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Boddy et al.

[11] **3,780,328**

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[54] **LIGHTING UNIT FOR USE UNDERWATER AND IN WET ENVIRONMENT**

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[52] **U.S. Cl.** **313/184,** 313/51, 313/220

[51] **Int. Cl.** **H01j 61/30**

[58] **Field of Search** 313/184, 220

[56] **References Cited**

UNITED STATES PATENTS

2,159,794	5/1939	Hagen et al.	313/220
2,217,421	10/1940	Scott	313/220
2,241,968	5/1941	Suits	313/220
3,662,203	5/1972	Kuhl et al.	313/220

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[57] **ABSTRACT**

An underwater lighting unit comprises a low voltage tungsten-halogen lamp within an outer envelope of borosilicate glass, with an evacuated cavity between the two. The envelope is designed to withstand 8,000 p.s.i. in water. Connections are made onto metal pins sheathed in glass sleeves or protrusions integral with the envelope.

The pins are inserted into receptacles embedded in an insulating core within a shell of a free flooding lampholder. Rubber sleeves on the pins are compressed into spaces between the sleeves and the bottoms of recesses in the glass core. There are spring contact clips between the pins and bores in the pin receptacles.

4 Claims, 5 Drawing Figures

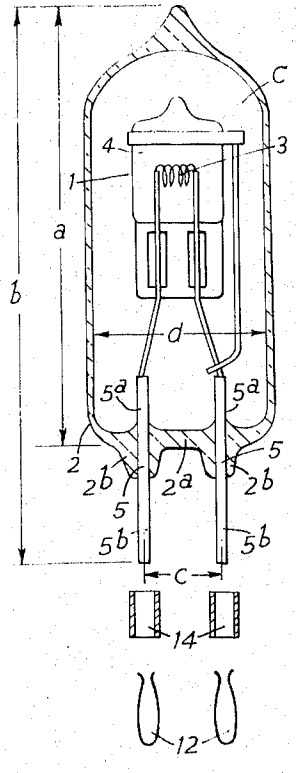


FIG. 1

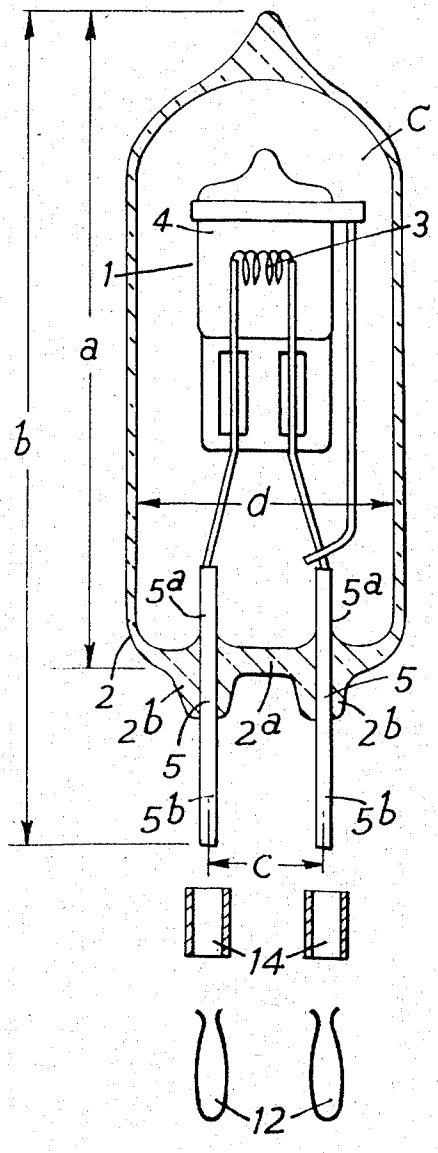

C
4
3
1
a
b
d
5a
5a
2
2b
2a
2b
5
5
5b
5b
c
14
12

FIG. 5

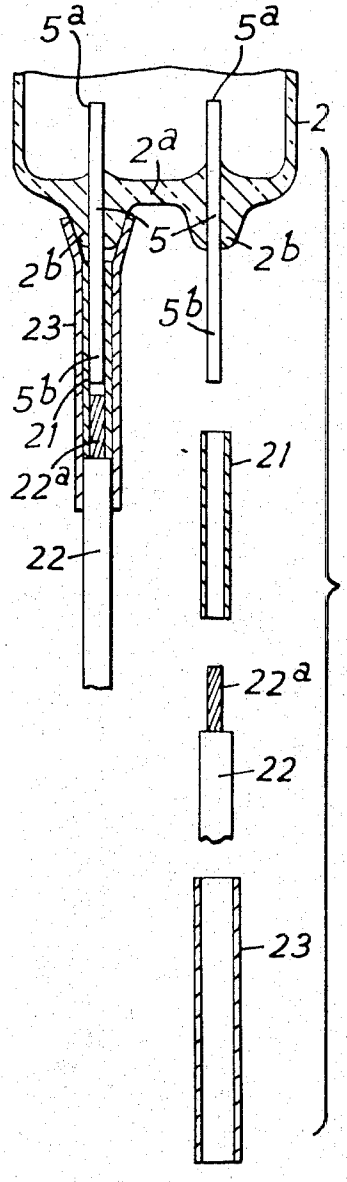

5a
5a
