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Lash et al.

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- [54] **MARINE SAFETY LIGHT**
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Canada
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G08B 5/36
- [52] **U.S. Cl.** **362/244; 362/158; 362/186;**
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340/985
- [58] **Field of Search** 362/477, 545,
362/158, 184, 185, 186, 244–246, 235,
236, 276, 252, 800, 807, 802; 340/984,
985, 815.45

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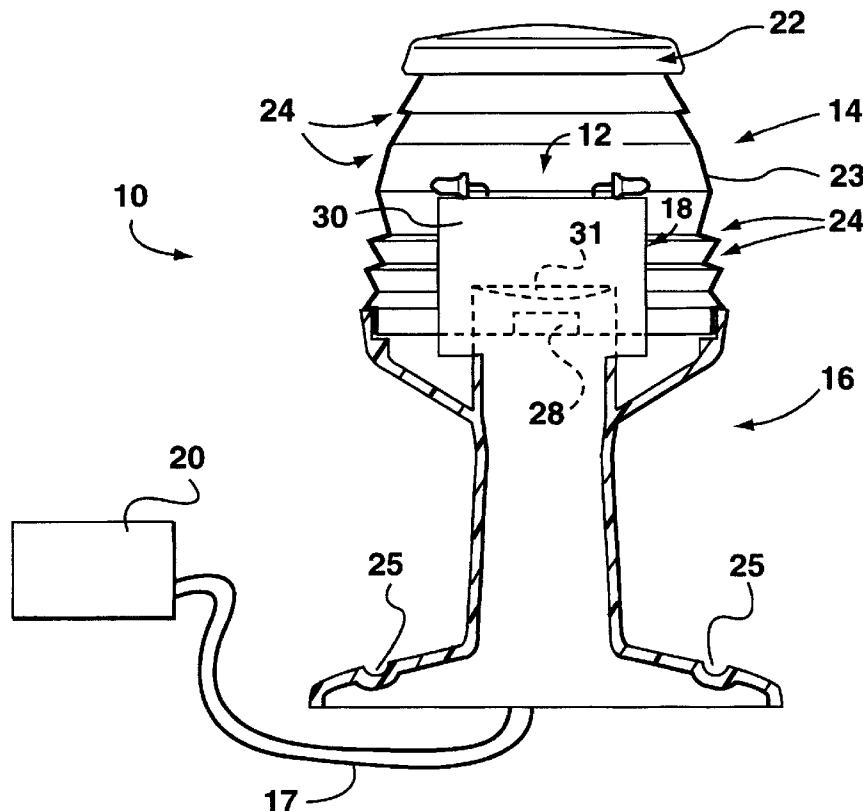
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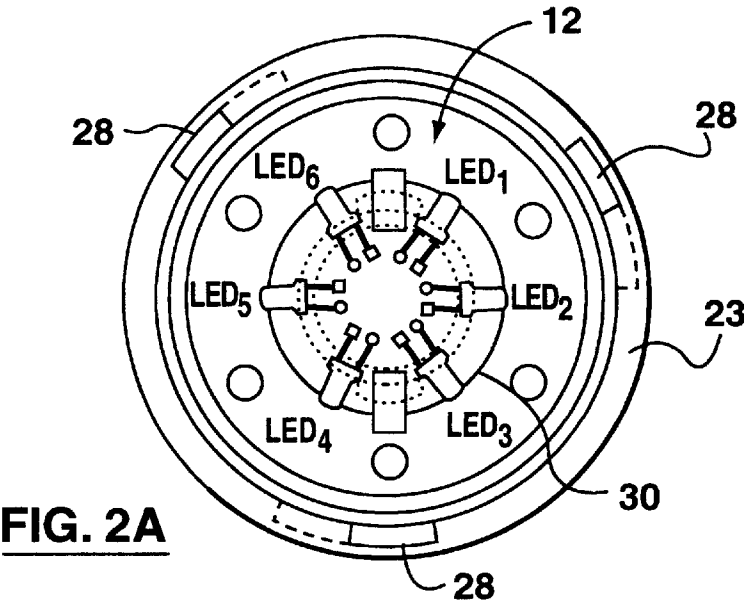
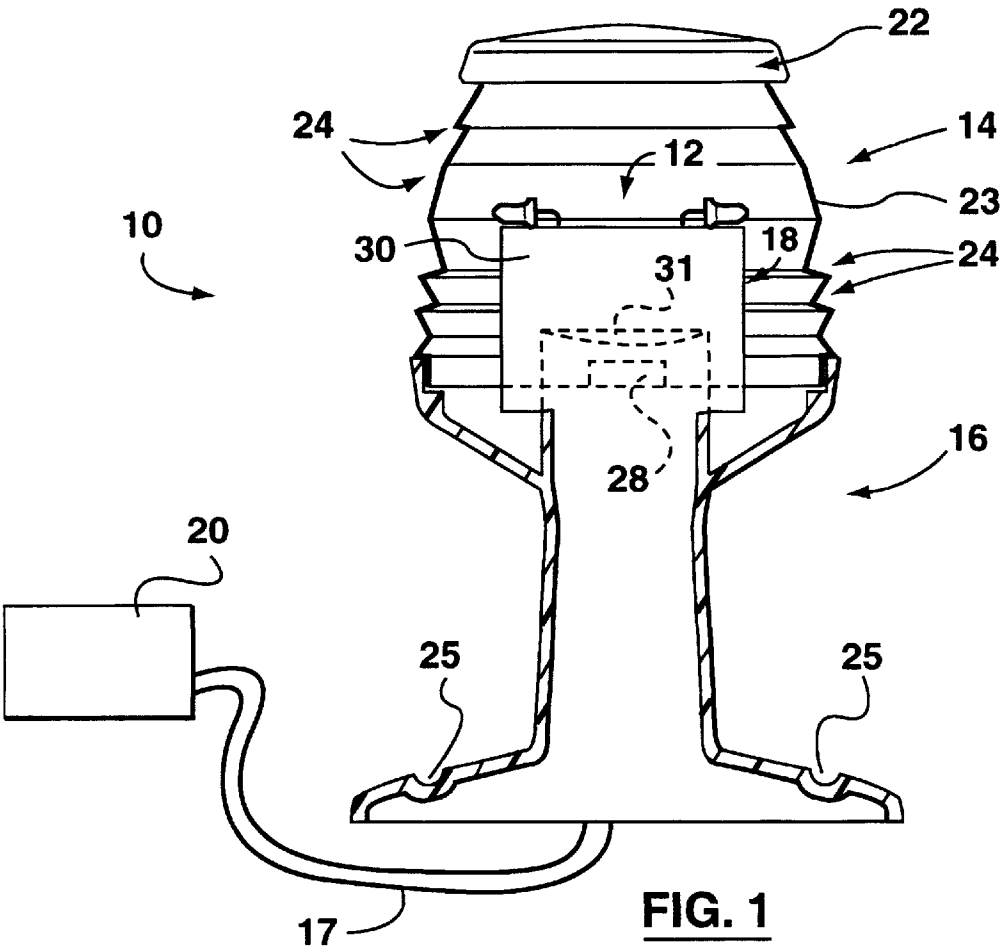
Primary Examiner—Alan Cariaso
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[57] **ABSTRACT**

