

[DESCRIPTION] Specification

[TITLE OF INVENTION]

ILLUMINATION DEVICE

[Technical Field]

5 [0001]

The present disclosure relates to an illumination device.

Priority is claimed on Japanese Patent Application No. 2015-234760, filed
December 1, 2015, the content of which is incorporated herein by reference.

[Background Art]

10 [0002]

As is shown, for example, in Patent Document 1, an observation device on
which an illumination device has been installed is used to observe the interior of an LNG
(Liquefied Natural Gas) tank. In order to enable this observation device to capture
images of the entire interior of a large LNG tank, the observation device is provided with
15 multiple light sources. Moreover, this type of observation device is normally inserted
into an LNG tank through a nozzle having a small internal diameter that is provided in a
ceiling of the LNG tank. Because of this, in order to limit any increase in the size of the
device when the device is seen in plan view, multiple light sources are arrayed in a
vertical direction of the device. Illumination devices are also disclosed in Patent
20 Literature 2~4.

[Citation List]

[Patent Document]

[0003]

[Patent Document 1]

25 Japanese Unexamined Patent Application, First Publication No. H09-43030

[Patent Document 2]

Japanese Unexamined Patent Application, First Publication No. H03-223599

[Patent Document 3]

Japanese Unexamined Patent Application, First Publication No. 2012-182152

5 [Patent Document 4]

Japanese Unexamined Patent Application, First Publication No. 2011-086602

[Summary of Invention]

[Technical Problem]

[0004]

10 In recent years, in order to, for example, lighten the weight and reduce the power consumption of a device, proposals have been made to use light source elements (i.e., LED light sources) that contain LED (light-emitting diodes) as the above-described light sources. However, at an ultra-low temperature below the boiling point of LNG (i.e., at -162 °C or less), the value of the current flowing through an LED light source is reduced
15 due to the semiconductor characteristics thereof, and illuminance cannot be guaranteed.

[0005]

In order to counter this decrease of illuminance in an LED light source, heating the LED light source by placing a heater inside a container in which the LED light source is housed may be considered. However, in order to secure a sufficient quantity of light
20 to enable the entire interior of an LNG tank to be observed, it is necessary to place a large number of LED light sources. If a large number of this type of LED light sources are arrayed in a vertical direction, then the housing container is necessarily extended in the vertical direction, so that there is considerable unevenness in the temperature distribution inside the housing container when heating is applied via a heater. As a result, it is
25 difficult to heat all of the LED light sources to an appropriate temperature.

[0006]

Furthermore, if localized high-temperature portions are generated because of this uneven temperature distribution inside the housing container, there is an increase in the amount of boiling of the external LNG around these localized high-temperature portions, and this is a factor in causing boil-off gas to increase unnecessarily.

Because of this, a way of heating each one of a large number of LED light sources to an appropriate temperature is currently being sought.

[0007]

The present disclosure was conceived in view of the above-described circumstances, and an object thereof is to make it possible, in an illumination device that is provided with multiple light-emitting elements that contain light-emitting diodes and that is immersed in a low temperature liquefied gas, for each light-emitting element to be appropriately heated to a temperature at which the light emission efficiency is increased.

[Solution to Problem]

15 [0008]

A first aspect of the present disclosure is an illumination device configured to be immersed in low-temperature liquefied gas that is provided with a base portion, and multiple light source units that are disposed in the base portion, wherein each light source unit of the multiple light source units includes a light-emitting element that contains a light-emitting diode, a heater that generates heat by being supplied with power, and a thermostat that is placed on a power supply line to the heater and that alters the energization state of the heater in accordance with the temperature.

[Advantageous Effects of Invention]

[0009]

25 According to the present disclosure, there are provided multiple light source

units that include a light-emitting element that contains a light-emitting diode, and a heater and a thermostat are installed in each light source unit. Because of this, the temperature can be controlled in each light source unit, and it is possible to prevent uneven temperature distributions from occurring. In addition, each light-emitting
5 element can be appropriately heated to a temperature at which the light emission efficiency is increased.

[Brief Description of Drawings]

[0010]

FIG. 1 is a perspective view showing the schematic structure of an illumination
10 device according to an embodiment of the present disclosure.

FIG. 2 is a side view of an illumination unit provided in the illumination device according to the embodiment of the present disclosure.

FIG. 3 is a vertical cross-sectional view of the illumination unit provided in the illumination device according to the embodiment of the present disclosure.

15 FIG. 4A is an enlarged side view that includes a circuit board provided in the illumination device according to the embodiment of the present disclosure.

FIG. 4B is a front view as seen from a direction indicated by an arrow A in Fig.
4A.

