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PHOTOFLASH LAMP HAVING LAMINATED GLASS ENVELOPE

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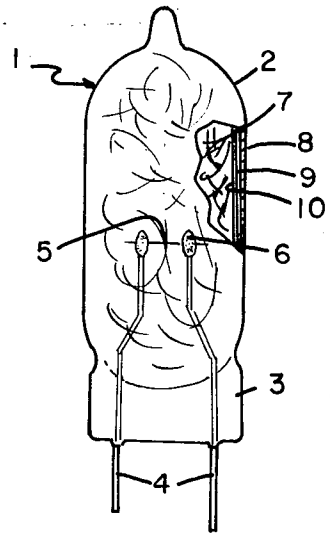


FIG.1



FIG.2

JOHN WALLACE ANDERSON
FREDERICK ARDEL LOUGHRIDGE
INVENTORS

BY James Theodoropoulos

AGENT

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PHOTOFLASH LAMP HAVING LAMINATED GLASS ENVELOPE

John Wallace Anderson, Danvers, and Frederick Ardel Loughridge, Manchester, Mass., assignors to Sylvania Electric Products Inc.

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ABSTRACT OF THE DISCLOSURE

A laminated glass envelope of a photoflash lamp comprises three separate layers of glass fused to one another to provide an integral envelope. The center layer of glass has a higher coefficient of thermal expansion than the inner and outer layers with the result that the center layer is in tension and the other layers are under compressive stress. The envelope as a result is stronger than conventional single layer glass envelopes and more resistant to internal pressure when the lamp is flashed.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to photoflash lamps of the type comprising a glass envelope containing a loose filling of metal filamentary material and a combustion supporting gas such as oxygen.

When the lamp is flashed, a reaction between the combustible material and the gas produces an instantaneous flash of actinic light of high intensity.

Description of the prior art

Photoflash lamps generally comprise a soft glass envelope having a seal at one end thereof and having combustible material within the envelope. Means for igniting the combustible material can be a wire or filament through which an electrical current can be passed whereby the wire is heated sufficiently to initiate ignition, or the means can be of the percussive type where an external blow to a tube protruding through the seal of the envelope can percussively ignite the lamp. A percussive type lamp is shown in U.S. Pat. 3,535,064, issued on Oct. 20, 1970 to L. F. Anderson et al.

To increase light production per unit volume of a photoflash lamp, heavier loadings of combustible material can be used accompanied by suitable increases in quantity of combustion supporting gas. However, this leads to increased difficulty of both static containment and dynamic containment upon flashing of the lamp. The plastic coatings enclosing glass photoflash lamps are effective in containing lamps of the prior art even though the glass lamp wall often does break into pieces due to thermal shock and impact from hot particles. At higher pressures, it becomes more difficult to contain the glass.

It is an object of this invention to provide an improved envelope which permits a reduction in the size thereof and/or increased pressure in the combustion supporting gas so as to permit a high lumen output from such lamps.

SUMMARY OF THE INVENTION

A glass envelope for photoflash lamps in accordance with this invention comprises three separate layers of glass fused together so as to provide the appearance and characteristics of a single integral glass article. The center layer of glass must have a higher thermal coefficient of expansion than that of the two outer layers so that after the glass envelope has been formed, the center layer is under tension while the two outer layers are in compression. The three layers of glass must be fused together in

such a manner so as not to substantially reduce the light transmittance over that of a single layer of glass having the same wall thickness. However, the center layer must not have a coefficient of thermal expansion so much higher than that of the two outer layers as to result in cracking or fracture of the glass structure merely from normal cooling after fusion of the three layers. Also, the coefficients of thermal expansion of each of the three layers must not be so disparate as to prevent the usual sealing of metal wires or tubes through the glass envelope.

The glass may be made by fusing together three concentric tubes of the proper glass and drawing them to a suitable diameter and wall thickness. Or the glass may be manufactured at an initial tube drawing operation by flowing the three glasses over a suitable mandrel and drawing them into a unitary tube.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a photoflash lamp of the electrically ignitable type. A portion of the lamp envelope is shown broken away and imaginary lines are used to show the three layer construction of the glass envelope.

FIG. 2 shows a percussively ignitable photoflash lamp in accordance with this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, one example of an electrically ignitable photoflash lamp **1**, in accordance with this invention, comprises a glass envelope **2**, a seal **3** at one end of envelope **2**, two lead-in wires **4** extending through seal **3**, a filament **5** connected across the internal ends of wires **4**, a primer ignition coating **6** disposed at the internal ends of wires **4** and a filling within envelope **2** comprising metal filamentary material **7**, such as aluminum or zirconium, and a combustion supporting gas, such as oxygen.