A marine safety light for maximizing a boat's visibility to other boaters during darkness and inclement weather conditions consisting of a LED array which consists of a plurality of LEDs arranged in a star configuration. The LED array preferably consists of six white LEDs evenly spaced in the horizontal plane and positioned within a fresnel lens such that an even omni-directional distribution of light is emitted. LED array is powered using a power circuit which includes two conventional DC to DC converters which regulate the output voltage, allowing the marine light to operate at a constant brightness for a substantial period of time on a conventional 1.5 volt power source. Further, the power circuit automatically shuts the marine safety light off when sufficient ambient light is available and provides a continuous flashing signal when the power source is low.

10 Claims, 5 Drawing Sheets





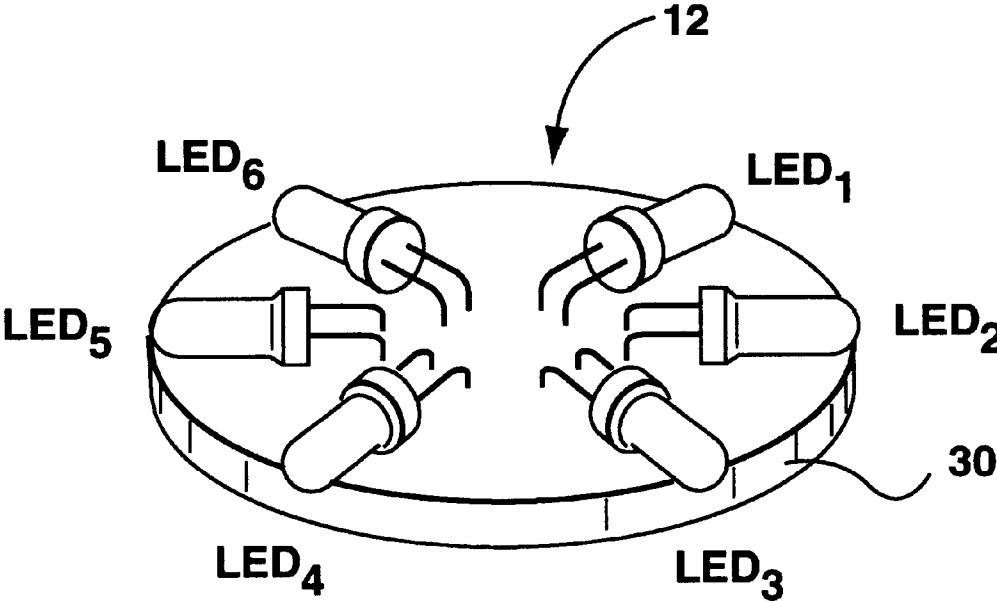


FIG. 2B