FIG. 4C is a rear view as seen from a direction indicated by an arrow B in Fig.
20 4A.

FIG. 5A is a graph showing experiment results for a light-emitting element provided in the illumination device according to the embodiment of the present disclosure.

FIG. 5B is a graph showing experiment results for a light-emitting element
25 provided in the illumination device according to the embodiment of the present

disclosure.

FIG. 5C is a graph showing experiment results for a light-emitting element provided in the illumination device according to the embodiment of the present disclosure.

5 FIG. 6 is a cross-sectional view taken along a line C-C in FIG. 3.

FIG. 7 is a wiring diagram schematically showing connection relationships in an illumination unit provided in the illumination device according to the embodiment of the present disclosure.

10 [Description of Embodiments]

[0011]

Hereinafter, an embodiment of the illumination device according to the present disclosure is described with reference to the drawings. Note that, in order to make each component a recognizable size in the following drawings, the scale of each component

15 has been suitably altered.

[0012]

FIG. 1 is a perspective view showing the schematic structure of an illumination device 1 of the present embodiment. The illumination device 1 of the present embodiment is supported by being suspended from a cable K, and is raised or lowered as

20 a result of the cable K being wound onto or unwound from a storage drum. As is shown in FIG. 1, the illumination device 1 of the present embodiment is provided with a turning unit 2 and an illumination unit 3.

[0013]

The turning unit 2 forms an upper portion of the illumination device 1 of the

25 present embodiment, and is provided with a body portion 2a, a rotation shaft portion 2b,

and a drive mechanism (not shown in the drawings). The body portion 2a is a substantially circular cylinder-shaped component that houses the drive mechanism and the like (not shown in the drawings). A connecting portion 2a1 to which the cable K is connected is provided at an upper end portion of this body portion 2a. The rotation
5 shaft portion 2b is provided so as to protrude downwards from a lower end portion of the body portion 2a, and is turnably connected to the body portion 2a. This rotation shaft portion 2b is connected to the drive mechanism that is housed inside the body portion 2a, and is able to be rotated by the drive mechanism around a vertical axis thereof relative to the body portion 2a. A lower end portion of this rotation shaft portion 2b is fixed to the
10 illumination unit 3.

[0014]

The illumination unit 3 forms a lower portion of the illumination device 1 of the present embodiment. FIG. 2 is a side view of the illumination unit 3. Additionally, FIG. 3 is a vertical cross-sectional view of the illumination unit 3.

15 As is shown in these drawings, the illumination unit 3 is provided with a base portion 4, a connector 5, body portion units 6 (i.e., light source units), body portion cases 7, a lower end portion unit 8 (i.e., a light source unit), and a lower end portion case 9.

[0015]

The base portion 4 is a component that supports the body portion units 6, the
20 body portion cases 7, the lower end portion unit 8, and the lower end portion case 9, and is provided with an upper flange 4a that is connected to the turning unit 2, and a lower flange 4b to which the lower end portion unit 8 is fixed. Two apertures 4c inside which the body portion units 6 are housed are formed in a central portion in the up-down direction of this base portion 4. This base portion 4 functions as a heat sink in order to
25 prevent the body portion units 6 and the lower end portion unit 8 from overheating. The

connector 5 is provided in the center, when looked at in plan view, of the upper flange 4a of the base portion 4, and protrudes upwards from an upper surface of the upper flange 4a. This connector 5 is connected to the turning unit 2, and is electrically connected to the turning unit 2 and the illumination unit 3.

5 [0016]

Two body portion units 6 are provided. Each body portion unit 6 is fixed to the base portion 4 so as to be able to be inserted through the apertures 4c in the base portion 4. The body portion units 6 are provided with a circuit board 6a, light-emitting elements 6b, lens units 6c, heaters 6d, a thermostat 6e, a front cover 6f, a rear cover 6g, and gaskets 6h.

[0017]

The circuit board 6a is a board-shaped component on which are mounted the light-emitting elements 6b, the lens units 6c, the heaters 6d, and the thermostat 6e, and is fixed to the base portion 4. The light-emitting elements 6b are mounted on the surface on the front surface side of the circuit board 6a. These light-emitting elements 6b include a light-emitting diode (LED), and emit light upon being supplied with power via wiring (not shown in the drawings).

[0018]

FIG. 4A is an enlarged side view that includes a circuit board 6a, FIG. 4B is a front view as seen from a direction indicated by an arrow A in FIG. 4A, and FIG. 4C is a rear view as seen from a direction indicated by an arrow B in FIG. 4A. As is shown in FIG. 4B, in the present embodiment, four light-emitting elements 6b are mounted on the circuit board 6a. These light-emitting elements 6b are arrayed along a vertical axis L that passes through the center of the circuit board 6a, and with this vertical axis L forming their central axis in sequence moving downwards, are disposed alternately to

the left and right of the vertical axis L.

