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(54) **Reflector lamp utilizing lens bonded with solder glass and method of making the same.**

(57) A method for constructing a reflector lamp and a lamp constructed using the method. A lamp assembly includes a reflector (14) having an optical axis (16) and a contact surface (34), a lens (20) having an optical axis (16) and a contact surface (32) and a solder glass (30) between the contact surface (32) of the lens (20) and the contact surface (34) of the reflector (14). The lamp assembly is heated to an elevated temperature sufficient to melt the solder glass (30). The elevated temperature is maintained for a time sufficient to bond the solder glass (30) to the lens (20) and the reflector (14), respectively. The solder glass (30) has a thermal expansion coefficient which is substantially matched to a thermal expansion coefficient of the lens (20) and the reflector (14). The solder glass (30) further requires processing times and temperatures which do not substantially degrade a reflective coating (18) on an inside surface of the reflector (14).

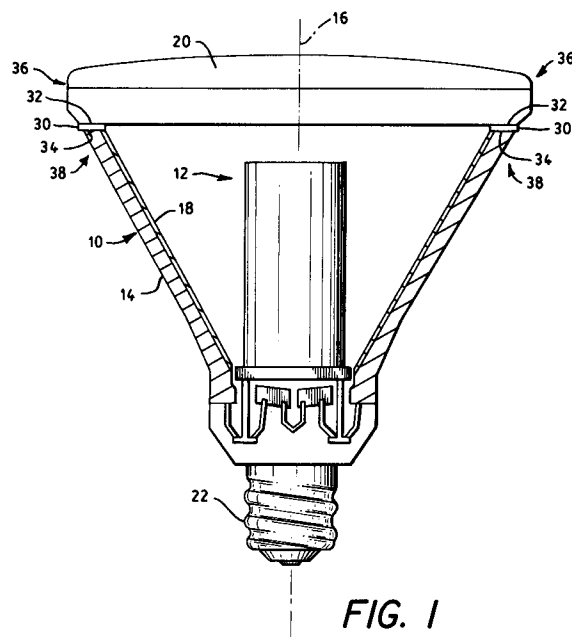


FIG. 1

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to the field of electric lamps for general illumination. More particularly, the present invention relates to reflector lamps which include a lens bonded to a reflector.

2. Discussion of the Related Art

Reflector lamps which utilize a lens bonded to a reflector are well-known. Examples include automobile headlamps and spotlights or floodlights for indoor and outdoor use. In these lamps, a light source is mounted in a sealed outer envelope which includes a reflecting interior surface, typically parabolic, for directing light in a preferred direction. The reflector is covered with a lens, and a base is provided for mounting the light source and for interconnection of the light source to an electrical energy source. Incandescent lamps, mercury arc tubes, metal halide arc tubes, and tungsten halogen light sources are utilized as light sources in reflector lamps.

During assembly of reflector lamps, the lens is usually bonded to the reflector at one end during one operation, and a base including the light source is inserted into the reflector and bonded to the other end of the reflector. Three techniques are conventionally used to bond the lens to the reflector. The first technique uses so-called "organic bonding" technology which involves applying an organic adhesive to the lens or reflector and then pressing the lens and reflector together. Thereafter, the lens and reflector assembly is placed in an oven and heated to approximately 200°C for a time sufficient to cure the organic adhesive. The type of organic adhesive most commonly employed is an epoxy. Organic bonding technology, however, is limited to a maximum operational temperature of approximately 250-300°C. If the temperature of the lens to reflector bond exceeds this temperature range during operation, such as when a high wattage lamp is on for an extended period of time, the epoxy has a tendency to char, which may cause the lens to pop off the reflector. This temperature limitation thus limits the maximum wattage of the light source and/or the minimum lamp size that will dissipate enough heat to prevent destruction of the epoxy bond.

More recently, so-called "inorganic bonding" technology, including adhesives such as ARON-D manufactured by Gosei Chemical, Japan, have been used to bond reflectors to lenses. Inorganic bonding technology is not restricted by the temperature limitation of organic bonding technology

and still retains the simplicity and flexibility of the bonded reflector and lamp construction technique.

