(12) UK Patent Application (19) GB (11) 2 413 840 (13) A

(43) Date of A Publication 09.11.2005

(21) Application No: 0410216.6

(22) Date of Filing: 07.05.2004

(71) Applicant(s):
Savage Marine Ltd
(Incorporated in the United Kingdom)
8A Jacknell Road,
Dodwells Bridge Industrial Estate,
HINCKLEY, Leicestershire, LE10 3BS,
United Kingdom

(72) Inventor(s):
Nigel Charles Savage

(74) Agent and/or Address for Service:
Serjeants
25 The Crescent, King Street, LEICESTER,
LE1 6RX, United Kingdom

(51) INT CL[7]:
F21S 8/10 , F21V 29/00 // F21Y 101:02

(52) UK CL (Edition X):
F4R RMP RMR R288 R335 R383 R417

(56) Documents Cited:
WO 2002/061330 A2
JP 2002042521 A
US 6616291 B1
US 20030052584 A1
US 20030048632 A1

(58) Field of Search:
UK CL (Edition W) **F4R**
INT CL[7] **F21S, F21V, F21Y**
Other:

(54) Abstract Title: **Underwater lighting unit with cooling means**

(57) An underwater lighting unit 1 comprises an array of light emitting diodes 13 that are mounted within a cavity of a metal housing 10, and a transparent screen 22 for covering and protecting the light emitting diodes 13. The screen 22, side walls 12 and a back wall 11 of the housing 10 are in direct contact with the water to provide a degree of cooling for the light emitting diodes 13. In the preferred embodiment, the underwater lighting unit 1 is used on marine vessel or ship, whereby the underwater lighting unit 1 is further attached to a cofferdam 2 of the ship.