2
2a
5
2b
2b
23
5b
5b
21
22a
22
21
22a
22
23

FIG. 2

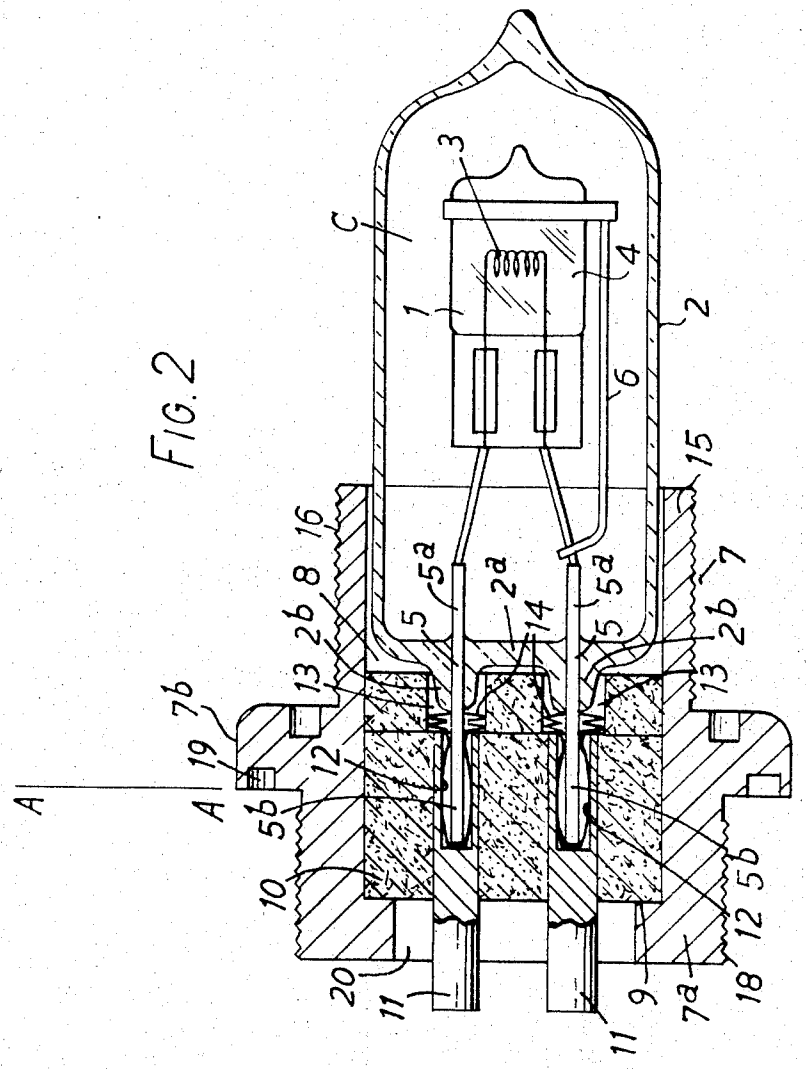


FIG. 3

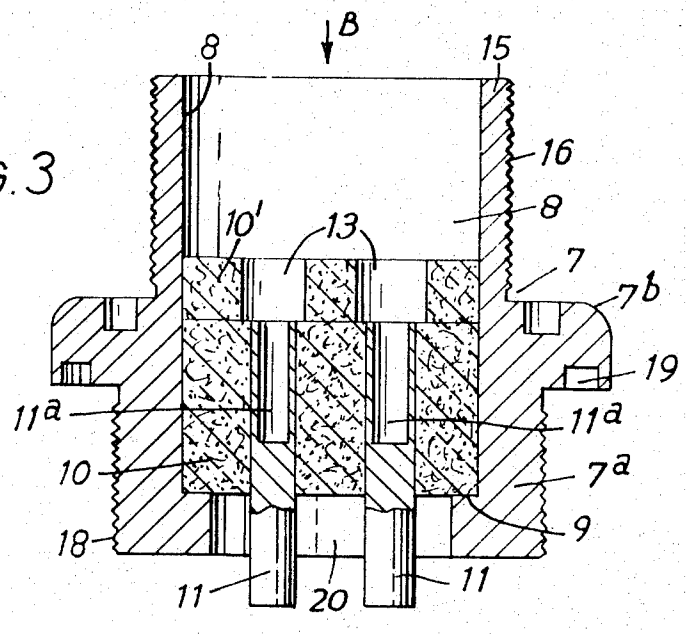
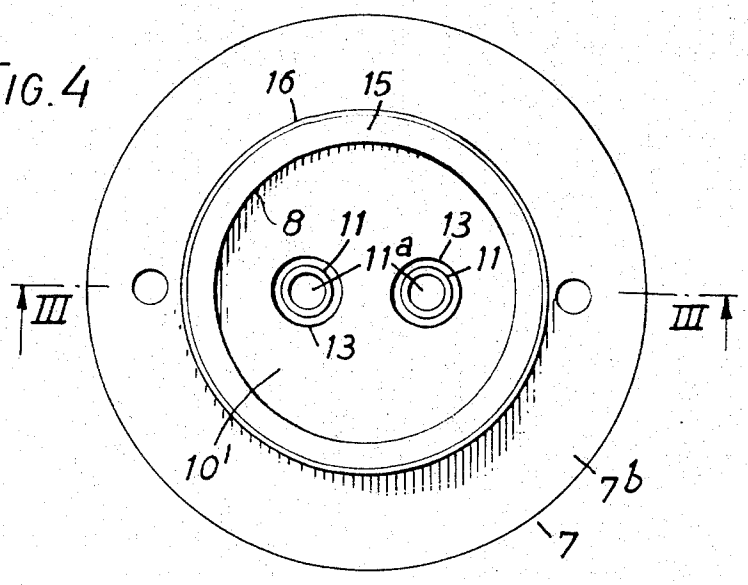

B
8
15
16
8
10'
13
7
7b
19
11a
11a
10
7a
9
18
11
20
11

FIG. 4


16
15
8
11
13
11a
11
III
III
13
10'
7b
7

LIGHTING UNIT FOR USE UNDERWATER AND IN WET ENVIRONMENT

BACKGROUND OF THE INVENTION

This invention appertains to a lighting unit for use not only underwater, but also in generally wet environments such, for instance, as those experienced when undertaking pipeline inspection work.

PROBLEMS AND PRIOR TECHNIQUES

Lighting in all such conditions presents several problems, a particularly important one of which is that douching or wholly or partially immersing in water a lamp having a high working temperature is liable to cause failure of the glass lamp enclosure due to thermal shock. Water in and around electrical connections is also a hazard. Moreover, to avoid breakdown it has heretofore been necessary to provide expensive precautions against the admission of water into underwater connectors and lamp housings.

Now due to their light output/physical size ratio, and color temperature tungsten-halogen, e.g. tungsten-iodine, lamps are very suitable for both underwater and pipeline inspection work in conjunction with specially designed television and film cameras. In sewer and like pipeline inspections by television and in similar wet environments, tungsten-halogen lamps have heretofore even been subjected to douching in acidic and alkali affluents and liquors. Since quartz and other types of glass used to form the envelopes for such light sources break down under acid or alkali attack, however mild, such a lamp has previously required the protection of a liquid-tight lamp housing which has substantially increased not only the physical size and weight of the unit but also its cost.

OBJECTS AND SUMMARY OF THE INVENTION

The object of the present invention is to provide, for use underwater or/and in wet environments, an improved lighting unit of a form which does not require the protection of a watertight lamp housing and electrical connector.

The lighting unit according to this invention comprises a low voltage electric lamp which has an operational voltage not exceeding 50 volts and is enclosed within an outer envelope of a practically inert glass having an extremely high resistance to thermal shock and the property of not contaminating any chemical reaction within the unit, there being between the lamp and the envelope a cavity which is evacuated at least to such a degree as to permit of expansion both of the lamp and of the residual gas or air within the cavity without causing stress on, and fracture of, the envelope from within, the envelope also being of a mechanical design to withstand substantial external pressure in water and the construction of the unit ensuring that the residual gas or air remains unchanged chemically notwithstanding heat generated within the outer envelope by the lamp.