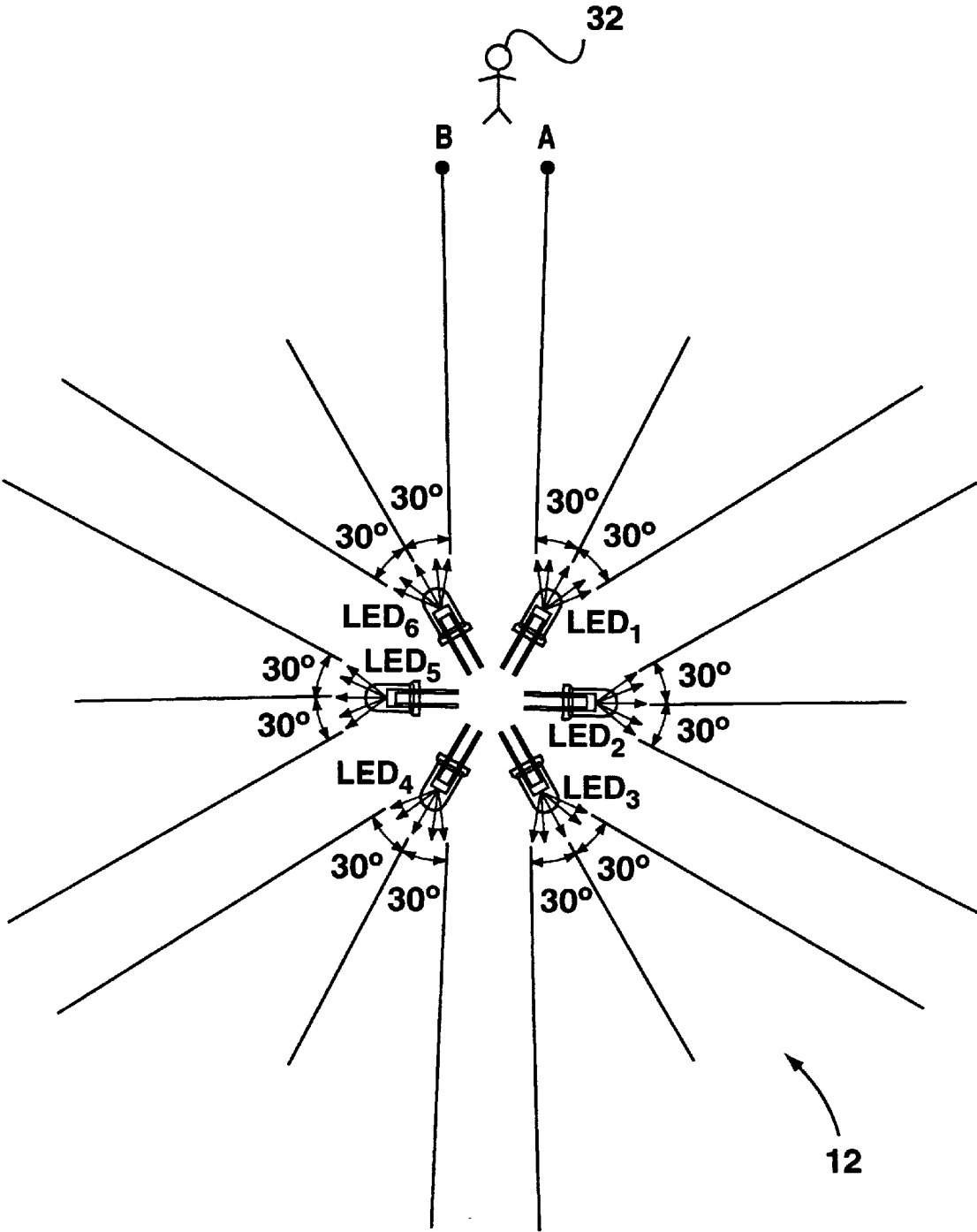


FIG. 3

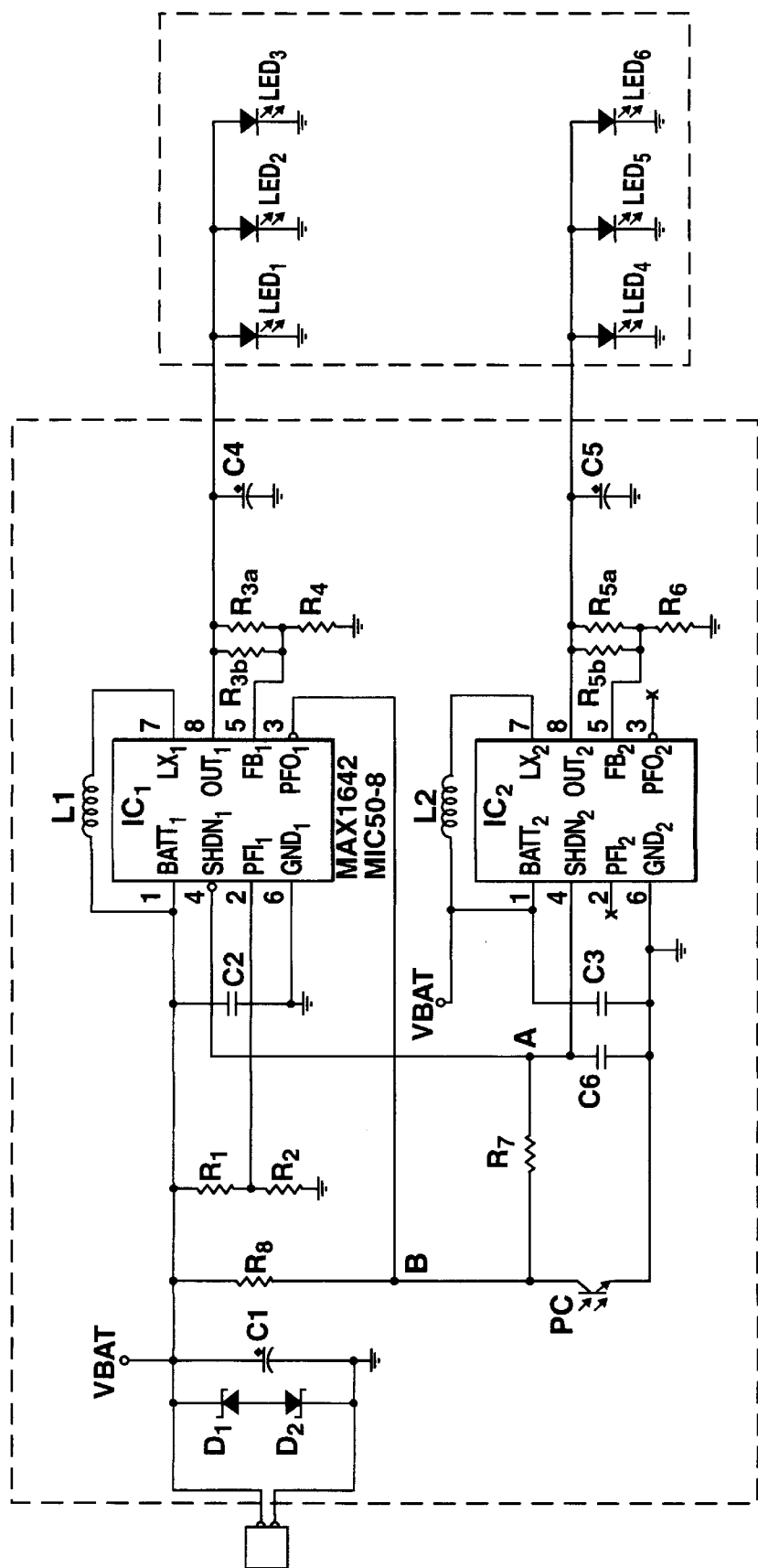


FIG. 4

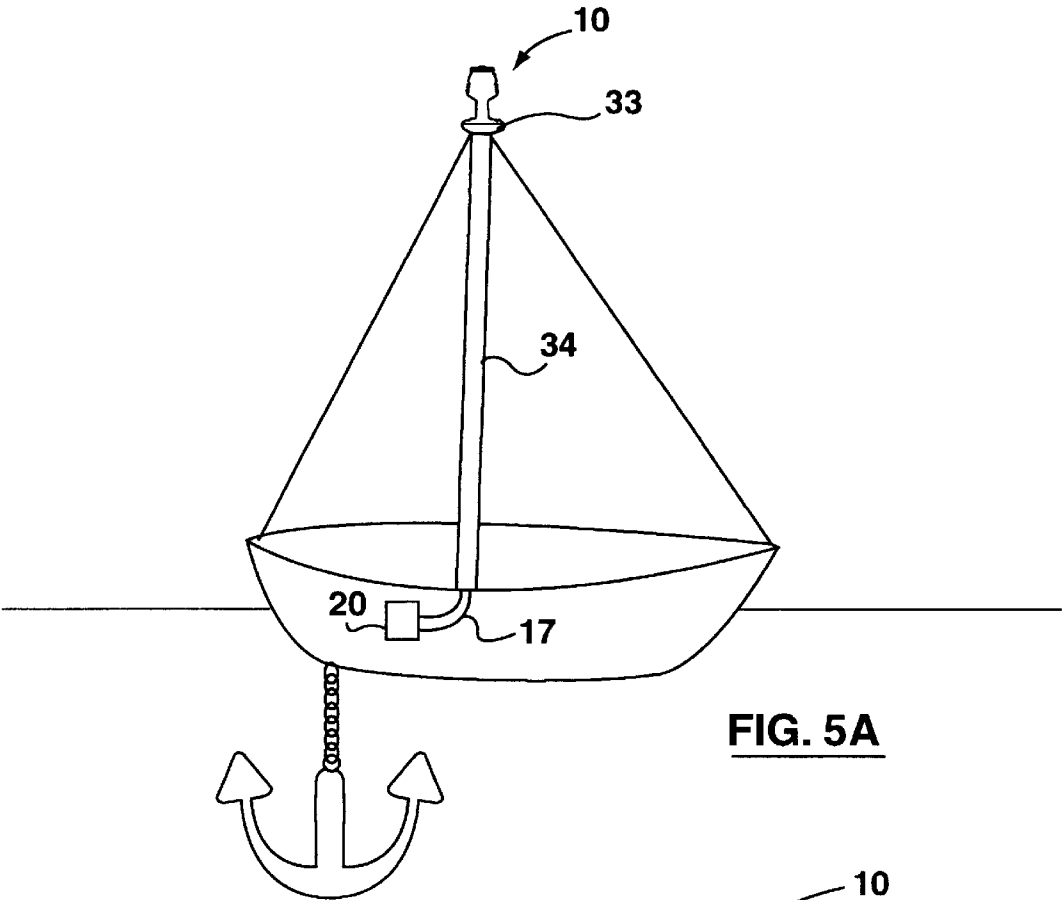


FIG. 5A

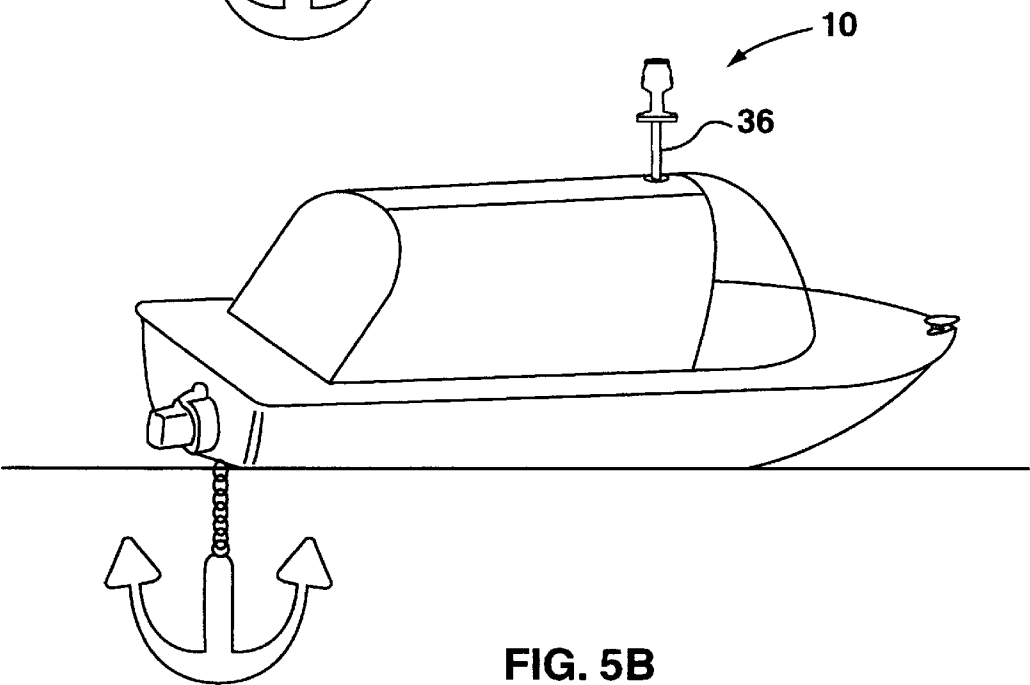


FIG. 5B

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MARINE SAFETY LIGHT

FIELD OF THE INVENTION

The present invention relates generally to lighting devices and in particular to a marine safety light for maximizing a boat's visibility to other boaters during darkness and inclement weather conditions.

