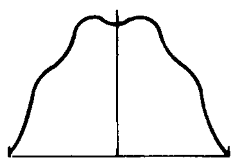
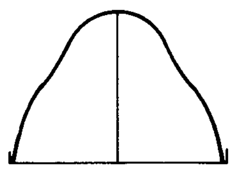
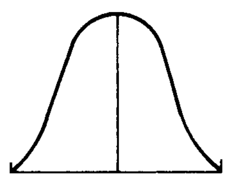
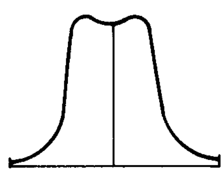
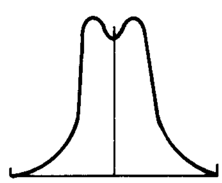
PATTERN	
	×
	△
	○
	◎
	○
	△

FIG. 6

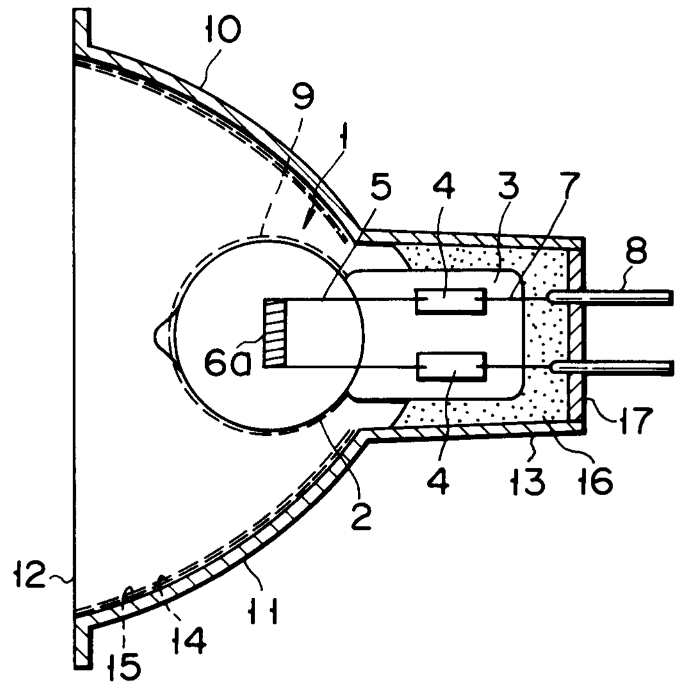

10
9
1
5
4
3
7
8
6a
4
17
4
13
16
2
12
11
14
15

FIG. 7

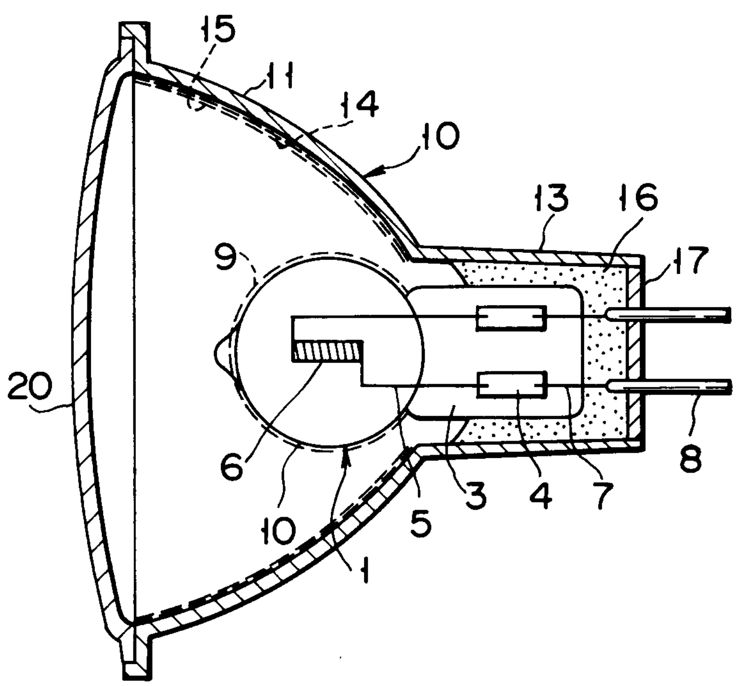

15
11
14
10
13
16
17
9
20
6
3
4
7
8
10
5
1

FIG. 8