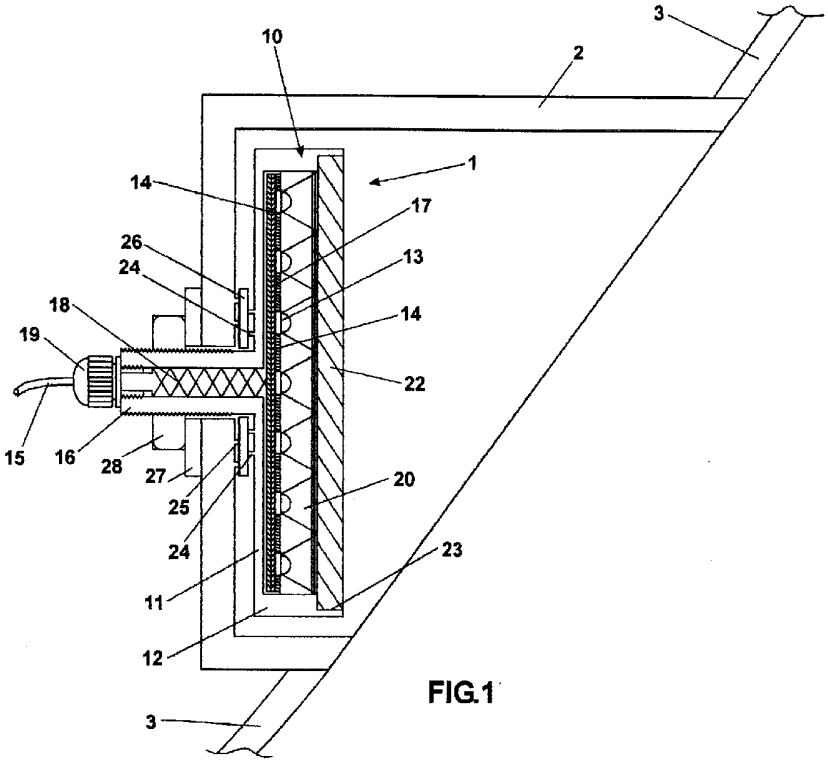

FIG.1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

Original Printed on Recycled Paper

GB 2 413 840 A

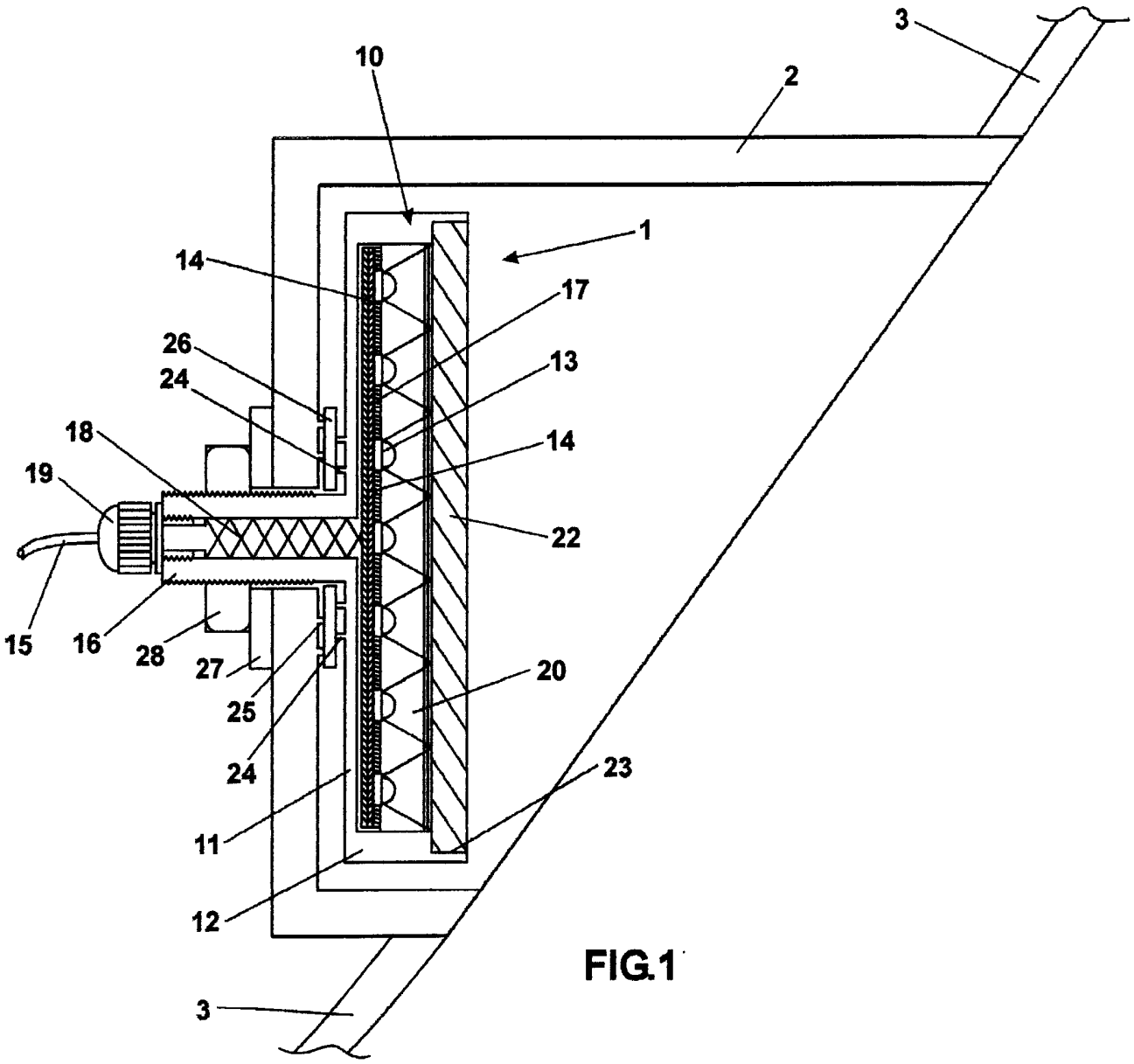

FIG.1

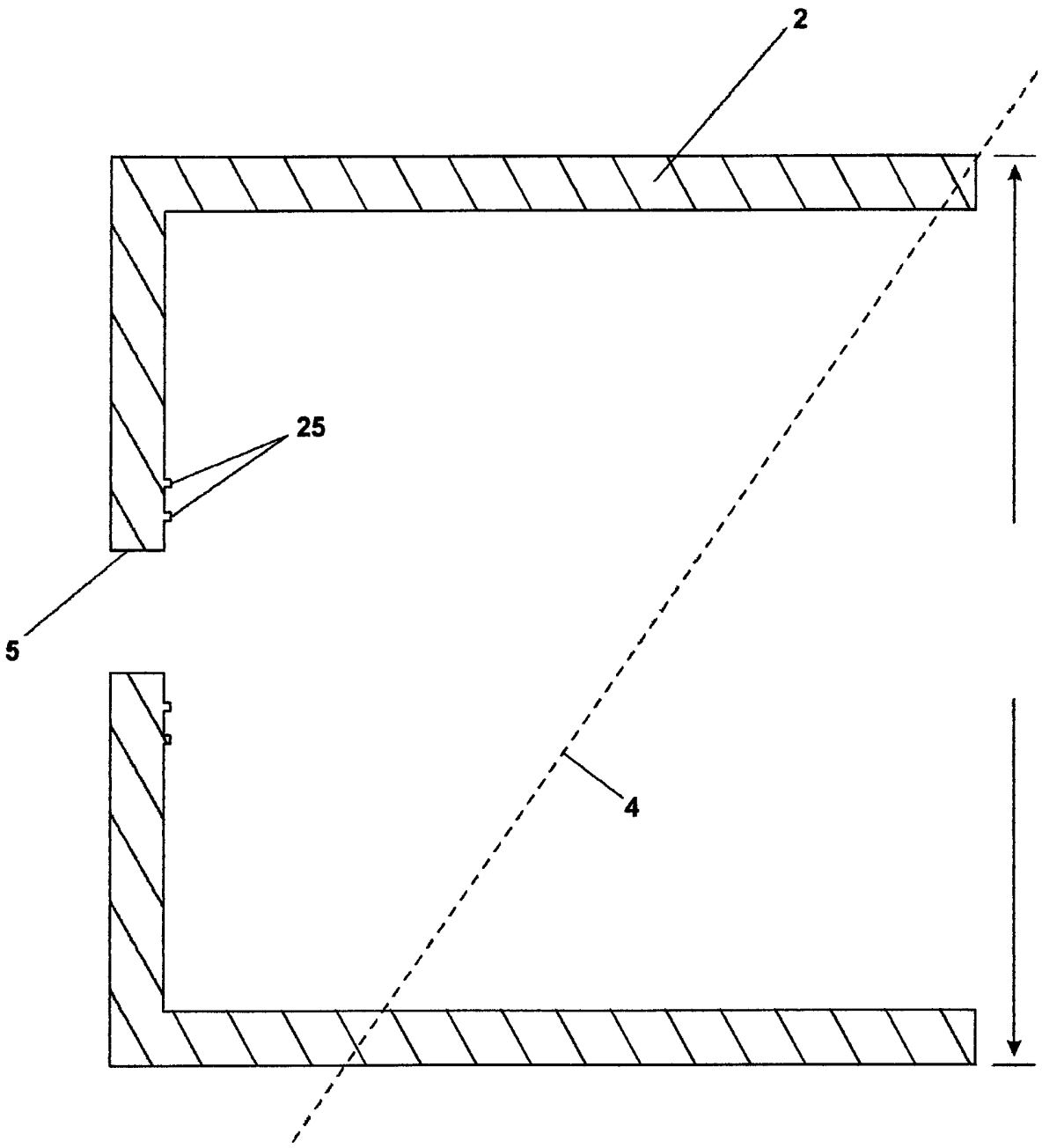

FIG.2

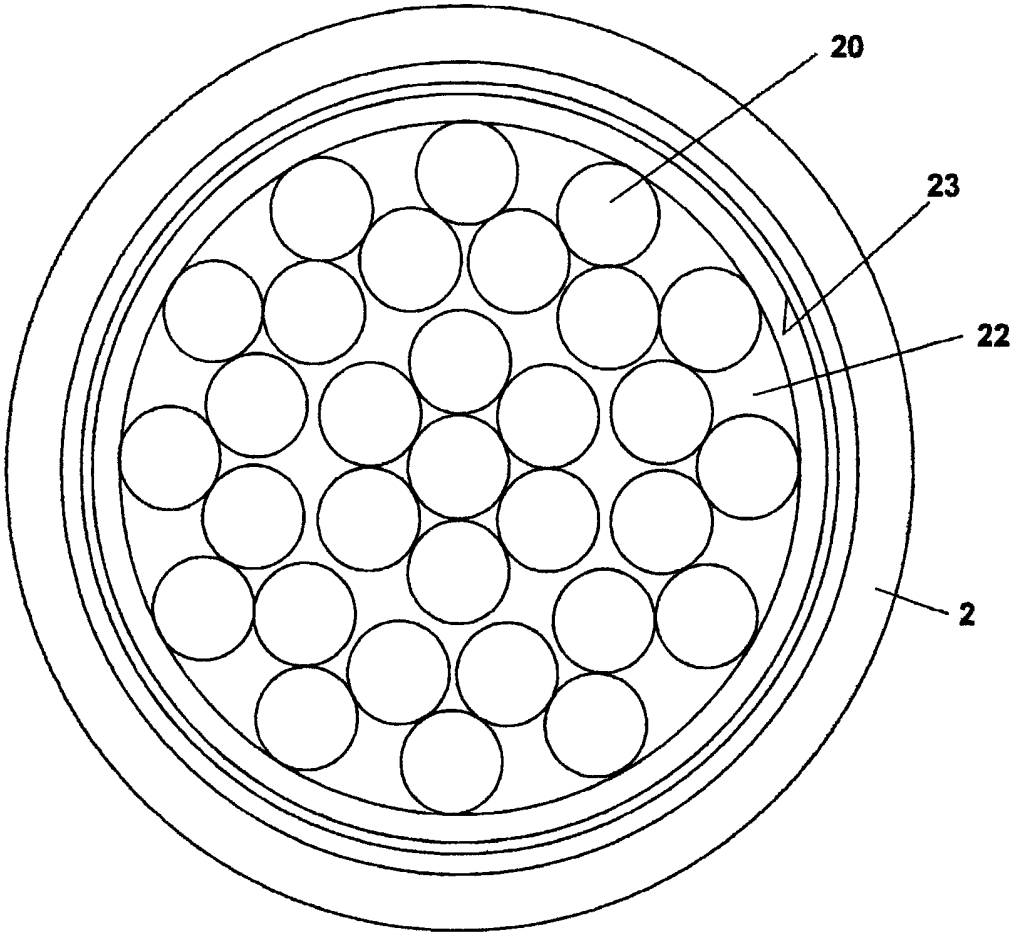

FIG.3

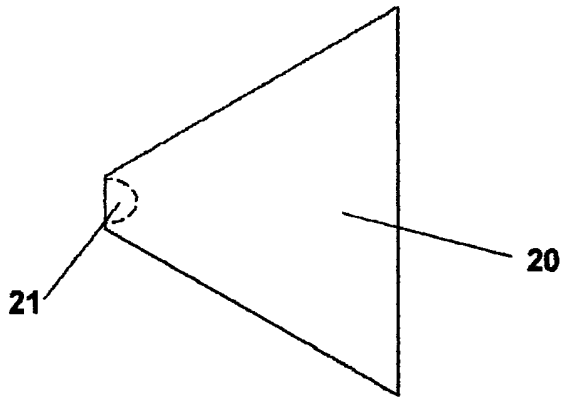

FIG.4

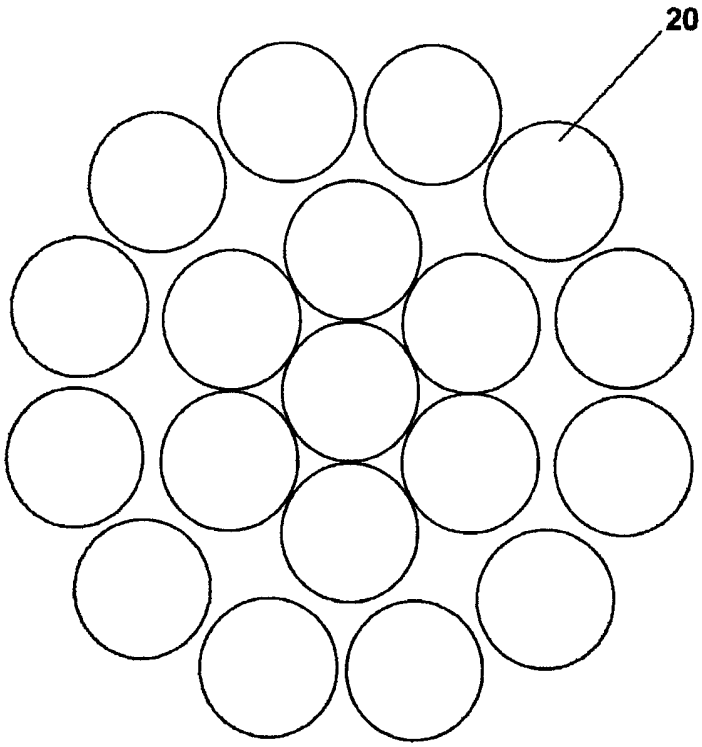

FIG.5

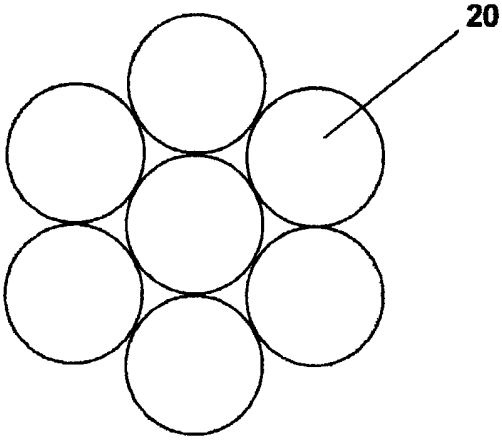

FIG.6

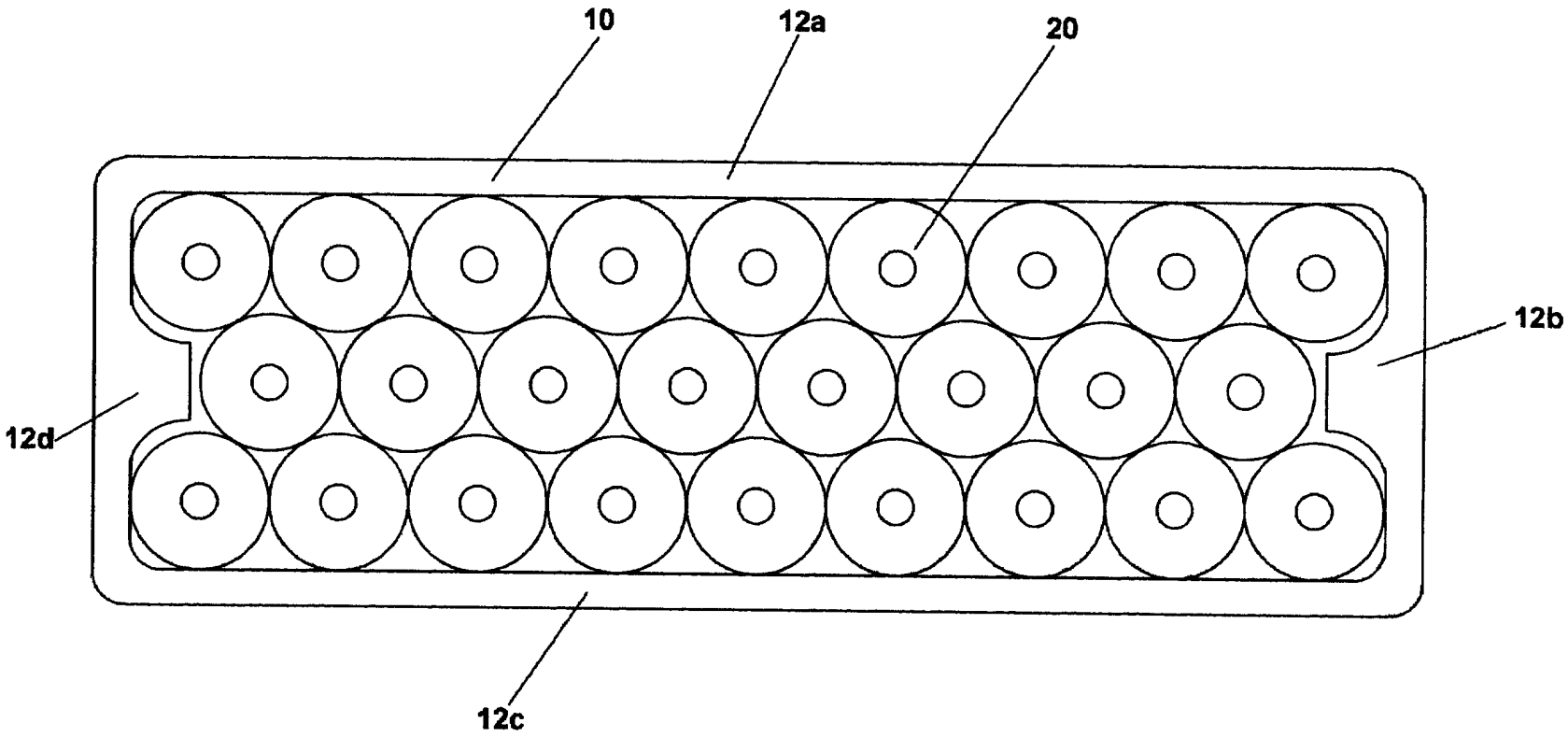

FIG.7

TITLE

Underwater Lighting

DESCRIPTION

Field of Invention

The invention relates to underwater lighting units for marine use, for swimming pools, and for other applications where high intensity illumination is required from a location that is permanently under water. The invention is particularly but not exclusively suited to underwater hull lighting units to be installed in cofferdams recessed into the hulls of yachts, boats and other marine craft for illuminating the water in the immediate vicinity of the craft.

Background Art

Submersible lights for swimming pools are known, and generally comprise a sealed light unit behind a removable glass window and recessed into the wall of the pool. For maintenance, the water level is lowered, the glass window unbolted or unscrewed, and the lamp replaced. The lamp itself is conventionally a tungsten filament lamp, a fluorescent discharge tube or even a quartz halogen lamp. The technology is very basic and unsophisticated.

Underwater hull light units for marine use are much more demanding. Generally, the illumination required is far brighter than a tungsten filament lamp bulb or fluorescent discharge tube could generate. Quartz halogen or metal halide HQI lamps are therefore used. The lamp is mounted internally of the marine vessel, and the light is directed outwardly through a window in the back of a cofferdam in the hull. A cofferdam is a recessed portion of the hull. In the case of a metal-hulled vessel the cofferdam is typically created by cutting a hole in the hull and welding in place a truncated metal cylinder. The line of truncation is flush with the outer surface of the hull., The back of the recess so created is typically vertical and includes the window through which the light shines. In the case of a fibre-reinforced hull the cofferdam is normally moulded integrally with the hull.