Thus, while any appropriate low voltage electric lamp may be incorporated in the improved lighting unit, it is most advantageous to use any suitable tungsten-halogen, e.g. tungsten-iodine, lamp having an operational voltage of, for instance, 24 volts, but not exceeding 50 volts, A.C. or D.C. It will usually be preferred to employ a standard low voltage tungsten-iodine lamp.

Again, while the outer envelope may be of any suitable glass having a low co-efficient of thermal expansion and hence a high resistance to thermal shock, an outer envelope of borosilicate glass is preferred. Borosilicate is a double salt of boric and sillicic acids.

The necessary electrical connections to the lamp may conveniently be made onto two metal pins which pass through the outer envelope in a glass-to-metal seal. Since the operating voltage is relatively low, only a small leakage current occurs directly between the pins during total immersion in water or saturated brine solution, and this can be obviated by creating a long leakage path between the pins, either by completely sleeving the pins and delivery conductors connected directly thereto with an insulating material, or by providing a free flooding lampholder of the character hereinafter to be described. The exclusion of water or brine solution from the pins or the lampholder is unnecessary providing that the leakage path between conductors is long.

A sufficiently long electrical leakage path for this purpose is formed when the lighting unit is mated with the aforementioned free flooding lampholder.

In order that the invention may be more clearly understood and readily carried into practical effect, a specific constructional example of the improved lighting unit, and also an example of a free flooding lampholder for use in conjunction therewith will now be described with reference to the accompanying drawings, wherein,

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view partly in elevation and partly in cross-section of the lighting unit per se,

FIG. **2** is a view partly in elevation and partly in cross-section of the lighting unit inserted into a free flooding lampholder,

FIG. **3** is a sectional view of the lampholder per se, taken on the line III — III of FIG. **4**, the view looking in the direction of the arrows,

FIG. **4** is a plan view of the lampholder as seen in the direction of the arrow B in FIG. **3**, and

FIG. **5** is a fragmentary detail view partly in elevation and partly in cross-section of the base of the outer enevelope showing the way in which the lamp pins of the lighting unit can be directly wired to twin tails.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. **1**, it will be seen that the lighting unit comprises a tungsten-halogen lamp **1** encapsulated within an outer envelope **2** of borosilicate glass. The lamp **1**, in this particular example, is a standard low voltage quartz iodine lamp including a tungsten filament **3** encapsulated within a bulb or envelope **4** of quartz glass. The operating voltage of the lamp **1** is 24 volts A.C. or D.C. and its power rating may be 70 watts. At such low voltage, the light output of the lamp is 1,750 lumens.

It will accordingly be appreciated that the lighting unit now being described is one comprising inner and outer envelopes, viz. an inner envelope **4** of quartz glass encapsulating the filament **3**, and an outer protective envelope **2** of borosilicate glass.

Tungsten pins **5** pass through a base **2***a* of the outer glass envelope **2** and are electrically connected with the ends of the tungsten filament **3**. At **6** is represented a nickel bracing strut.

Between the lamp **1** and the outer borosilicate glass envelope **2** is a cavity C which is evacuated and accordingly provides a void in which the tungsten-halogen lamp **1** can operate unaffected by the environment external to the outer envelope. The absence of gas or air within the outer envelope **2** also obviates changes in mechanical stress on the outer envelope, from within, which stress would otherwise be caused by the expansion and contraction of both the lamp **1** and the imprisoned air or gas.

The borosilicate glass of which the outer envelope **2** is formed is preferably one having the following formula:

Silica - 81%

Soda - 5%

Boric acid - 12%

Alumina - 2%

Important properties of such a borosilicate glass are:

i. It is practically inert and has little or no tendency to react with other chemicals.

ii. It is virtually free from metals such as copper, zinc, lead, chromium, manganese, arsenic and barium and can be relied upon not to contaminate any chemical reaction in an environment in which it is being used.

iii. It has an extremely high resistance to thermal shock.

Thus, property (ii) is an essential one inasmuch that the remnant gas within the outer envelope **2** of borosilicate glass, after evacuation, and the quartz glass envelope of the tungsten-halogen lamp remain unchanged chemically despite the heat which is generated.