Glass envelope **2** comprises three layers of glass fused together in order to yield the appearance and workability of unitary glass tubing. The three layers, illustrated in FIG. 1 by imaginary lines merely for convenience, comprise an outer layer **8**, a middle layer **9** and an inner layer **10**.

The composition of the glass in layers **8** and **10** is such that when the three layers have been fused together to form a laminate, layers **8** and **10** are in compressive stress. Layer **9** consists of a glass having a higher coefficient of thermal expansion than the glass of layers **8** and **10** with the result that, after the laminate has been formed, layer **9** is in tension.

One advantage to a photoflash lamp in accordance with this invention is its improvement in dynamic containment when compared to prior art lamps having the same size and wall thickness. Dynamic containment problems result from, upon ignition, the rapid reaction between the metal filamentary material (e.g., zirconium) and the combustion supporting gas (e.g., oxygen), a normal gas pressure of at least several atmospheres, the rapid heating of the gas while it is being consumed in the reaction with the filamentary material, and the bombardment of the internal envelope walls with extremely hot tiny particles of metal or metal oxide. The thermal stresses induced in the glass by this particle bombardment sometimes fracture the glass envelope and can cause fragmentation thereof if there is sufficient gaseous pressure within the envelope.

In a lamp of the instant invention, the inner compressive layer of glass counteracts the tensil stresses resulting from localized heating caused by the impacting particles and thereby reduces the problem of dynamic containment. Also, the laminated construction of the glass

envelope reduces the rate of propagation of cracks therethroughout with the result that the internal pressure can subside to a non-critical level before the envelope is cracked or fractured sufficiently for non-containment, as will be explained.

When a photoflash lamp is ignited, a reaction starts immediately between the filamentary metal, hereafter designated as zirconium, and the gas, hereafter designated as oxygen. The oxygen pressure in the envelope is usually several atmospheres, being higher in smaller envelopes. In the smallest commercially available lamps, it can be 10 atmospheres or higher. As the reaction proceeds, there is a large evolution of heat while at the same time the oxygen is consumed in forming zirconium oxide. The heat results in an increase of pressure within the envelope for a short period of time until sufficient oxygen is consumed to reduce the pressure. When the pressure is reduced to about one atmosphere or less, dynamic containment of the envelope no longer becomes a problem.

For example, in the AG1 flash lamp the oxygen pressure in the envelope is about 4½ atmospheres. Upon ignition the pressure rises to about 8 atmospheres and reduces to atmospheric pressure in about 40 to 50 milliseconds.

In the lamps with which this invention is generally concerned, the critical time interval is about 50 to 100 milliseconds after ignition. After that time interval, there is generally insufficient pressure within the envelope to cause fragmentation, at least in the usual commercial lamps where the amounts of zirconium and oxygen are approximately stoichiometric. As previously mentioned, the advantage of lamps having a laminated envelope in accordance with this invention is that the rate of propagation of cracks through the envelope wall is slower than that through prior art envelope walls and consequently the problem of dyanmic containment is reduced.

For example, in miniature photoflash lamps having an outer diameter of about 0.270 inch, a volume of 0.28 cc., an envelope wall thickness of about 0.037 inch, oxygen pressure of 22 atmospheres and a stoichiometric fill of zirconium, comparative tests were made between laminated glass in accordance with this invention and prior art single layer glass. Upon flashing, all of the laminated glass envelopes were contained while 60% of the prior art envelopes fragmented.

In one example of a flashcube lamp according to this invention, outer layer **8** and inner layer **10** were made of a potash soda lead glass having a coefficient of thermal expansion of 89×10^{-7} inch/inch/° C. Middle layer **9** was made of a soda lime glass having a coefficient of 92×10^{-7} inch/inch/° C. Potash soda lead glasses have the following composition (percent by weight): 50 to 60% SiO_2; 2 to 6% Na_2O; 6 to 12% K_2O; 26 to 34% PbO; 1 to 2% Al_2O_3. Soda lime glasses have the following composition (percent by weight): 70 to 76% SiO_2; 14 to 18% Na_2O; 3 to 6% CaO; 2 to 5% MgO; 1 to 2% Al_2O_3.

To make the envelope, three tubes of the above glasses were cut off to the same length; the two smaller diameter tubes were then inserted concentrically into the larger tube. The inner tube had a wall thickness of 35 mils and an outer diameter of 475 mils; the middle tube had a wall thickness of 25 mils and an outer diameter of 585 mils; the respective measurements on the outer tube were 35 mils and 678 mils. The three tubes were fused together in a glass lathe by flame heating the external tube, while they were being rotated, until all three tubes had reached their glass-working temperature and fused together. After fusion the outer diameter had decreased to about 9/16 inch and the wall thickness was about equal to the sum of the wall thicknesses of each tube. The fused tube was then drawn, by conventional techniques, into tubing having an outer diameter of 350 mils and a wall thickness of 37 mils.