For marine insurance purposes the cofferdam installation for an underwater hull lighting unit must be as reliable as the remainder of the hull. It is in fact tested as if it were an integral part of the hull. For that reason it has never before been thought feasible to wire the submersible lights through the wall of the cofferdam to the interior of the cofferdam. Almost always the wiring and the light source has been internally of the hull, and the light generated has been passed through the window in the cofferdam back wall. The only alternative method of mounting that has been used is to provide a sealed window across the front of the cofferdam, with the lighting unit housed inside a dry interior of the cofferdam and wired through the cofferdam wall to the hull interior. That has been feasible only because the cofferdam wall has been isolated from the surrounding water by the sealed front window.

The development of high output light emitting diodes (LEDs) of at least one watt per LED, more recently at least three watts per LED, has created a new and exciting opportunity for developing even brighter underwater lighting units. Modern high output LEDs have a very long mean lamp lifetime and can therefore be regarded as being substantially maintenance-free. They do, however, have a relatively high heat output from the rear of the LED and are therefore generally incorporated into relatively expensive cooling enclosures which obtain their cooling by complex heat sinks or by oil cooling.

It is an object of the invention to provide a robust and reliable underwater light unit utilising modern high power LEDs in a novel enclosure which, instead of isolating the light source from the surrounding water, takes maximum benefit from the cooling potential of the surrounding water and brings the LEDs and the surrounding water into close heat-exchange relationship.

The Invention

The invention provides an underwater lighting unit as specified in claim 1. The housing may be cast, formed or machined from a single piece of metal,

preferably stainless steel, aluminium or an aluminium alloy, so that the back and side walls are contiguous and joint-free. The screen, which is preferably of toughened glass, for example 8 mm thick heat-toughened borosilicate glass, is recessed into the housing by being received in the peripheral recess of the side wall or walls of the housing preferably so as to lie flush with the front edge of that side wall or of those side walls, and is preferably sealed and secured in place by a bead of silicone resin that is placed around the recess before installation of the glass screen.

The underwater lighting unit of the invention is preferably assembled by arranging the LEDs in the desired array against the back wall of the housing and passing the electrical leads for supplying electrical power to those LEDs through at least one aperture, preferably a central aperture, in the back wall of the housing. The LEDs are preferably cemented in place using a heat-conductive thermosetting resin and subsequently potted in a resin which covers the whole of the back wall of the housing and encapsulates all of the printed circuit boards and soldered connections associated with the array of LEDs, leaving only the LED lenses exposed. The or each aperture in the back wall of the housing preferably leads to a hollow tubular externally screw threaded mounting stem through which the electrical leads pass, and preferably additional thermosetting resin compound is injected into that hollow tubular mounting stem so as to encapsulate the electrical leads as they pass therethrough. In that way three distinct water barriers are created between the front of the lighting unit and the rear of the mounting stem. A first water barrier is created around the edge of the glass screen which is bonded to the housing through the waterproof silicone seal. A second water barrier is created by the potting compound that encapsulates all but the lens portions of the array of LEDs. A third water barrier is created by the potting compound which encapsulates the electrical connector wires as they pass through the mounting stem. An additional water barrier could, if desired, be created by incorporating a waterproof gland around the connecting wires and between

the connecting wires and the mounting stem, as the wires pass from the rear of that mounting stem.

Collimators, reflectors or lenses are preferably incorporated into the assembly before the glass screen is fitted. Preferably one collimator is placed in front of each LED lens before fitting the glass screen. Each collimator may be a solid conical moulding of clear acrylic resin, with a small recess formed at the apex of each cone for fitting closely around and receiving the lens portion of the associated LED. Light generated by the LEDs is reflected by total internal reflection from the conical surfaces of the collimators, and the cone angle dictates whether the collimated beam produced by the array of LEDs is convergent, divergent or parallel. Preferably the axial length of each conical collimator is substantially equal to the distance between the potting compound holding the LEDs in place and the inside wall of the glass screen, so that the collimators provide support for the glass screen across the entire face of the screen, to reinforce the support provided by its edge mounting in the peripheral recess of the housing.

The lighting unit as so far described is complete in itself and can be used in any static underwater location such as a swimming pool or jetty, because the LEDs are well protected from the ingress of the surrounding water. In use, the water contacts the housing directly. When the lighting unit is submerged in use, the side wall or walls of the screen are in direct contact with the surrounding water, and preferably also the back wall of the housing, apart from the small mounting stem portion, is also in direct contact with the water. The water in which the lighting unit is used is an excellent cooling medium, and provides a proper degree of cooling for the LEDs.

One very important application for an underwater lighting unit according to the invention is in underwater hull lighting systems for the hulls of yachts, boats and other marine craft. A lighting unit exactly as described above may be mounted across the back of a cofferdam that is recessed into the hull of the

craft. No glass window is provided across the cofferdam in front of the lighting unit, so that the water in which the craft is afloat enters the cofferdam and surrounds the side wall or walls and optionally part of the back wall of the housing to achieve the LED cooling described above. The screw threaded mounting bolt and associated electrical wiring pass through a preferably screw-threaded aperture in the back of the cofferdam and into the inside of the hull. There is no danger at all of water passing through the lighting unit to the hull interior through the hollow mounting stem, and the only seal that is needed between the lighting unit and the rear wall of the cofferdam is a seal around the base of the mounting stem. Preferably that seal is as described and claimed in British Patent Specification No. 2258035. An annular sealing gland such as a silicone rubber seal or a polyurethane rubber seal concentric with the mounting stem is compressed between the rear wall of the housing and the back wall of the cofferdam. An outstanding annular rib is formed on the rear face of the back wall of the housing; and a cooperating annular rib is formed on the inside of the back of the cofferdam, concentrically around the mounting hole. The ribs are of different radii, so that the sealing gland is deformed as it passes around first of all the rib on the back of the lighting unit and then the rib on the back wall of the cofferdam. Such a seal is more or less as disclosed in British Patent Specification No. 2258035 but a considerable improvement in the sealing function can be obtained by having two or more annular ribs on the back of the cofferdam and two or more annular ribs on the back of the lighting unit, of progressively increasing diameters so that on tightening the sealing gland is bent into a generally corrugated shape as it is bent over the successive ribs on the lighting unit and cofferdam. If desired further sealing flanges can be provided within the hole, where the screw threaded mounting stem is secured and locked in place by a nut.