In accordance with an important aspect of the invention, the void within the outer envelope **2** is essentially of such a volume that it will contain the additional volume of the actual tungsten-halogen lamp **1** under expansion and permit the outer envelope to be of a mechanical design adapted to withstand very substantial external pressure. Accordingly, the properties of the borosilicate glass combined with the shape and size of the outer envelope **2** (which, as previously mentioned, is in the nature of a capsule encapsulating the lamp) enable the envelope to withstand a high degree of thermal shock without damage to the actual lamp within.

Portions of the tungsten lamp pins **5** intermediate their opposite ends are sheathed in glass sleeves or protrusions 2b which constitute integral portions of the base **2***a* of the outer borosilicate glass envelope **2.** In this way, an efficient glass-to-metal seal is provided at the base of the lighting unit. The inner end portions of the pins **5** which are electrically connected with the ends of the filament **3** are designated **5***a*, whereas the outer end portions of these same pins which extend freely from the lighting unit are designated **5***b*.

A free flooding lampholder suitable for combination with the herein described improved lighting unit will now be described with reference to FIGS. **2 – 4.** Such lampholder comprises an axially bored and counter bored stainless steel outer shell **7.** A counterbore **8** within the outer shell provides an annular shoulder **9** upon which is seated a core **10** of insulating material, preferably sintered glass. Firmly embedded within the insulating core **10** was two axially bored lamp pin receptacles **11** of gold plated nylo **48.** In this way there is presented a long leakage path at the source of power for the lamp. The pin receptacles **11** are set apart the same distance as the lamp pins **5,** and, as shown in FIGS. **3** and **4,** each of them has formed in its inner end an axial bore **11***a* into which the outer end portion **5***b* of the corresponding pin **5** is inserted. As will be seen in FIG. **2,** the diameter of the bores **11***a*, i.e., the internal diameter of the pin receptacles, is made greater than the diameter of the lamp pins **5,** and spring contact clips **12** of beryllium copper are inserted into the spaces so created so as to be in contact both with the pins and the bore walls. In this manner, good electrical contact between the lamp pins **5** and the lamp pin receptacles **11** within the lamp holder is ensured.

The spring contact clips **12** also serve to afford the differing rates and extents of mechanical expansion and contraction of lamp base and lamp holder, thus obviating stresses in either. If lamp pins and pin receptacles were made to mate with only a small tolerance, the lamp base would fracture due to pressure on the pins caused by the differing co-efficients of expansion of the two units.

The relative diameters of the lamp pins **5** and pin receptacles **11** and the employment of spring contact clips **12** serve yet another useful purpose in providing a resilient mounting for the lamp, thus increasing the degree of mechanical shock to which the lampholder may be subjected before damage is occasioned to the lamp.

Recesses **13** are provided in the core **10** of sintered glass in co-axial alignment with the entrances into the lamp pin receptacles **11,** and the aforementioned glass sleeves or protrusions **2***b* sheathing the intermediate portions of the lamp pins **5** fit into these recesses. The length of the sleeves or protrusions **2***b* outwardly from the base **2***a* of the outer glass envelope **2** is a little less than the axial dimension, i.e., the depth, of the recesses **13** in the insulating core **10.** Accordingly, there are clearance spaces between the outer ends of the sleeves or protrusions and the bottoms of the recesses when the lighting unit is fitted within the lampholder. It will be appreciated that the electrical leakage path between the lamp pins **5** is thus increased by a factor of approximately two in the particular example illustrated.

To provide still further insulation, the lamp pins **5** have placed over them and are surrounded by silicone rubber sleeves **14** which, during insertion of the lighting unit into the lampholder, concertina and become compressed (as shown in FIG. **2**) into the clearance spaces between the ends of the glass sleeves or protrusions **2***b* and the bottoms of the recesses **13.**

The counterbored portion of the outer shell **7** extending in front of the core **10** of sintered glass provides a socket **15** for accommodation of that portion of the outer glass envelope **2** adjoining the lamp pin sleeves or protrusions. This socket **15** is exteriorly screwthreaded at **16** to receive, say, a lamp reflector mounting. The rear portion **7***a* of the lampholder shell **7** is exteriorly screwthreaded at **18** for direct bulkhead mounting, and an annular recess **19** formed in the back of an outwardly flanged portion **7***b* of the outer shell **7** is for accommodation of an 'O' ring seal.

In actual practice, the core **10** of sintered glass would be made in two parts as shown in FIG. **3,** the recesses **13** being, in fact, initially constituted by round holes formed right through a comparatively thick ring **10'** of the glass.