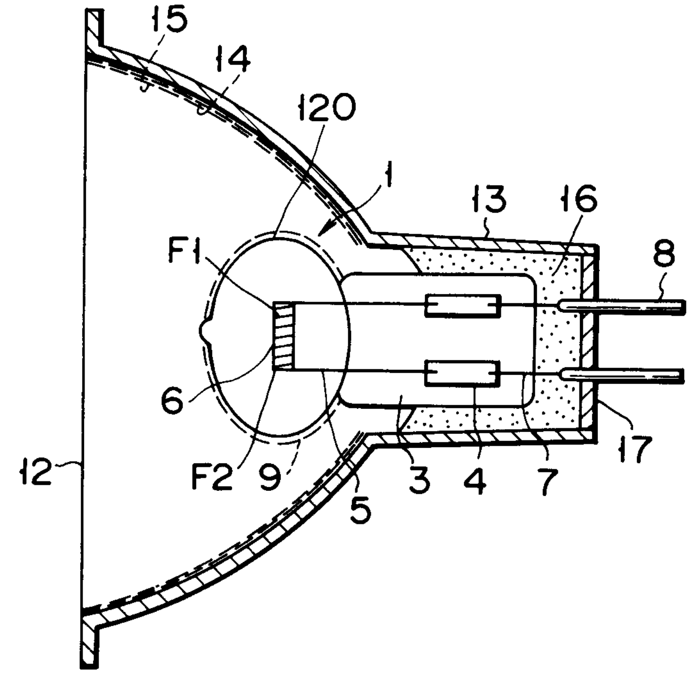

15
14
120
1
13
16
8
F1
6
17
12
F2
9
3
4
7
5

FIG. 9

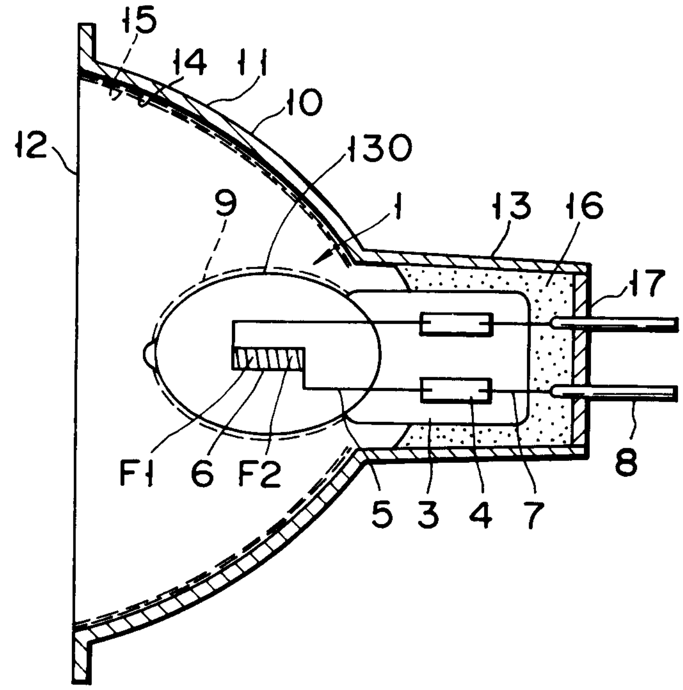
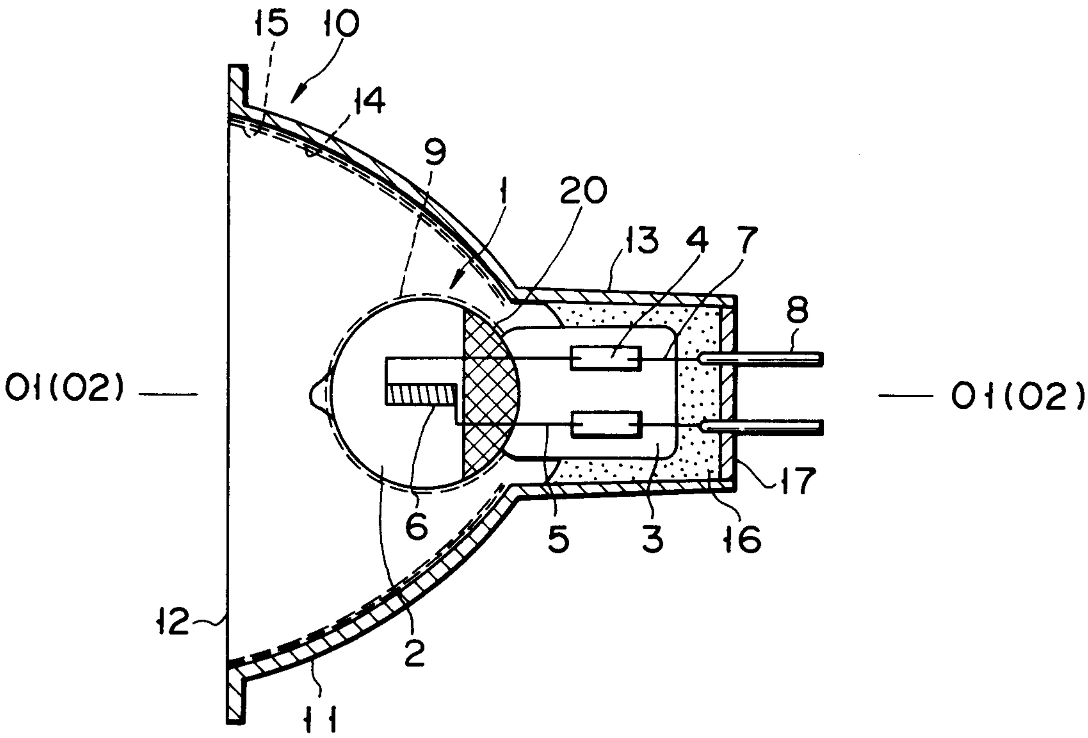
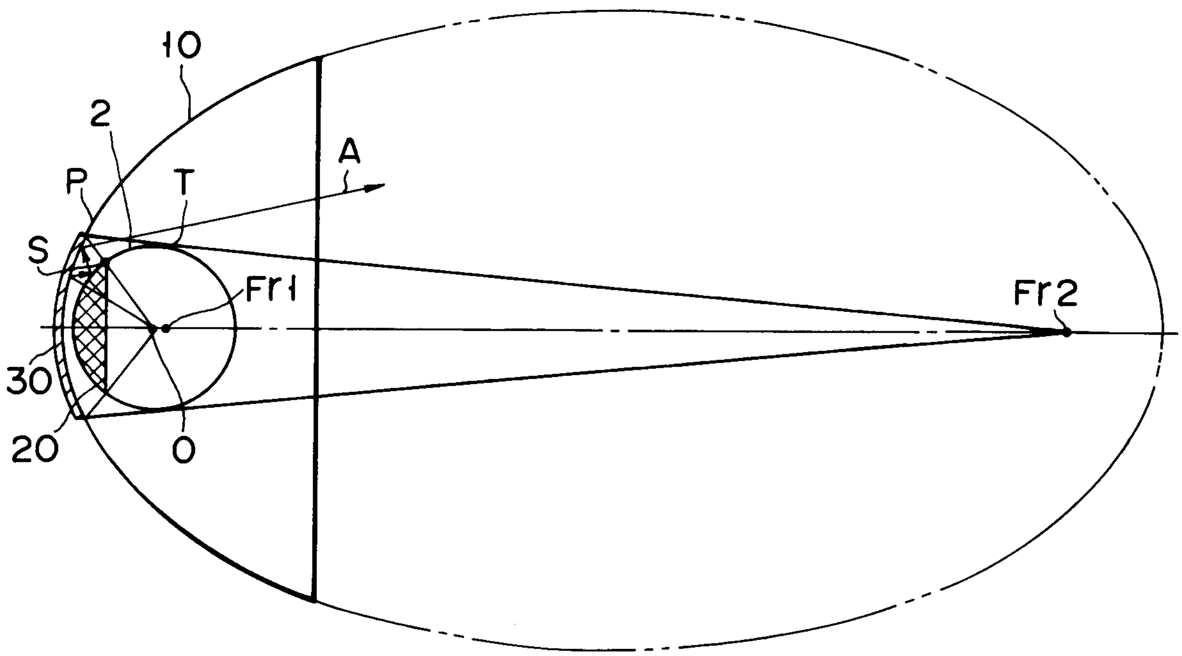