Drawings

Figure 1 is an axial section through a marine hull underwater lighting unit according to the invention mounted in a cofferdam welded to the hull of a marine craft;

Figure 2 is an axial section through the cofferdam itself, before it is cut to the angle of the hull;

Figure 3 is a front view of the lighting unit of Figure 1;

Figure 4 is a side view of a collimator as used in Figure 1;

Figures 5 and 6 are schematic front views of similar lighting units, showing alternative numbers of LEDs in the array; and

Figure 7 is a front view of an alternative lighting unit in which the housing is generally rectangular in section rather than circular.

Referring first to the embodiment of Figures 1 to 4, the marine hull underwater lighting assembly comprises a lighting unit 1 according to the invention mounted at the back of a cofferdam 2 incorporated into the hull 3 of the craft. The cofferdam itself is illustrated in Figure 2, and is a flat-ended cylindrical cup, which is formed from a single piece of metal, preferably stainless steel, aluminium or an aluminium alloy, so that it is joint-free. As initially formed, the cofferdam 2 has a constant axial length as shown in Figure 2. It is then cut along the broken line 4 indicated in Figure 2, which corresponds to the hull angle at the point of installation. The angle of the line of truncation 4 can be any angle consistent with the shape of the hull at the point of installation. Angles of 50° to the vertical are easily attainable, given a sufficient axial depth of the original cofferdam 2. The cofferdam 2 is welded to the boat hull 3, both externally and internally, so that structurally it becomes an integral part of the boat hull. The only point of potential ingress of water to the inside of the hull is a central mounting aperture 5 (Figure 2) but this is reliably sealed as described below.

The rear wall of the cofferdam 2 is vertical, so that when a number of cofferdams are incorporated around the edge of the hull of the marine craft, all at the same level, the underwater lighting shining out from the lighting units 1

all shine horizontally and at the same depth, giving a uniform level of illumination when viewed from the deck of the craft.

The lighting unit 1 of the invention comprises a housing 10 which is machined from a single piece of stainless steel, aluminium or aluminium alloy. There are therefore no joints in the housing to form potential water leakage points. The housing 10 is of dished shape, with a back wall 11 surrounded by a cylindrical side wall 12. The side wall 12 is described as a single side wall because it is circular, but a rectangular shape of lighting unit as shown in Figure 7 could be considered as having four side walls 12a, 12b, 12c and 12d. The housing of the lighting unit of Figure 7 would still, however, preferably be formed from a single piece of metal, by milling.

Across the back wall 11 is arranged an array of LEDs 13 each mounted on its own printed circuit board 14. Preferably the printed circuit boards 14 are wired together in groups of LEDs 13 electrically connected in series or in parallel depending on which LEDs and which driver is used.. The circuitry on the printed circuit boards 14 is preferably such that if any LED 13 in a series fails, then that failed LED is electrically by-passed so that the other LEDs in that same series still illuminate.

Electrical wiring 15 from the printed circuit boards 14 is gathered together and passes down the centre of an externally screw-threaded mounting stem 16 which is formed integrally with the remainder of the housing 10. A thermosetting resin compound 17 is spread across the back wall 11 of the housing, encapsulating the printed circuit boards 14 and securing them to the back wall 11, and leaving only the LEDs 13 exposed. The resin compound 17 'pots' the printed circuit boards and preferably has good thermal conductivity so that the printed circuit boards make good thermal contact with the back wall 11. A similar resin 18 is injected into the mounting stem 16, to encapsulate the electrical wiring 15. A screw cap 19 with a rubber sealing gland (not shown), that is tightened around the wiring 15 by screwing the cap

19 down hard is optionally applied as a further security precaution to prevent the ingress of water into the boat hull if all of the other seals were to break down or leak.

In front of the each LED 13 is placed an acrylic collimator 20. Each collimator 20 is a cone of clear acrylic resin with a planar front face and a small indentation 21 at the apex of the cone, for receiving the associated LED 13. The collimators are sized so that they only just touch the inside surface of a glass screen 22. The screen 22, of 8 mm thick toughened glass, is located in a peripheral recess 23 around the inner front edge of the side wall 12 and is secured and sealed in place by a continuous bead of silicone resin (not shown).

Around the mounting stem 16 at the rear face of the lighting unit housing 11 are integrally formed a pair of rearwardly extending concentric annular ribs 24. The ribs 24 lie between a pair of oppositely facing outwardly extending concentric annular ribs 25 on the back wall of the cofferdam 2, and on assembly of the lighting unit 1 to the cofferdam 2 an initially flat sealing disc 26 of a silicone compound, or polyurethane rubber, or other elastomeric material is trapped between the oppositely facing ribs 24 and 25. The mounting stem 16 is externally screw-threaded, and is pushed through the aperture 5 in the back wall of the cofferdam 2 where it is held in place by a washer 27 and nut 28. The nut 28 can therefore be screwed tight until the sealing disc 26 is distorted into a corrugated section by the opposed ribs 25 and 26. British Patent No 2258035 discloses the establishment of a very reliable seal by the use of an intermediate sealing gland and one such rib on each of two flat faces to be clamped together. The use of more than one concentric rib on each of the cofferdam back wall and the lighting unit back wall establishes a uniquely efficient seal. Even greater sealing security can be achieved (although not shown in the drawings) by partially recessing the initially flat sealing disc 26 and the ribs 24 or 25 in a circular recess in the rear wall of the housing 11 around the mounting stem 16 or in the back wall of the

cofferdam 2 around the aperture 5. Depending on the depth of the circular recess and the thickness of the sealing disc 26, accurate control can be achieved of the spacing between the rear wall of the housing 16 and the back wall of the cofferdam 2 when the unit is assembled and fully tightened. Preferably the spacing established between the two walls is from no space at all (surfaces touching) to a 2 mm spacing to allow for extra water cooling, which may be desirable depending on the power of the LEDs used.