As to the outer solid ends of the pin receptacles **11,** these extend, as shown in FIGS. **2** and **3,** right through

the core **20** in the shell **7** and clear of the rear end of the latter. If it is not mounted in a bulkhead, the lampholder can alternatively mate with a free cable entry gland.

With the combination shown in FIG. **2** in use underwater, everything to the left of the line A — A is dry, whereas everything to the right of this line is wet.

Instead of inserting the lighting unit into a free flooding lampholder as described, it is alternatively possible to directly wire the lamp pins to two conductors, i.e., 'twin tails' in the manner illustrated in FIG. **5.**

As will be seen, a tubular metal receptacle **21** is in this case used to connect each lamp pin **5** to a bared end **22***a* of a rubber or plastic covered wire conductor **22.** That is to say, the pins **5** and the bared ends **22***a* of the wires are inserted into respectively opposite ends of the two tubular metal receptacles **21,** the wires being rigidly secured in the receptacles by soldered or welded joints. Silicone rubber sleeves **23,** previously placed upon the coverings of the wire conductors **22,** are thereafter slid along into position to additionally embrace both the tubular metal receptacles **21** and the glass pin sleeves or protrusions **2***b*. For convenience in illustration, the component elements of such a direct connection are shown 'exploded' at the right-hand side of FIG. **5.**

Although the dimensions of the unit may vary, the following are quoted merely by way of example and with reference to the drawing:

a = 2'' (50.8 mm)

b = 2-⅜''(60.32 mm)

c = ¼'' (6.35 mm)

d = 1.025'' (26.035 mm)

While water or brine solution is allowed to enter the lamp pin receptacles **11** within the lampholder, the electrical leakage path is blocked completely by the hereinbefore described methods, thus preventing pin and pin receptacle damage by electrolytic action, when direct current is employed as a source of power, and avoiding a wastage of electrical power to the operating medium.

The invention makes possible the provision of underwater lighting equipment which is smaller, simpler and less expensive than such equipment provided heretofore. Moreover, the light output/weight and bulk ratio of the improved lighting unit is substantially greater than that of any unit currently available. As previously mentioned, the improved unit will also help in solving lighting problems in wet environments, e.g. sewer pipeline inspection by television, in which lamps are subject to douching with water, effluent or brine.

The improved lighting unit is such that it can be allowed to reach its maximum working temperature in air even before being totally immersed into ice cold water, without failure of either the tungsten-halogen lamp or the outer envelope of borosilicate glass.

On test, the standard version of the improved lighting unit has withstood 8,000 p.s.i. in water, so that such a lamp will operate at a depth of approximately 17,500 feet.

Since the lamps and lampholders are free flooding, they obviate the need for heavy housings and troublesome seals. Moreover, lamps can be replaced underwater when necessary.

The low operating voltage of the lamp ensures the safety of the user of hand held equipment, wet or dry.

We claim:

1. A lighting unit for use underwater, including a bulb, a low voltage tungsten-halogen lamp having a filament enveloped in the bulb and a operational voltage not exceeding 50 volts, an outer borosilicate glass envelope within which said lamp is enclosed, said borosilicate glass envelope having a base and, being resistant to thermal shock to the extent that it can safely attain its maximum working temperature in air before being immersed in ice cold water, said envelope having smooth curves and a wall thickness sufficient to withstand uniformly over its exterior surface an ambient pressure in water of 8,000 p.s.i., there being between the lamp and the outer envelope a cavity which is evacuated to permit of expansion both of the tungsten-halogen lamp and of the residual gas within the cavity but only to such an extent as to ensure that the outer envelope will withstand stress from within resulting in explosive fracture thereof, the void within the outer envelope being of such volume that it will contain the additional volume of the lamp under expansion, two metal pins passing through the outer envelope and by which electrical connections to the low voltage tungsten-halogen lamp are made, and glass sleeves which are integral portions of the base and in which sleeves portions of the pins adjoining the base are sheathed.

2. The lighting unit according to claim **1,** wherein the low voltage lamp has an operating voltage of 24 volts A.C. or D.C., a power rating of 70 watts and a light output of 1,750 lumens.

3. The lighting unit according to claim **1,** wherein the low voltage lamp consists of a tungsten-iodine lamp.

4. The lighting unit according to claim **1,** wherein the borosilicate glass is one having the following formula: silica 81 percent; soda 5 percent; boric acid 12 percent; and alumina 2 percent.

* * * * *