15
14
11
10
12
130
9
1
13
16
17
F1
6
F2
8
5
3
4
7

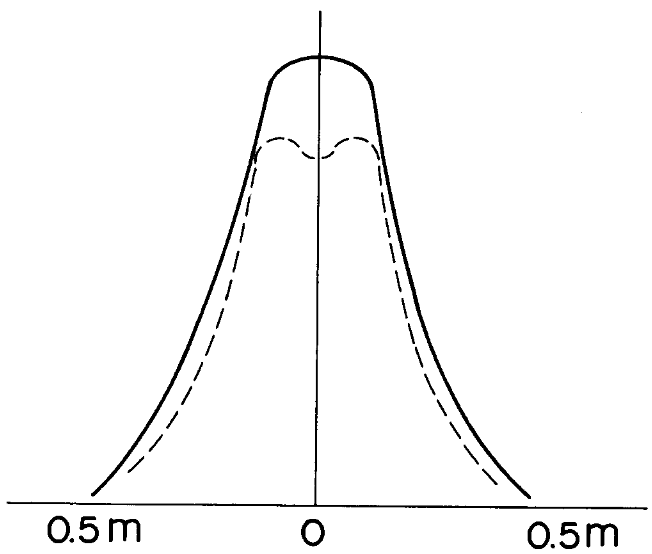
FIG. 10



F I G. 11



F I G. 12



F I G. 13

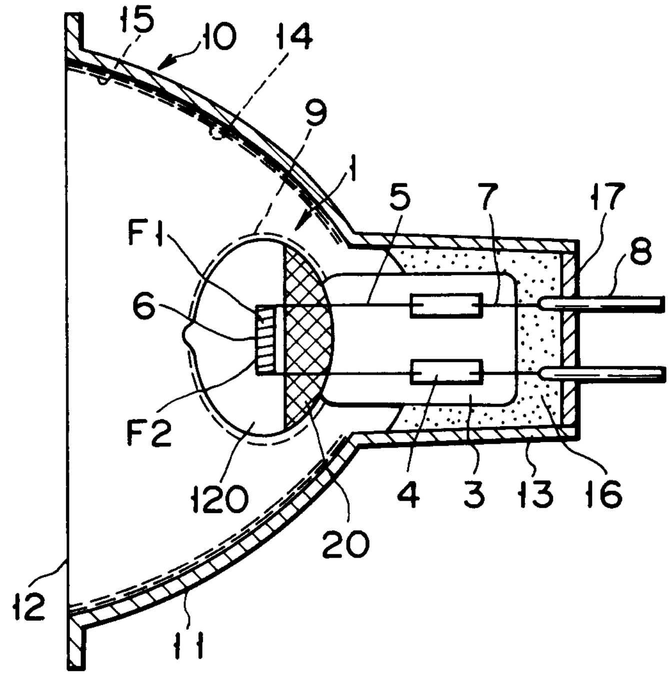

15
10
14
9
1
5
7
17
8
F1
6
F2
120
4
3
13
16
20
12
11