The cofferdams 2 are generally submerged by no more than 1 or 2 metres, so the water pressure on the hull around the lighting units 1 is not excessive. However the security provided by the invention against leakage, and against water penetration to the interior of the hull, is massive. Water cannot pass to the hull interior through the lighting unit because the peripheral seal around the edge of the glass screen 22 provides a first seal. The glass is secure because it is a thick screen of toughened glass and because it receives support not only around its complete periphery but also across the whole of its face area from the collimators 20. A second water seal is provided by the resin 17 in which the printed circuit boards 14 of the LEDs 13 are set and encapsulated. A third water barrier and seal is provided by the resin 18 that has been injected into the central bore of the mounting stem 16 around the wiring 15. A fourth water barrier (optional) is provided by the cap and gland 19.

Neither can water pass to the hull interior around the lighting unit 1 and between the mounting stem 16 and the cofferdam 2 because of the unique arrangement of the different diameter concentric ribs 24 and 25 and the way in which those ribs distort the initially flat sealing disc 26.

In use the cofferdam is below water level, and the water in which the craft is afloat fills the cofferdam 2 and contacts the glass screen 22, the side wall(s) 12 and optionally most of the rear wall 11 of the lighting unit 1. It has been found that a spacing of about 2 mm between the side walls of the lighting unit

1 and the cofferdam 2 is sufficient to achieve efficient cooling of the LEDs while being small enough to discourage unwanted marine growth such as barnacle growth. The LEDs are in good thermal contact with the back wall 11, and if the water surrounding the lighting unit includes 2 mm of water between the back wall 11 and the back wall of the cofferdam 2 then the heat dissipation properties of the water are sufficient to achieve excellent cooling of the LEDs. It had been found that a lighting unit according to the invention with 30 one-watt LEDs arranged as shown in Figure 3 and an external diameter of no more than 150 mm has a light output in excess of any small sized submersible lighting unit currently on the market. However a prototype has also been constructed and tested with 30 three-watt LEDs in a similar configuration, and that vastly exceeds the light output of any currently available underwater lighting units of similar size and price.

The cooling water does not have to contact the back wall 11 of the lighting unit housing 10; it is sufficient that it is in good heat exchange contact with the side wall(s). The metal of the back wall 11 forms a good heat conduction path to transport the heat of the LEDs to the side walls for dissipation into the water. However it is within the scope of the invention to provide an oil cooling structure within the light housing 1 so that heat generated by the LEDs is transported by the cooling oil to the side wall(s) 12 from where it is dissipated by heat exchange with the water.

Figures 5, 6 and 7 show alternative arrays of LEDs that can be incorporated into lighting units according to the invention.

CLAIMS

1. An underwater lighting unit comprising an array of light emitting diodes (LEDs) mounted against the back wall of a metal housing, for shining a beam of optionally focussed or collimated light through a transparent screen that is mounted in a peripheral recess around the side wall or walls of the housing, the side wall or walls, the screen and optionally part of the back wall of the housing being in direct heat exchange contact with the water in which the lighting unit is submerged in use so as to provide a proper degree of cooling for the LEDs.

2. An underwater lighting unit according to claim 1, wherein the housing is cast, formed or machined from a single piece of metal so that the back and side walls are contiguous and joint-free.

3. An underwater lighting unit according to claim 1 or claim 2, wherein the transparent screen is a toughened glass screen.

4. An underwater lighting unit according to claim 3, wherein the screen is received in the peripheral recess around the side wall or walls of the housing so as to lie flush with the front edge of the side wall or walls, and is sealed and secured in place by a continuous bead of silicone resin placed around the recess before installation of the glass screen.

5. An underwater lighting unit according to any preceding claim, wherein the housing is formed from stainless steel.

6. An underwater lighting unit according to any of claims 1 to 4, wherein the housing is formed from aluminium or aluminium alloy.

7. An underwater lighting unit according to any preceding claim, wherein each LED is individually mounted on its own printed circuit board.

8. An underwater lighting unit according to any preceding claim, wherein the printed circuit boards are secured to the back wall of the housing and to all adjacent printed circuit boards by encapsulating the printed circuit boards in a thermosetting resin compound with only the LEDs exposed.

9. An underwater lighting unit according to any preceding claim, further comprising a collimator in front of each LED, for directing illumination from that LED towards the transparent screen.

10. An underwater lighting unit according to claim 9, wherein each collimator is a solid acrylic cone having a recess at its apex for receiving the associated LED.

11. An underwater lighting unit according to claim 10, wherein the collimators have planar front faces that lie together in a plane touching or marginally spaced from the inside surface of the transparent screen.

12. An underwater lighting unit according to any preceding claim, wherein electrical leads for supplying electrical power to the LEDs pass through a central aperture in the back wall of the housing.

13. An underwater lighting unit according to claim 12, wherein the central aperture leads to the interior of a hollow tubular mounting stem extending from the back wall of the housing, the mounting stem being externally screw-threaded for mounting the underwater lighting unit through a back wall of a cofferdam of a marine vessel.

14. An underwater lighting unit according to claim 13, wherein the electrical leads pass through the mounting stem and are sealed therein by having thermosetting resin injected into the hollow interior of the mounting stem around the electrical leads.