However, both organic bonding technology and inorganic bonding technology suffer from a further limitation which restricts their use in reflector lamps. None of the organic adhesives or inorganic adhesives form a gas or water vapor impermeable bond. If, for a variety of reasons, such as the intended lamp use or the particular light source to be used within the lamp, it is necessary to maintain a moisture or oxygen-free atmosphere inside the assembled reflector lamp, organic or inorganic adhesives will not work. Additionally, inorganic adhesives do not form an impermeable barrier to liquid water. Consequently, in any application in which the lamp may be exposed to liquid moisture, inorganic bonding technology cannot be used, despite its superior temperature performance when compared to organic bonding technology.

In view of these limitations, the traditional approach to bonding a lens to a reflector when assembling a reflector lamp that will have a high operational temperature and/or requires a sealed environment within the lamp has been to use so-called "flame sealing" or fusing technology. In a flame sealing operation, the lens and the reflector are assembled into a lamp assembly and heated to an elevated temperature such that a portion of the glass at the contacting surfaces between the lens and the reflector melts and fuses together. However, the flame sealing process is expensive and difficult to carry out. The glass must be heated through multiple heating stages up to its working temperature (the temperature at which the glass can be formed or worked) which is generally greater than 1,200°C. Temperatures this high tend to degrade or destroy the reflective coating on the inside surface of the reflector, since these coatings can only withstand temperatures of up to approximately 550°C. Thus, the flame sealing process has a tendency to damage the coating close to the joint between the lens and the reflector. Furthermore, since heat is applied from the outside of the lamp assembly, controlling the formation of the seal between the lens and the reflector inside the lamp envelope is difficult. This can result in stresses which cause cracking of the lamp envelope. Finally, multiple cooling stages are required in which the lamp is cooled at a controlled rate to avoid inducing additional stresses into the lamp envelope, which may cause failure at a later time during operation.

It is a general object of the present invention to provide improved reflector lamps and improved methods of making reflector lamps.

A further object of the present invention is to provide a simpler and lower cost method for bonding a lens to a reflector during construction of a

reflector lamp that provides a lamp having the same or greater range of operational temperatures and impermeability to gases and liquids as a lamp constructed using the flame sealing process.

Another object of the present invention is to provide a simple, low cost method for bonding a lens to a reflector during construction of a reflector lamp that does not substantially degrade the performance of a reflective coating applied to an inside surface of the reflector.

Yet another object of the invention is to provide a lamp having the same or greater range of operational temperatures and impermeability to gases and liquids as a flame-sealed lamp but at a lower assembly cost.

SUMMARY OF THE INVENTION

The foregoing and other objects and advantages of the present invention are achieved in a method for constructing an electric lamp and a lamp constructed by the method, including a reflector having an optical axis and a contact surface and a lens having an optical axis and a contact surface. The method includes the steps of applying a solder glass to the contact surface of either the reflector and/or the lens, and forming a lamp assembly by moving the reflector and the lens together to join the reflector and the lens so that the solder glass is located between the contact surface of the lens and the contact surface of the reflector. The method further includes heating the lamp assembly to an elevated temperature sufficient to soften the solder glass and maintaining the lamp assembly at the elevated temperature for a time sufficient to bond the solder glass to the lens and the reflector, respectively, and to seal the lens to the reflector.

In a preferred embodiment, the solder glass is first applied to either the lens or the reflector and the lens or reflector is individually heated to remove any binder material from the solder glass. The solder glass is chosen so that a thermal expansion coefficient of the solder glass is substantially matched to a thermal expansion coefficient of the lens and reflector to avoid fracturing of the lamp assembly due to thermal cycling during lamp operation.

In a preferred embodiment, the reflector and lens are made from a pyrex-type glass such as Corning 7251 having a thermal expansion coefficient of $37.5 \times 10^{-7}/^{\circ}\text{C}$, as measured over a range $0-300^{\circ}\text{C}$, and the solder glass has a thermal expansion coefficient of $43.2 \times 10^{-7}/^{\circ}\text{C}$, as measured over a range $0-300^{\circ}\text{C}$. The particular solder glass used in a preferred embodiment is chosen such that the elevated temperature and time necessary to bond the solder glass to the reflector and lens

do not substantially degrade the performance of a reflective coating, such as a dichroic or aluminum coating, applied to an inside surface of the reflector.