FIG. 14

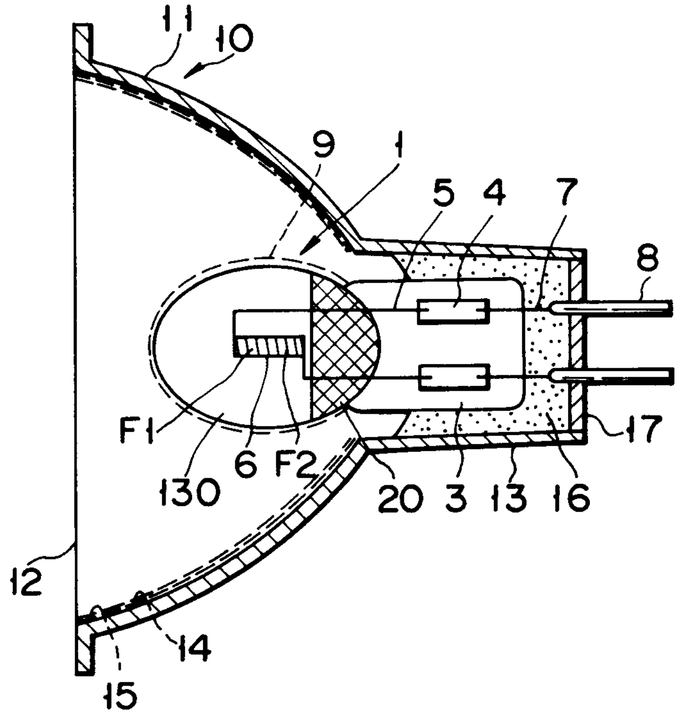

11
10
9
1
5
4
7
8
F1
6
F2
130
20
3
13
16
17
12
14
15

FIG. 15

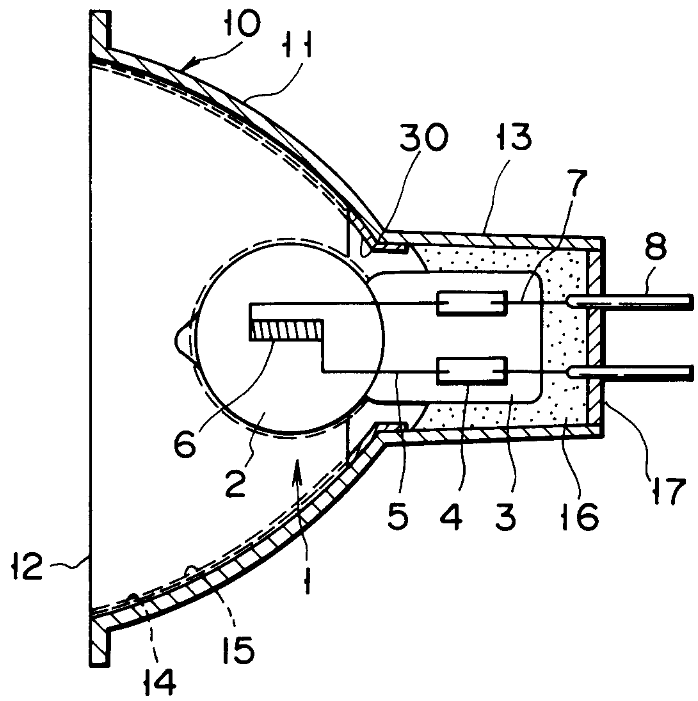
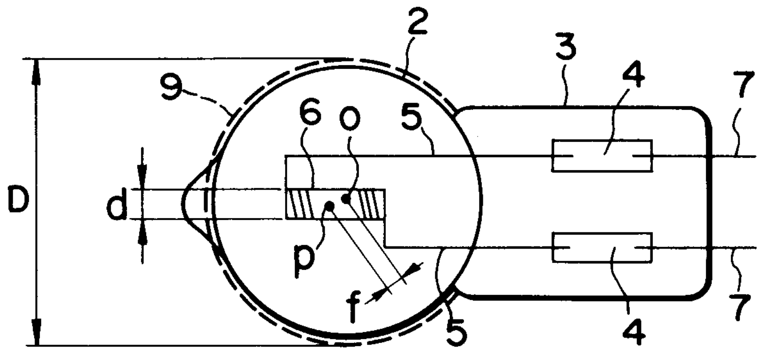
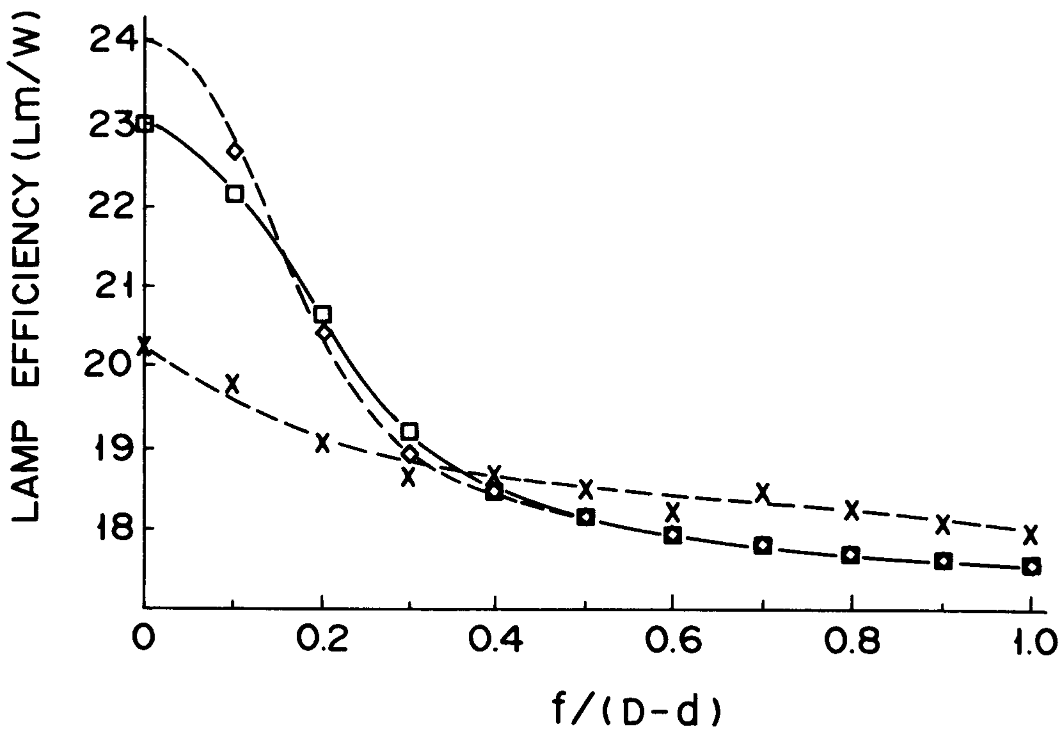