BACKGROUND OF THE INVENTION

The increased popularity for boating has resulted in increased waterway traffic and created a substantial need for reliable and effective marine safety lighting equipment for boats. National coast guard and international marine regulations require power driven and sailing vessels to display an all-round white anchor light with a visibility of two nautical miles, except in designated anchorages. While reliable operation of a safety light is critical to preventing accidental collisions during darkness and inclement weather conditions, many boats still do not consistently comply with these regulations due to a lack of market available reliable and energy efficient marine safety lights.

Most marine safety lighting systems such as that disclosed in U.S. Pat. No. 5,711,591 to Jordan utilize one or more incandescent light bulbs as the light source. Incandescent bulbs are used for their omni-directional light characteristics as they provide illumination 360 degrees around the bulb. However, the use of incandescent bulbs results in an unreliable and ineffective device which requires a high degree of maintenance, due to several physical shortcomings of incandescent lamps and their general incompatibility with the marine environment.

Incandescent bulbs consist of a resistive tungsten filament suspended by support wires with a vacuum inside a glass envelope. As a result, they are highly susceptible to damage due to variations in temperature, mechanical shock or vibration and voltage spikes or transients. Since safety marine lights are generally positioned on top of a masthead for optimal visibility, severe environmental and/or mechanical damage may occur when the boat traverses rough water. Under such conditions additional forces and stresses are exerted on the entire masthead light assembly. Further, since the typical life of incandescent lamps usually averages around a thousand hours, it must be replaced several times during the course of the year simply due to normal life expiry. It is common for users to forget or delay replacing bulbs when they have expired, especially when the marine safety light is inconveniently positioned on the boat (i.e. on a masthead).

Further, since incandescent bulbs have high power requirements, their use in a marine safety light can cause other significant safety problems. Most marine safety lights such as those disclosed in U.S. Pat. No. 4,856,452 to Pingel et al. are adapted to draw power through the boat's electrical system from the boat's battery. However, since incandescent bulbs will run down a boat's battery at a rapid rate due to the high draw of the bulb, crucial boat systems can be affected resulting in significant inconvenience and even serious danger. This eventuality causes boaters to neglect to use their safety lights due to the effect on their boat's power system. Further, the use of a stand alone battery powered safety light system requires frequent replacement of the battery as incandescent bulbs run down battery power at a high rate.

Thus, there is a need for a marine light which can safely and reliably provide omni-directional light, which can operate for a long period of time on a convenient energy supply, and which requires minimal maintenance.

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BRIEF SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a marine safety light for a boat for alerting other vessels of the presence of the boat, said marine light comprising:

- (a) an array of light emitting diodes having a uniform star configuration around a centre point such that the diodes are equally spaced around the centre point and such that the diodes face outwardly from the centre point;
- (b) a light transmitting member surrounding the array of light emitting diodes; and
- (c) a power supply for supplying electrical power to the array of light emitting diodes.

Further objects and advantages of the invention will appear from the following description, taken together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a cross-sectional side view of a preferred embodiment of a marine light according to the invention;

FIG. 2A is a top view of the LED array positioned within the lamp base of FIG. 1;

FIG. 2B is a side perspective view of the LED array positioned on a disk-shaped printed circuit board.

FIG. 3 is a top view of the lighting characteristics of the LED array of FIG. 1;

FIG. 4 is a schematic view of the marine light;

FIG. 5A shows the marine light installed on a masthead; and

FIG. 5B shows the marine light installed on a pedestal.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is first made to FIG. 1 which shows a marine safety light 10 made in accordance with a preferred embodiment of the present invention. Marine light 10 comprises a light emitting diode (LED) array 12, lens 14, lamp base 16, power circuit 18 and power source 20.

LEDs are semiconductor devices which emit a visible light when current biased in the forward direction. Unlike standard bulb type lamps, LEDs are immune to failure conditions such as filament breakage due to sudden shocks or bumps and are well suited for use in the turbulent and extreme weather conditions of a typical marine environment. In addition, LEDs are highly energy efficient as they only require a small amount of electricity to generate a relatively strong light. For example, a typical incandescent lamp operates on 5 volts and uses a current of 115 milliamps while a LED can operate on 3 volts and draw current on the order of 5 milliamps. Accordingly, LEDs are a particularly desirable lighting source in applications where energy efficiency is important and only limited power sources are available, such as on a motor or sailing boat.

The LEDs of LED array 12 are preferably 5 milliamp white LEDs such as the NSPW series white LED manufactured by Nichia Chemical Industries, Ltd. of Japan. Since the rated lifetime of these LEDs is approximately 15 years, LED array 12 provides marine light 10 with an extremely energy efficient, long lasting and durable light source. The inventors have determined that such an LED array 12 produces visible light over one nautical mile away from the vessel.

Lens 14 includes an opaque top cap 22 and a conventionally known fresnel lens 23 formed out of clear plastic. Using

well known fresnel techniques, the stepped setbacks **24** of fresnel lens **23** provide the optical properties of a much thicker lens causing low vertical dispersion of the light produced by LED array **12**. Fresnel lens **23** thus produces a focal point of light along a horizontal plane which cuts through the centre of lens **14**. Lens **14** also has three rectangular protrusions (not shown) protruding down from the bottom of the rim edge of lens **14**. Rectangular protrusions are used to removably lock lens **14** into lamp base **16**.

Lamp base **16** is moulded and fabricated out of plastic and contains circular grooves **25** to securely mount marine light **10** onto a horizontal surface of a boat. Lamp base **16** also has three restraining locking rectangular grooves **28** positioned along the top inside rim of lamp base **16** which are designed to removably interlock with the three rectangular protrusions of lens **14**. The interior of lamp base **16** is hollow (not shown) to permit a pair of lamp wires **17** to run through lamp base **16** between power circuit **18** and power source **20**.