The foregoing and other objects, features, and advantages of the present invention will be more readily understood and apparent from the following detailed description of the invention, which should be read in conjunction with the accompanying drawings, and from the claims which are appended at the end of the detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, in which like elements have been given like reference characters,

FIG. 1 is a cross sectional view of a reflector lamp in accordance with the present invention; and

FIG. 2 is an exploded perspective view of the lamp shown in FIG. 1.

DETAILED DESCRIPTION

Reference is now made to FIGS. 1 and 2, which illustrate a lamp constructed in accordance with the method of the present invention. A lamp envelope 10 provides a sealed enclosure for a light source assembly 12. Light source assembly 12 may be, for example, a tungsten halogen light source, a mercury arc tube, an incandescent lamp, or a metal halide arc tube. The lamp envelope 10 includes a reflector 14 having circular symmetry about an optical axis 16 of the lamp. A reflecting surface 18 on the interior surface of reflector 14 typically has a parabolic shape. The reflecting surface 18 can be an aluminum coating, a dichroic reflector, or any other suitable reflector. Reflector 14 is closed by a lens 20 bonded to reflector 14. A base 22 provides a means for supplying electrical energy to the light source assembly 12 and for mounting of the lamp. In some applications, the lamp envelope 10 may be filled with an inert gas such as nitrogen. An electric lamp of the type shown in FIG. 1 is typically utilized as a downlight, spotlight, or a floodlight for indoor or outdoor illumination.

Lens 20 is bonded to reflector 14 by a solder glass seal 30. Solder glass seal 30 bonds contact surface 32 of lens 20 to contact surface 34 of reflector 14. Contact surface 32 extends around an entire perimeter 36 of lens 20. In the same manner, contact surface 34 extends around an entire perimeter 38 of reflector 10. The solder glass used in seal 30 is typically a glass having a sealing temperature which is relatively low compared to the melting point of the parts being bonded. The sealing temperature is the temperature at which a

hermetic seal can be made because the viscosity of the glass has changed so that the solder glass is fluid enough to fill any voids. When the solder glass is heated to its sealing temperature, there is substantially no deformation of the parts being bonded.

In constructing the electric lamp illustrated in FIGS. 1 and 2, the solder glass comprising seal 30 is applied to either contact surface 34, contact surface 32, or both surfaces. The solder glass can be applied either dry as a frit or in a binder, such as an amyl acetate/nitrocellulose system, in which case the solder glass and binder have a paste-like consistency. When an amyl acetate vehicle is used, the mixture preferably comprises 8 to 14 parts frit for each part of the vehicle. The mixture is preferably combined with nitrocellulose to produce a paste that is 98.8% frit and vehicle and 1.2% nitrocellulose binder.

When the solder glass has been applied to either contact surface 34 or contact surface 32, the lens or reflector is placed in an oven and is heated to an elevated temperature of approximately 300-375°C. The lens or reflector is held at this temperature for a time sufficient to oxidize and burn the binder material out, leaving only the solder glass itself. This process usually takes approximately 30 minutes at approximately 350°C. Heating in air is preferred because the carbon or hydrocarbons in the binder can be oxidized and burned out of the solder glass. Next, the lens or reflector is further heated to approximately 450°C for approximately 10 minutes to vitrify the solder glass in place on the lens or reflector. Next, the lens or reflector is brought through a cool-down cycle in which the lens or reflector is cooled as fast as possible without causing cracking or inducing additional stress.

Then, lens 20 and reflector 14 are coaxially aligned along optical axis 16 and moved towards each other along optical axis 16 in the direction of arrows 40 and 42 respectively, until solder glass seal 30 is in intimate physical contact with lens 20 and reflector 10 to form a lamp assembly as best shown in FIG. 1. One skilled in the art will appreciate that a suitable jig can be used for holding either lens 20 or reflector 14 stationary, and the remaining piece is moved into contact with the stationary piece. One skilled in the art will also appreciate that conventional automated lamp assembly machines can be used for aligning and pressing reflector 14 and lens 20 together.