Although the tubing appeared to be made of a single layer of glass, examination under a polariscope revealed the three layer construction. The thickness of each layer was about proportional to the thicknesses of the three original tubes.

The stress on each layer of glass was measured in a polarizing microscope, using a calibrated quartz wedge. Outer layer **8** was under a compressive stress of 800 p.s.i.; middle layer **9** was under a tensile stress of 1100 p.s.i.; inner layer **10** was under a compressive stress of 400 p.s.i.

Lamp envelopes were prepared by cutting off proper lengths of the laminated tubing and lamps were manufactured from said lengths by usual manufacturing techniques. Lead-in wires **4** were made of a copper clad nickel-iron alloy having an expansion coefficient of 90×10^{-7} inch/inch/° C. Since these lamp envelopes were more resistant to fragmentation than prior art single glass envelopes of equal size and wall thickness, they could be filled with more zirconium and oxygen in order to deliver more light, in terms of lumen-seconds, than the prior art envelopes.

As mentioned above, the improvement in the laminated envelope results from the inner and outer layers of glass being in compression. The inner layer reduces the rate of propagation of thermal cracks through the envelope wall while the outer layer aids in dynamic containment. An increase in the compressive stress on these two layers will improve resistance to crack propagation and fragmentation. Such an increase can be obtained by increasing the difference in expansion coefficients between the middle layer and the other layers. In the flashcube example, mentioned above, if the soda lime glass used for middle layer **9** had a coefficient of, say, 95×10^{-7}, instead of 92×10^{-7}, outer layer **8** and inner layer **10** would have been under higher compressive stress than 800 p.s.i. and 400 p.s.i., respectively. But the coefficient for the middle layer glass should not be so much higher than that for the other layers as to result in fracture or cracking of the fused tubing upon cooling, or to prevent formation of a satisfactory glass-to-metal seal when lead-in wires or metal percussive tubes are sealed in the envelope.

The above embodiments show examples of lamps in accordance with this invention having laminated envelopes made of so-called soft glass. For use with a harder glass, say, borosilicate glasses, where the lead-in wires or percussive tubes are made of a lower expansion alloy, such as iron-nickel-cobalt, an example would be as follows. A commonly used iron-nickel-cobalt alloy for such applications has a coefficient of thermal expansion of 50×10^{-7} inch/inch/° C. Outer layer **8** and inner layer **10** could be made of No. 7052 borosilicate glass (Corning Glass Co. designation) which has an expansion coefficient of 46×10^{-7}. Middle layer **9** could be made of No. 7060 borosilicate glass which has a coefficient of 50×10^{-7}.

For use with tungsten metal, which has an expansion coefficient of 44×10^{-7}, the inner and outer layers could be made of No. 7720 borosilicate glass, which has a coefficient of 36×10^{-7}; the middle layer could be made of No. 3320 borosilicate glass, which has a coefficient of 40×10^{-7}.

It is not necessary, for purposes of this invention, that outer layer **8** and inner layer **10** have the same glass composition or the same expansion coefficient. However, it is necessary that they have a lower expansion coefficient than the middle layer in order to place them in compression and the middle layer in tension.

Also, it is not necessary that the laminated tubing be formed by fusing three separate glass tubes together. The laminated tubing could be formed at the initial tube drawing operation by means of a tube-forming mandrel surrounded by an orifice consisting of three separate rings. Each ring would be fed molten glass from a separate glass melter. As the three glasses flowed from the orifice, they would fuse together and could be drawn to a desired size.

The percussively ignited flash lamp shown in FIG. 2 has a metal tube **11** sealed in, and extending through envelope **2** instead of the lead-in wires of the lamp shown in FIG. 1.

Metal tube **11** was made of a nickel-chrome-iron alloy having an expansion coefficient of 90×10^{-7}, while envelope **2** was made of the same laminated glass as that of FIG. 1.

We claim:

1. In a photoflash lamp having an igniter and having a sealed light transmissive glass envelope and a shredded metal fill and combustion supporting gas within said envelope whereby, upon ignition, said metal fill and gas react to produce an instantaneous flash of actinic light, the improvement comprising a laminated envelope of three layers of glass fused together, the coefficient of thermal expansion of the middle glass layer being higher than that of the inner and outer glass layers, whereby the inner and outer glass layers are in compression and the middle layer is in tension.

2. The lamp of claim **1** wherein a metal lead-in wire is hermetically sealed to, and extends through, said envelope.

3. The lamp of claim **1** wherein a metal tube is hermetically sealed to, and extends through, said envelope.

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EDWARD J. MICHAEL, Primary Examiner

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