Lens **14** can be locked into lamp base **16** by positioning and lowering the three rectangular protrusions over and into the three rectangular grooves **28** and turning lens **14** clockwise as is conventionally known. This locks in lens **14** into an watertight fit with lamp base **16**. Lens **14** can also be removed as is conventionally known by turning lens **14** counterclockwise and lifting lens **14** vertically out of lamp base **16**.

Power circuit **18** is coupled to power source **20** and provides regulated DC power to LED array **12**. Power circuit **18** powers LED array **12** such that each LED receives approximately 4 milliamps of current. The inventor has determined that this level of current causes LEDs of LED array **12** to produce sufficient brightness that the device can be seen at a distance of one nautical mile under clear conditions. Power circuit **18** also turns marine light **10** off when sufficient ambient light is available or when navigation lights are on, and provides a visual indication of a low battery. Power circuit **18** is implemented on a printed circuit board **30** which is securably positioned within a restraining clamp **31** of lamp base **16**.

Power source **20** comprises a conventional battery adapter and battery with corrosion resistant connections to endure marine conditions. The battery is electronically protected against accidental short circuits. Power source **20** is typically positioned below the deck of a boat to further protect power source **20** from elemental corrosion. Since power source **20** is separate from the boat's battery system, the operation of marine light **10** does not affect other crucial systems. Power source **20** is a battery pack which comprises a plurality of 1.5 volt batteries connected in parallel.

Reference is next made to FIG. 2A which shows a top view of LED array **12** positioned within lamp base **16** with lens **14** removed. LED array **12** is shown to comprise six individual LEDs, LED₁, LED₂, LED₃, LED₄, LED₅ and LED₆ arranged in an equally spaced six-point star configuration. Since LED array **12** comprises six LEDs, LED₁ will be oriented 60 degrees from LED₂, LED₂ will be 60 degrees from LED₃ and so forth. A top section of fresnel lens **23** is shown surrounding LED array **12**. Three lamp base grooves **28** are also shown positioned around LED array **12** in the top inside rim of lamp base **16**.

FIG. 2B shows a side perspective view of LED array **12** positioned within lamp base **16** with lens **14** removed. As shown, LED array **12** is mounted on top of a disk-shaped top portion of printed circuit board **30**.

FIG. 3 shows the light characteristics of LED array **12**. Each Nichia brand LED has an output beam width (bounded

by its one-half intensity points) of 60 degrees. That is, a 50 per cent falloff in light output occurs at the edge of the 60 degree cone of light produced by each LED. The inventor has determined that by arranging the six LEDs, LED₁, LED₂, LED₃, LED₄, LED₅ and LED₆ in an evenly spaced manner, an even omni-directional distribution of light is produced. As shown, each cone of light is centred around the front face of each LED. It should be noted that since the light emitting centres of the LEDs of LED array **12** are spaced apart to form a ring, the edges of the respective light cones do not exactly coincide. However, at reasonable viewing distances from marine light **10**, a viewer **31** will perceive an even light extending 360 degrees around LED array **12**.

For any particular horizontal vantage point around marine light **10**, the light from at least two LEDs will be seen. This allows for slight faults and non-uniformity in brightness characteristics of individual LEDs. Further, since light brightness is linearly additive, the brightness of the LED array **12** will never fall below 50% of any one of its individual LEDs. For example, a viewer **31** at a distance of 100 feet will see the light emitted from both LED₁ and LED₆. LED₁ at point A emits 50% of its full rated brightness at 100 feet and LED₆ at point B will emit 50% of its full rated brightness at 100 feet. Thus, viewer **31** will perceive full rated brightness of either LED₁ or LED₆ at 100 feet. At further distances such as a half or quarter mile, also typically in marine application, viewer **31** will perceive a strong horizontally focussed light source due to the effect of the star configuration of LED array **12** in combination with fresnel lens **23**.

FIG. 4 shows an exemplary implementation of marine light **10** using two commercially available DC to DC voltage conversion integrated circuits IC₁ and IC₂, which may typically be a MAX1642 DC—DC converter ICs supplied by Maxim Integrated Products of Sunnyvale, Calif. The MAX 1642 DC—DC converter is designed to provide power to devices from a single alkaline cell and provides 80% of the power stored in a battery to LED array **12** over the course of battery life. The output remains constant as the power source discharges.

Power source **20** is coupled to power circuit **18**, which in turn provides LED array **12** with optimal operating conditions. Power source **20** can consist of a battery pack having 24 1.5 volt D-Cell Alkaline batteries to provide one year of operation. Power circuit **18** converts input voltage received from power source **20** into two 2.8 volt sources to drive LED array **12**. Power circuit **18** includes a protection circuit and utilizes integrated circuits IC₁ and IC₂ to provide full power to LED array **12** while power circuit **18** is in full operation. Power circuit **18** also causes LED array **12** to shut down when sufficient ambient light is available and causes LED array **12** to flash continuously when power source **20** is experiencing a low battery.

LED array **12** comprises two LED strings **12a** and **12b**. LED string **12a** comprises LEDs LED₁, LED₂ and LED₃ connected in parallel and LED string **12b** comprises LEDs LED₄, LED₅ and LED₆ connected in parallel. LED string **12a** is powered through integrated circuit IC₁ and LED string **12b** is powered through integrated circuit IC₂ as each integrated circuit can only provide enough current for three LEDs.

Power source **20** is connected to a common anode arrangement of 2.4 volt diodes D₁ and D₂ to provide circuit protection as is conventionally known. Accordingly, power circuit **18** is prevented from being damaged by transients that exceed 2.4 volts or in the event that a user connects

power source **20** in reverse. The cathodes of diodes D_1 and D_2 are connected across a 100 microfarad capacitor C_1 which is used to filter out variations in power source **20** voltage and to produce voltage V_{BAT} .