Thereafter, the lamp assembly is placed in an oven, which is preferably a tunnel kiln, which elevates the temperature of the lamp assembly to a temperature sufficient to soften the solder glass comprising seal 30 to thereby bond lens 20 to reflector 14 at contact surfaces 32 and 34. The

lamp assembly remains in the tunnel kiln for a time sufficient to complete the bonding process. In a preferred embodiment, the temperature of the kiln is approximately 450°C and the lamp assembly remains in the kiln for approximately 10 minutes.

After the bonding process is completed, the lamp is put through a cool-down cycle in which the lamp assembly is cooled at a controlled rate, such as 3°C/minute to a temperature that is approximately 50 degrees below the strain temperature of the solder glass. The strain temperature is the temperature above which stress or strain may be induced in the lamp assembly. The strain temperature is generally approximately 15 degrees below the transformation temperature of the solder glass. In a preferred solder glass used in the present invention to be described in greater detail hereinafter, the transformation temperature is approximately 309°C. Consequently, the strain temperature is approximately 294°C. Thus, the cool-down cycle cools the lamp assembly from 450°C to approximately 244°C at the rate of 3°C per minute to avoid introducing additional stresses into the lamp assembly which may cause failure during lamp operation later on. When the lamp has reached a temperature of approximately 50 degrees below the strain temperature, the lamp assembly can be cooled more rapidly.

In another embodiment of the invention, the solder glass comprising seal 30 is applied to either lens 20 at contact surface 32 or to reflector 10 at contact surface 34. Lens 20 and reflector 14 are then coaxially aligned on optical axis 16 and moved toward each other along optical axis 16 in the direction of arrows 40 and 42, respectively, until solder glass seal 30 is in contact with lens 20 and reflector 10. Thereafter, the lamp assembly is placed in the oven and is heated to approximately 350°C for approximately 30 minutes to oxidize and burn out the binder. Thereafter, the lamp assembly is heated to approximately 450°C for approximately 10 minutes to bond the lens to the reflector. Finally, the lamp assembly is put through a similar cool-down cycle as described in the preferred embodiment. This embodiment thus eliminates the operation of separately heating the individual lens or reflector, as described in the preferred embodiment. Although this single step process may cause slight oxidation of or condensation on the reflective coating inside the lamp due to outgassing of the binder within the lamp assembly, the oxidation problem can be overcome by heating the lamp in an oxygen-free atmosphere, such as nitrogen. Although the single step process does not produce a lamp of the same quality as the preferred embodiment, the single step process is useful in cases where cost of lamp production is more important than obtaining the highest quality lamp or in the

case where the reflective coating is not degraded due to condensation or oxidation caused by the sealing process.

An important aspect of the present invention is the choice of solder glass used. Since solder glasses are glasses, they are rigid materials. Using a solder glass bond between lens 20 and reflector 14 means that lens 20 is rigidly bonded to reflector 14. Consequently, unless the thermal expansion coefficients of the lens, solder glass, and reflector match very closely, stress caused by thermal cycling due to lamp operation may cause a fracture in the lamp envelope 10. We have discovered that this problem can be overcome by selecting a solder glass having a thermal expansion coefficient that is substantially matched to a thermal expansion coefficient of the lens and reflector. In a preferred embodiment of the invention, the lens and reflector are constructed from a pyrex-type glass, such as Corning 7251 which has a thermal expansion coefficient of $37.5 \times 10^{-7} / ^\circ\text{C}$, and the solder glass is a lead borate composite having a thermal expansion coefficient of $43.2 \times 10^{-7} / ^\circ\text{C}$, such as type LS-1301 manufactured by Nippon Electric Glass Company.

In addition to having a compatible thermal expansion coefficient, the solder glass must also be amenable to processing conditions which are within the limitations of the parts being bonded. In the construction of a reflector lamp, the primary limitation is the temperature at which the dichroic coating 18 on the inside surface 24 of reflector 14 begins to degrade due to oxidation of the coating or condensation on the coating of outgas by-products during the burning out of the binder, which is caused by exposure to the elevated temperature and outgassing of the solder glass itself. Most solder glasses require sealing temperatures and processing times in excess of the maximum temperature capability of the dichroic reflective coating, which is usually in the $450\text{--}550^\circ\text{C}$ range. The solder glass used in a preferred embodiment of the invention, LS-1301, has a sealing temperature and processing time that are within the temperature capability range of the dichroic reflective coating. In one experiment, a processing temperature of 450°C and a processing time of 10 minutes was found to produce a measured compressive stress exerted on the lens and reflector by the solder glass seal at room temperature of 560 PSI (Pounds per Square Inch), without substantially changing or deteriorating the dichroic reflector surface.