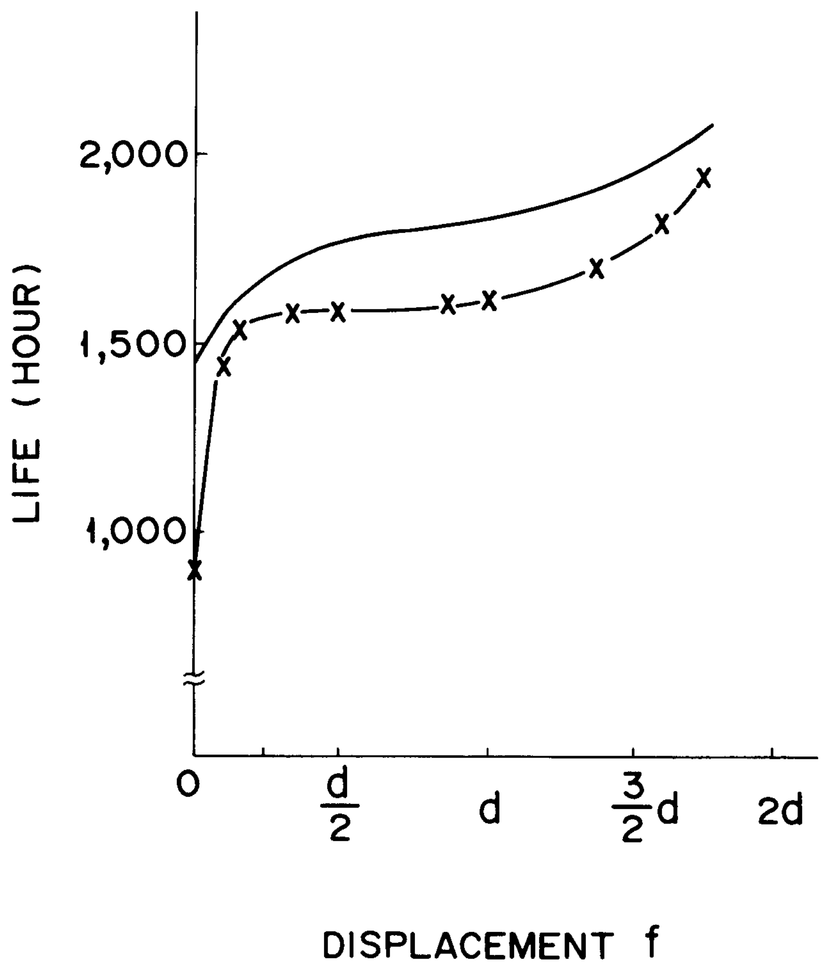
FIG. 16


2
3
4
7
9
6
o
5
D
d
p
f
5
4
7

F I G. 17


LAMP EFFICIENCY (Lm/W)
24
23
22
21
20
19
18
0
0.2
0.4
0.6
0.8
1.0
f/(D-d)

F I G. 18



F I G. 19