Power circuit **18** also includes integrated circuits IC_1 , and IC_2 which are individually configured, in part, according to manufacturer's specifications to operate as a step up DC to DC voltage converter. Integrated circuits IC_1 and IC_2 have pins GND_1 and GND_2 connected to ground and pins $BATT_1$ and $BATT_2$ connected to voltage V_{BAT} . Pins $BATT_1$ and $BATT_2$ are also coupled to ground through capacitor C_2 and C_3 to further stabilize the voltage of $BATT_1$ and $BATT_2$ and each have values of 0.1 microfarads. Pins $BATT_1$ and $BATT_2$ of integrated circuits IC_1 and IC_2 are also connected through inductors L_1 and L_2 to pins LX_1 and LX_2 . Inductors L_1 and L_2 produce a voltage stepup, in this case from 1.5 volts to 3 volts, and each has a value of 100 millihenry. Power circuit **18** can operate in three different modes of operation, normal full power mode, daylight turnoff mode and low battery mode.

In full power mode, integrated circuits IC_1 and IC_2 are configured to provide operational voltage to LED array **12**. Specifically, pin FB_1 is connected to a resistor voltage divider circuit comprising resistors R_{3a} , R_{3b} , and R_4 between pins OUT_1 and GND_1 and pin FB_2 is connected to a resistor voltage divider circuit comprising resistors R_5 and R_6 between pins OUT_2 and GND_2 . Since pins FB_1 and FB_2 regulate to 1.23 volts, the values of resistors R_{3a} , R_{3b} , and R_4 can be selected according to:

$$\frac{R_{3a}R_{3b}}{R_{3a} + R_{3b}} = R_4 \left(\frac{V_{OUT_1}}{V_{REF}} - 1 \right) \quad 30$$

and similarly the values of resistors R_{5a} , R_{5b} , and R_6 can be chosen according to:

$$\frac{R_{5a}R_{5b}}{R_{5a} + R_{5b}} = R_6 \left(\frac{V_{OUT_2}}{V_{REF}} - 1 \right)$$

where $V_{REF}=1.23$ volts. It is preferred that pins OUT_1 and OUT_2 provide 3 volts to LED strings **12a** and **12b**. Accordingly, resistors R_{3b} , R_4 , R_{5b} and R_6 have values of 475 Kohms, 365 Kohms, 475 Kohms and 365 Kohms, respectively. R_{3a} and R_{5a} are chosen during assembly so as to trim or adjust the resistance between pins OUT_1 and FB_1 and pins OUT_2 and FB_2 respectively, such that pins OUT_1 and OUT_2 provide the preferred voltage to LED strings **12a** and **12b**. Thus, when power circuit **18** is in a normal operation mode, pin OUT_1 will provide 3 volts to the anodes of LED_1 , LED_2 and LED_3 and pin OUT_2 will provide 3 volts to the anodes of LED_4 , LED_5 and LED_6 . This will result in approximately 4 milliamps being drawn through each LED of LED array **12**. Capacitors C_4 and C_5 limit output peak current and each have a value of 22 microfarads in this implementation.

In daylight turnoff mode, integrated circuits IC_1 and IC_2 are configured such that while ambient light is detected by a photocell PC, pins OUT_1 and OUT_2 will not provide power to LED array **12**. Photocell PC is connected in series with resistor R_7 and capacitor C_6 . When pins $SHDN_1$ and $SHDN_2$ go low, they cause integrated circuits IC_1 and IC_2 to shutdown. Voltage V_A at node A will depend on the values of resistors R_7 and R_8 , which are 10 Mohms and 1 Mohms respectively. Consequently, voltage V_A is typically non-zero during normal full power (evening) operation.

During the night or during inclement weather, photocell PC will not detect the requisite amount of light and will not

conduct any current. As a result, node A will remain at non-zero voltage V_A and the non-zero voltage at pins $SHDN_1$ and $SHDN_2$ will keep integrated circuits IC_1 and IC_2 active. When daylight is detected by photocell PC, photocell PC will start conducting current and since resistor R_7 is 1 Mohms, all the current flowing from V_{BAT} through resistor R_8 will be directed down through photocell PC to ground causing node A to drop low. As long as daylight is detected, node A will remain low and integrated circuits IC_1 and IC_2 will remain inactive. When daylight is no longer detected, photocell PC will stop conducting current and node A will return to a non-zero voltage as current starts conducting again through resistors R_8 and R_7 and through capacitor C_6 to ground.

In low battery mode, integrated circuits IC_1 and IC_2 are configured such that pins OUT_1 and OUT_2 provide intermittent power to LED array **12** causing marine light **10** to flash on and off continuously. This signals that it is time to install a new power source **20**. When the voltage of power source **20** at pin $BATT_1$ falls lower than the threshold voltage set through pin PFI_1 then pin PFO_1 will sink current to ground (or the voltage at GND_1). Voltage divider comprising resistors R_1 and R_2 is connected across power source **20** and ground, producing a voltage at pin PFI_1 to set the threshold voltage. In this implementation, resistors R_1 and R_2 are 221 Kohms and 475 Kohms, which produces a voltage of 1.024 volts at pin PFI_1 . The threshold can then be calculated according to the following equation:

$$V_{TH} = \left(\frac{R_1}{R_2} + 1 \right) V_{PFI_1}$$

Thus, when power source **20** falls below approximately 900 millivolts, pin PFO_1 will begin to sink current to ground.

When pin PFO_1 sinks current to ground, the circuit enters into a similar state as was the case when photocell PC was conductive. That is, current will flow from V_{BAT} through resistor R_8 and into pin PFO_1 causing voltage V_A at node A to drop to ground. This will cause pins $SHDN_1$ and $SHDN_2$ to shut down integrated circuits IC_1 and IC_2 . Once integrated circuits IC_1 and IC_2 are placed into shutdown mode, the internal MOSFETs will turn off and pins PFO_1 and PFO_2 will go high impedance. This will force current to flow again from V_{BAT} through resistors R_8 and R_7 and capacitor C_6 to ground, and capacitor C_6 will charge up again. Once capacitor C_6 charges up such that V_A pulls pins $SHDN_1$ and $SHDN_2$ high, integrated circuits IC_1 and IC_2 will become operational again.