Although LS-1301 is a preferred solder glass, other solder glasses which have thermal expansion coefficients in the range of $39 \times 10^{-7} / ^\circ\text{C}$ to $48 \times 10^{-7} / ^\circ\text{C}$ can also be used in the method and lamp of the present invention in order to produce a measured compressive stress exerted on the lens

and reflector by the solder glass seal at room temperature of less than 3,000 PSI. In a preferred embodiment, the measured compressive stress in the solder glass seal is no more than 1,500 PSI. In one reflector lamp constructed in accordance with the method of the present invention using Corning 7251 pyrex-type glass for the lens and reflector, and LS-1301 as the solder glass, the measured compressive stress in the solder glass seal was 560 PSI, well within the preferred range.

Having thus described one particular embodiment of the invention, various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements as are made obvious by this disclosure are intended to be part of this disclosure although not expressly stated herein, and are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only and is not intended as limiting. The invention is limited only as defined in the following claims and the equivalents thereto.

Claims

1. A method for constructing an electric lamp including a reflector having an optical axis and a contact surface and a lens having an optical axis and a contact surface, comprising the steps of:
 - applying a solder glass to the contact surface of the reflector;
 - forming a lamp assembly by moving the reflector and the lens together to join the reflector to the lens so that the solder glass is located between the contact surface of the lens and the contact surface of the reflector;
 - heating the lamp assembly to an elevated temperature sufficient to soften the solder glass; and
 - maintaining the lamp assembly at the elevated temperature for a time sufficient to bond the solder glass to the lens and the reflector, respectively, and to seal the lens to the reflector.
2. The method of claim 1, wherein a thermal expansion coefficient of the solder glass is substantially matched to a thermal expansion coefficient of the lens and reflector.
3. The method of claim 1, further comprising the step of:
 - after applying the solder glass to the contact surface of the reflector and prior to forming the lamp assembly, heating the reflector to an elevated temperature for a time sufficient to bond the solder glass to the reflector.