15. An underwater lighting unit according to claim 13 or claim 14 secured through the back wall of a cofferdam of a marine vessel, with a seal between the housing of the lighting unit and the back wall of the cofferdam comprising an initially flat elastomeric sealing disc being trapped between a pair of rearwardly facing annular ribs on the back wall of the housing and a pair of forwardly facing annular ribs on the back wall of the cofferdam, both sets of ribs being concentric with the mounting stem of the housing and being of alternately increasing diameters so that the sealing disc is distorted into a corrugated shape as the housing and cofferdam are drawn tightly together by a nut screwed onto the mounting stem.

16. An underwater lighting unit according to claim 15, wherein the seal between the housing of the lighting unit and the back wall of the cofferdam is further enhanced by the sealing disc being received in a circular recess in the back wall of the cofferdam or in the back wall of the housing, with the associated annular ribs of the cofferdam or the housing extending from the base of the circular recess.

17. An underwater lighting unit according to any preceding claim, wherein the LEDs are each at least one watt in power.

18. An underwater lighting unit according to any of claims 1 to 16, wherein the LEDs are each at least three watts in power.

19. An underwater lighting unit according to any preceding claim, wherein there are up to 30 LEDs in the array.

Amendments to the claims have been filed as follows

14

CLAIMS

1. An underwater lighting unit comprising an array of light emitting diodes (LEDs) mounted against the back wall of a metal housing, for shining a beam of optionally focussed or collimated light through a transparent screen that is mounted in a peripheral recess around a side wall or walls of the housing, the side wall or walls and the screen being in direct heat exchange contact with the water in which the lighting unit is submerged in use so as to provide a proper degree of cooling for the LEDs.

2. An underwater lighting unit according to claim 1 in which part of a back wall of the housing is also in direct heat exchange with the water in which the lighting unit is submerged.

3. An underwater lighting unit according to claim 1 or claim 2, wherein the housing is cast, formed or machined from a single piece of metal so that the back and side walls are contiguous and joint-free.

4. An underwater lighting unit according to any preceding claim, wherein the transparent screen is a toughened glass screen.

5. An underwater lighting unit according to claim 4, wherein the screen is received in the peripheral recess around the side wall or walls of the housing so as to lie flush with the front edge of the side wall or walls, and is sealed and secured in place by a continuous bead of silicone resin placed around the recess before installation of the glass screen.

6. An underwater lighting unit according to any preceding claim, wherein the housing is formed from stainless steel.

7 An underwater lighting unit according to any of claims 1 to 5, wherein the housing is formed from aluminium or aluminium alloy.

8. An underwater lighting unit according to any preceding claim, wherein each LED is individually mounted on its own printed circuit board.

9. An underwater lighting unit according to any claim 8, wherein the printed circuit boards are secured to the back wall of the housing and to all adjacent printed circuit boards by encapsulating the printed circuit boards in a thermosetting resin compound with only the LEDs exposed.

10. An underwater lighting unit according to any preceding claim, further comprising a collimator in front of each LED, for directing illumination from that LED towards the transparent screen.

11. An underwater lighting unit according to claim 10, wherein each collimator is a solid acrylic cone having a recess at its apex for receiving the associated LED.

12. An underwater lighting unit according to claim 11, wherein the collimators have planar front faces that lie together in a plane touching or marginally spaced from the inside surface of the transparent screen.

13. An underwater lighting unit according to any preceding claim, wherein electrical leads for supplying electrical power to the LEDs pass through a central aperture in the back wall of the housing.

14. An underwater lighting unit according to claim 13, wherein the central aperture leads to the interior of a hollow tubular mounting stem extending from the back wall of the housing, the mounting stem being externally screw-threaded for mounting the underwater lighting unit through a back wall of a cofferdam of a marine vessel.

15. An underwater lighting unit according to claim 14, wherein the electrical leads pass through the mounting stem and are sealed therein by having thermosetting resin injected into the hollow interior of the mounting stem around the electrical leads

16. An underwater lighting unit according to claim 14 or claim 15 secured through the back wall of the cofferdam of the marine vessel with a seal between the housing of the lighting unit and the back wall of the cofferdam comprising an initially flat elastomeric sealing disc being trapped between a pair of rearwardly facing annular ribs on the back wall of the housing and a pair of forwardly facing annular ribs on the back wall of the cofferdam both sets of ribs being concentric with the mounting stem of the housing and being of alternately increasing diameters so that the sealing disc is distorted into a corrugated shape as the housing and cofferdam are drawn tightly together by a nut screwed onto the mounting stem.

17. An underwater lighting unit according to claim 16, wherein the seal between the housing of the lighting unit and the back wall of the cofferdam is further enhanced by the sealing disc being received in a circular recess in the back wall of the cofferdam or in the back wall of the housing, with the associated annular ribs of the cofferdam or the housing extending from the base of the circular recess.

18 An underwater lighting unit according to any preceding claim, wherein the LEDs are each at least one watt in power.

19. An underwater lighting unit according to any of claims 1 to 17, wherein the LEDs are each at least three watts in power.

20. An underwater lighting unit according to any preceding claim, wherein there are up to 30 LEDs in the array.

INVESTOR IN PEOPLE

Application No: GB0410216.6 17 **Examiner:** Richard So

Claims searched: 1 to 19 **Date of search:** 5 October 2004

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 12, 17 and 18.	US 2003/0048632 A1 (ARCHER). See whole documents in particular figures 4 and 5; paragraphs 0028 and 0029; and claim 13.
A	-	US 2003/0052584 A1 (MATSUI et al.). See whole document in particular figures 8 to 10; and paragraph 0056.
A	-	US 6616291 B1 (LOVE). See whole document in particular the figures; and column 1 lines 12 to 18.
A	-	JP 2002042521 A (INAX CORP.). See whole document in particular the figures; translated abstract; and Derwent abstract 2002-356435.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{W} :

F4R

Worldwide search of patent documents classified in the following areas of the IPC^{07}

F21S; F21V; F21Y

The following online and other databases have been used in the preparation of this search report

EPODOC; JAPIO; WPI