Once operational, power source **20** will be detected as falling below 900 millivolts and pin PFO_1 will again sink current to ground causing current to flow from V_{BAT} through resistor R_8 and into pin PFO_1 and capacitor C_6 will then discharge through resistor R_7 . Voltage V_A at node A will then drop to ground and cause pins $SHDN_1$ and $SHDN_2$ to shut down integrated circuits IC_1 and IC_2 . This action will result in a continuous flashing of LED array **12** until power source **20** is removed or replaced. Since resistor R_7 and capacitor C_6 together constitute a RC circuit, the frequency of the flashing of LED array **12** is dependent on the resonant circuit's time constant. In this implementation, resistor R_7 has a value of 10 Mohms and capacitor C_6 has a value of 0.22 microfarads resulting in a time constant of 2.2 seconds. Accordingly, when marine light **10** is operating in low battery mode, LED array **12** will flash at a frequency of approximately 2.2 seconds.

Marine light **10** must be installed on a boat such that the light produced is sufficiently visible to other boaters along

the surface of a body of water. Power source **20** is preferably located below decks, although it may be placed in any other convenient location which will protect the batteries and metal connections of power source **20** from corrosive environmental effects.

As shown in FIG. 5A, marine light **10** can be attached to the top of a masthead **33** where it will have optimal visibility when a boat is moored. Masthead **33** is connected to a mast **34** which will preferably be hollow. Lamp wires **17** will then connect power circuit **18** positioned in lamp base **16**, through mast **34**, to power source **20** positioned below deck.

As shown in FIG. 5B, marine light **10** may also be installed on top of a pedestal **36** mounted on a cabin of a motor powered vessel. Pedestal **36** will preferably be hollow to allow lamp wires **17** to connect power circuit **18** to power source **20**. While this position will not provide optimal visibility, this configuration is compatible with the design of motor powered vessels.

In use, marine light **10** is installed on a boat such that the light produced by light array **12** through lens **14** is visible to other marine crafts. Since marine light **10** automatically shuts down when there is sufficient ambient light and can operate for up to a year on a single 1.5 volt battery pack, the user may install marine light **10** and simply leave the light running. When the power circuit determines that the batteries are running low, marine light **10** begins to flash on and off continuously to signal that it is time for a new battery pack.

Thus, marine light **10** provides a long lasting safety light for marine craft which includes a low battery warning and which automatically shuts off during the day. The star configuration of the LED array **12**, is especially suited to application in the marine environment, due to the omnidirectional nature of its output light and the fact that the LEDs themselves are highly resistant to the corrosive effects of a marine environment.

Various alternatives to the preferred embodiment of marine light **10** are possible. For example, the LED array **12** of marine light **10** can be fabricated out of different combinations of LED colours to produce a white light. Further, while it is preferred to use six LEDs in the LED array, it is also possible to implement LED array **12** with fewer or larger numbers of LEDs. For example, eight LEDs could be arranged in a star pattern 45 degrees apart. While the light projected by marine light **10** will not be as uniform with fewer LEDs as it would using the preferred embodiment, it is possible to achieve a functional safety light using such an arrangement. Different types of lenses could be used in place of fresnel lens **23**. Power circuit **18** can be comprised of any regulation/power circuit which can convert battery power into 3 volts for consumption by LED arrays **12a** and **12b**. Also, it is possible for marine light **10** to have variable brightness settings by adapting power circuit **18** to provide higher current to LED array **12** and by installing a potentiometer within power circuit **18**. Finally, power source **20** can comprise alternative power sources such as a solar charged battery.

As will be apparent to persons skilled in the art, various modifications and adaptations of the structure described above are possible without departure from the present invention, the scope of which is defined in the appended claims.

We claim:

1. A marine safety light for a boat for alerting other vessels of the presence of the boat, said marine safety light comprising:

(a) an array of light emitting diodes having a uniform star configuration around a centre point such that the light emitting diodes are equally spaced around the centre point and such that the light emitting diodes face outwardly from the centre point;

(b) a light transmitting member surrounding the array of light emitting diodes; and

(c) a power supply for supplying electrical power to the array of light emitting diodes, said power supply comprising a power circuit and a battery such that power circuit provides uniform light output over the course of the lifetime of the battery, the power circuit including a low battery circuit which causes the power circuit to turn the electrical power on and off continuously when the battery is low.

2. The marine safety light of claim 1 wherein the array of light emitting diodes comprises six light emitting diodes arranged 60 degrees apart.

3. The marine safety light of claim 2 wherein the light emitting diodes are spaced apart from each other and oriented such the light emitting diodes produce a series of cones of light, each cone of light having edges that represent a 50 percent falloff in light output from a light emitting diode, the edges of the light cone of one light emitting diode being substantially coincidental with the edges of the light cone of an adjacent light emitting diode.

4. The marine safety light of claim 1 wherein the array of light emitting diodes is comprised of white light emitting diodes.

5. The marine safety light of claim 1 wherein the light transmitting member is a fresnel lens.

6. The marine safety light of claim 1 wherein the light emitting diode array is orientated in the horizontal plane.

7. The marine safety light of claim 1 wherein the battery is a 1.5 volt battery.

8. The marine safety light of claim 1 wherein the power circuit includes a photocell which causes the power circuit to shut off electrical power to the array of light emitting diodes when sufficient ambient light is available.

9. The marine safety light of claim 1 wherein the light emitting diode array and the power circuit are housed within a lamp base.

10. The marine safety light of claim 9 wherein the lamp base and the lens are removably securable and form a watertight enclosure, such that the light emitting diode array and the power circuit are completely housed in the watertight enclosure.

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