4. The method of claim 3, wherein the reflector and lens are made from a pyrex-type glass.
5. The method of claim 4, wherein the solder glass has a thermal expansion coefficient between $34 \times 10^{-7} / ^\circ\text{C}$ and $48 \times 10^{-7} / ^\circ\text{C}$ inclusive. 5
6. The method of claim 5, wherein the solder glass has a thermal expansion coefficient of approximately $43.2 \times 10^{-7} / ^\circ\text{C}$. 10
7. The method of claim 6, wherein the pyrex-type glass has a thermal expansion coefficient of approximately $37.5 \times 10^{-7} / ^\circ\text{C}$. 15
8. The method of claim 7, wherein the pyrex-type glass is Corning 7251 type glass.
9. The method of claim 2, wherein the reflector further comprises a reflective coating on an inside surface of the reflector and wherein the elevated temperature and the time to bond the solder glass are chosen to be within a range that does not substantially degrade the dichroic reflective coating. 20 25
10. The method of claim 1, wherein the step of forming the lamp assembly further comprises coaxially aligning the reflector and the lens. 30
11. A method for constructing an electric lamp including a reflector having an optical axis and a contact surface and a lens having an optical axis and a contact surface, comprising the steps of: 35
 - applying a solder glass to the contact surface of the lens;
 - forming a lamp assembly by moving the lens and the reflector together to join the lens to the reflector so that the solder glass is located between the contact surface of the lens and the contact surface of the reflector; 40
 - heating the lamp assembly to an elevated temperature sufficient to soften the solder glass; and 45
 - maintaining the lamp assembly at the elevated temperature for a time sufficient to bond the solder glass to the lens and the reflector, respectively, and to seal the lens to the reflector. 50
12. The method of claim 11, wherein a thermal expansion coefficient of the solder glass is substantially matched to a thermal expansion coefficient of the lens and the reflector. 55
13. The method of claim 12, further comprising the step of:
 - after applying the solder glass to the contact surface of the lens and prior to forming the lamp assembly, heating the lens to an elevated temperature for a time sufficient to bond the solder glass to the lens.
14. The method of claim 13, wherein the lens and the reflector are made from a pyrex-type glass.
15. The method of claim 14, wherein the solder glass has a thermal expansion coefficient between $34 \times 10^{-7} / ^\circ\text{C}$ and $48 \times 10^{-7} / ^\circ\text{C}$ inclusive.
16. The method of claim 15, wherein the solder glass has a thermal expansion coefficient of approximately $43.2 \times 10^{-7} / ^\circ\text{C}$.
17. The method of claim 16, wherein the pyrex-type glass has a thermal expansion coefficient of approximately $37.5 \times 10^{-7} / ^\circ\text{C}$.
18. The method of claim 17, wherein the pyrex-type glass is Corning 7251 type glass.
19. The method of claim 12, wherein the reflector further comprises a reflective coating on an inside surface of the reflector and wherein the elevated temperature and the time to bond the solder glass are chosen to be within a range that does not substantially degrade the dichroic reflective coating.
20. The method of claim 11, wherein the step of forming the lamp assembly further comprises coaxially aligning the lens and the reflector.
21. An electric lamp, comprising:
 - a reflector having an optical axis and a contact surface;
 - a lens having an optical axis and a contact surface; and
 - a solder glass seal disposed between the contact surface of the lens and the contact surface of the reflector to seal the lens to the reflector.
22. The electric lamp of claim 21, wherein a thermal expansion coefficient of the solder glass is substantially matched to a thermal expansion coefficient of the lens and reflector.
23. The electric lamp of claim 22, wherein the reflector and lens are made from pyrex-type glass.

24. The electric lamp of claim 23, wherein the solder glass has a thermal expansion coefficient between $34 \times 10^{-7} / ^\circ\text{C}$ and $48 \times 10^{-7} / ^\circ\text{C}$ inclusive. 5
25. The electric lamp of claim 24, wherein the solder glass has a thermal expansion coefficient of approximately $43.2 \times 10^{-7} / ^\circ\text{C}$.
26. The electric lamp of claim 25, wherein the pyrex-type glass has a thermal expansion coefficient of approximately $37.5 \times 10^{-7} / ^\circ\text{C}$. 10
27. The electric lamp of claim 26, wherein the pyrex-type glass is Corning 7251 type glass. 15
28. The electric lamp of claim 22, wherein the reflector further comprises a dichroic reflective coating on an inside surface of the reflector. 20
29. The electric lamp of claim 21, wherein the lens and the reflector are coaxially aligned.
30. The method of claim 3, wherein the solder glass is in a binder, and the reflector is further maintained at an elevated temperature for a time sufficient to burn out the binder. 25
31. The method of claim 13, wherein the solder glass is in a binder, and the lens is further maintained at an elevated temperature for a time sufficient to burn out the binder. 30

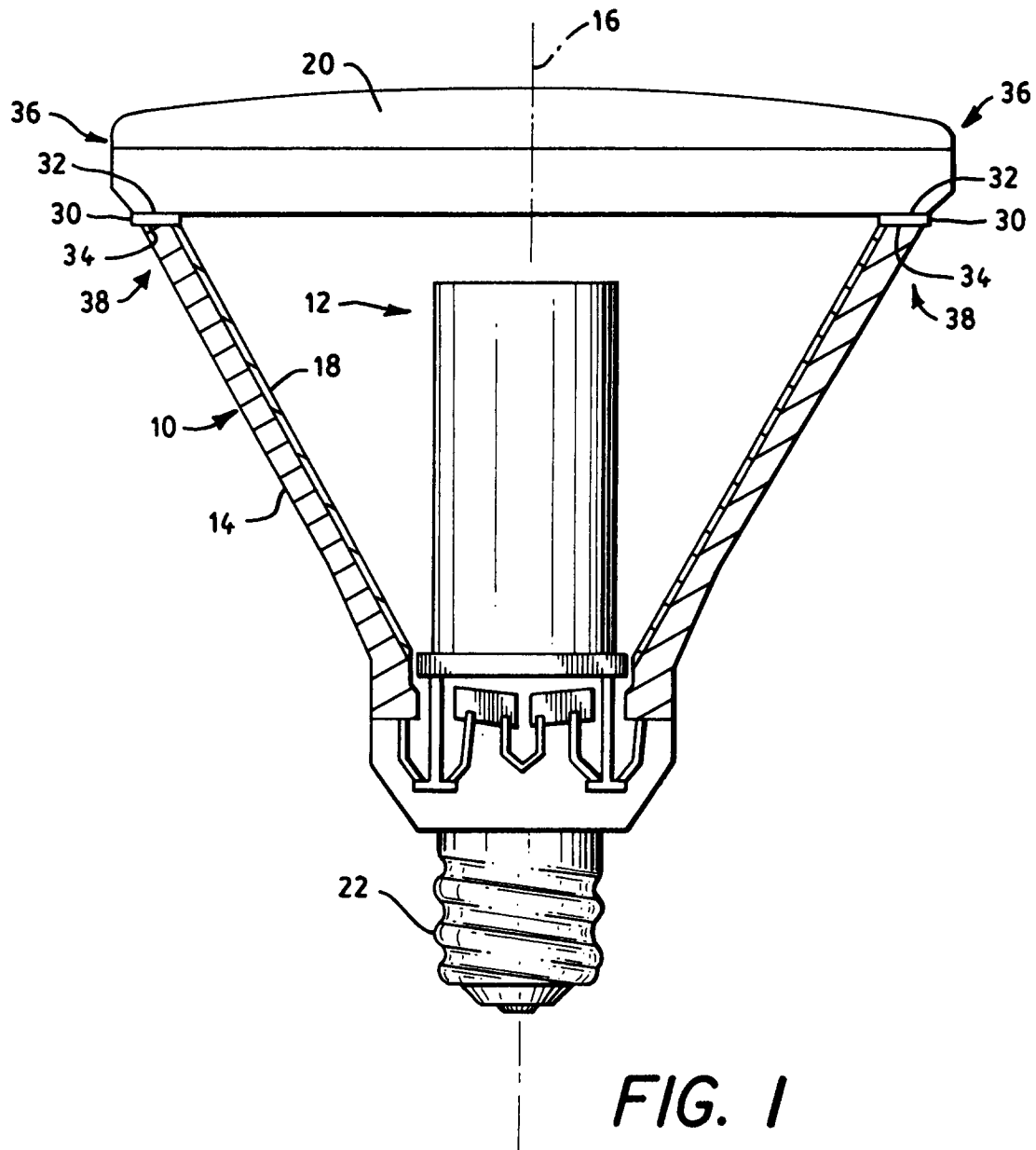
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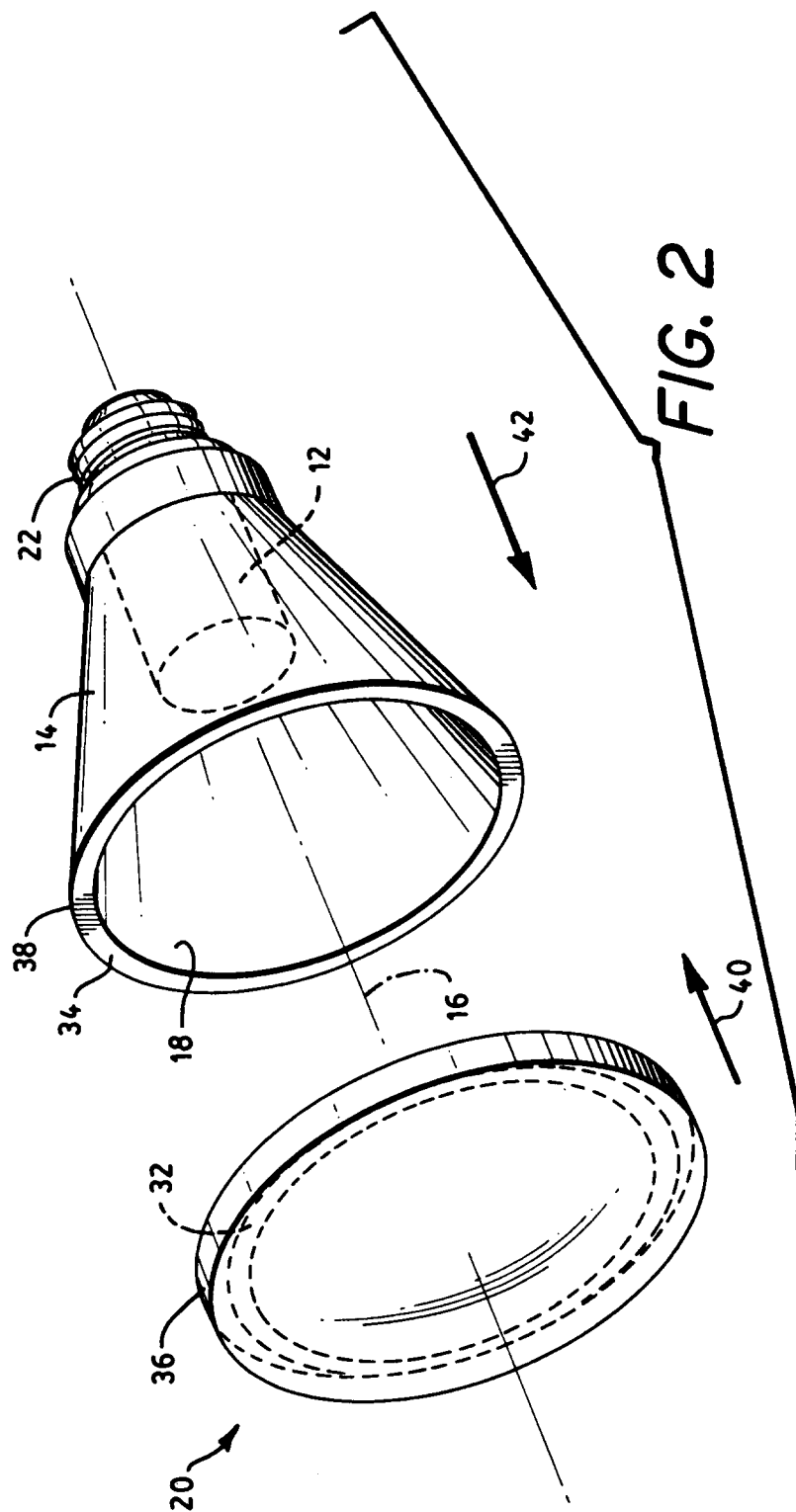
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European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 12 1845

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)
X	US-A-4 238 704 (BONK et al.) * Abstract; figures 1,2; column 1, lines 1-45; column 2, lines 38-39,48-51; column 3, lines 59-66; column 4, lines 59-62; column 4, line 67 - column 5, line 1; column 6, lines 9-26 *	1,2,9-12,19-27,29-31	F 21 V 17/00 H 01 J 9/26 H 01 J 61/36
Y	---	2,4-8,14-18	
A	---	3,13,28	
X	US-A-2 643 020 (DALTON) * Column 1, lines 21-25; column 1, line 50 - column 2, line 6; column 4, lines 20-64 *	1-4,9-14,19-23,29	
X	US-A-2 889 952 (CLAYPOOLE) * Paragraph 1; claims 1-4,12; figure 1; column 1, lines 36-39,49-56; column 5, lines 51-62; column 6, lines 12-15 *	1-3,9-13,19-22,29-31	
Y	US-A-3 258 350 (MARTIN et al.) * Column 1, lines 16-28,55-59; column 3, lines 29-35; column 4, lines 49-51 *	1-8,11-18	TECHNICAL FIELDS SEARCHED (Int. Cl. 5) F 21 V H 01 J
Y	US-A-3 217 088 (STEIEMAN) * Column 1, lines 17-20,37-56; column 2, lines 38-42; figure 1 *	1,3-8,11-18	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 07-04-1993	Examiner MARTIN VICENTE M A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			