The lens units 6c are fixed to the circuit board 6a, and are disposed on a front surface of the light-emitting elements 6b so as to cover the light-emitting elements 6b.

One lens unit 6c is provided respectively for each one of the light-emitting elements 6b.

- 5 In other words, as is shown in FIG. 4B, four lens units 6c are mounted on a circuit board 6a. These lens units 6c guide light emitted from the light-emitting elements 6b towards the front surface side of the circuit board 6a.

[0019]

- The heaters 6d are mounted on the surface on the rear surface side of the circuit board 6a. These heaters 6d generate heat upon being supplied with power via wiring (not shown in the drawings). As is shown in FIG. 4C, in the present embodiment, two heaters 6d are mounted on a circuit board 6a. These heaters 6d have an elongated configuration extending along the vertical axis L. Moreover, the heaters 6d are arrayed along the vertical axis L, with one heater 6d disposed on one side of the vertical axis L, and the other heater 6d disposed on the other side of the vertical axis L. In other words, the one heater 6d and the other heater 6d are disposed on mutually opposite sides sandwiching the vertical axis L.
- 10
15

[0020]

- The thermostat 6e is mounted on the surface on the rear surface side of the circuit board 6a. This thermostat 6e is placed on the power supply line of the heaters 6d, and switches the state of energization to the heaters 6d by switching the state of energization of the power supply line. Note that the thermostat 6e switches this state of energization between a power supply state in which power is supplied to the heaters 6d, and a power shut-off state in which power is not supplied to the heaters 6d.
- 20

25 [0021]

Here, the thermostat 6e switches the power supply state to the heaters 6d such that the surrounding temperature is held at a temperature at which the light emission efficiency of the light-emitting elements 6b is the highest. FIG. 5A is a graph showing an example of a relationship between temperature and illuminance in the light-emitting elements 6b used in the present embodiment. FIG. 5B is a graph showing a relationship between temperature and power consumption in the light-emitting elements 6b used in the present embodiment. FIG. 5C is a graph showing a relationship between power consumption and illuminance in the light-emitting elements 6b used in the present embodiment. Note that the graphs shown in FIG. 5A through FIG. 5C are obtained from an experiment in which a board on which the light-emitting elements 6b and a thermocouple are placed is immersed in liquid nitrogen, and is then extracted once it has cooled to an ultra-low temperature and is restored to room temperature. Furthermore, in FIG. 5A and FIG. 5C, the illuminance is standardized at the value when the temperature of the thermocouple is 20 °C. As is shown in FIG. 5A, the light-emitting elements 6b used in the present embodiment have the highest illuminance when the temperature thereof is in the vicinity of 0°C. Furthermore, as is shown in FIG. 5B, power consumption increases as the temperature rises. Moreover, as is shown in FIG. 5C, peak power consumption is in the vicinity of 25W, and this corresponds to when the light-emitting elements 6b are in the vicinity of 0°C. Because of this, the light emission efficiency is at the highest when the light-emitting elements 6b are in the vicinity of 0°C. For this reason, the switching temperature for the energization state of the thermostat 6e is set such that the surrounding temperature is 0°C. In other words, when the surrounding temperature is lower than 0°C, the thermostat 6e switches the state of energization to the heaters 6d to the power supply state, and when the surrounding

temperature is higher than 0°C, the thermostat 6e switches the state of energization to the heaters 6d to the power supply shut-off state. However, if the state of energization is switched using 0°C as a reference, then the switching of the state of energization occurs too frequently. Because of this, it is preferable for the state of energization to be
5 switched when the temperature shift from 0°C is considerable. For example, switching the state of energization from the power supply state to the power supply shut-off state when the temperature is equal to or greater than 20°C, and switching the state of energization from the power supply shut-off state to the power supply state when the temperature is equal to or less than -20°C may be considered.

10 [0022]

Returning to FIG. 3, the front cover 6f is a component that covers the entire circuit board 6a including the light-emitting elements 6b and the lens units 6c from the front surface side of the circuit board 6a, and is fastened to the base portion 4 via the gaskets 6h. Together with the gaskets 6h, this front cover 6f prevents external liquids
15 such as LNG (low-temperature liquefied gas) and the like from penetrating the interior of the front cover 6f. Furthermore, the front cover 6f also has viewing ports 6f1 that contain a transparent component in areas thereof opposite the lens units 6c. In other words, each front cover 6f has four viewing ports 6f1. These viewing ports 6f1 enable light from the light-emitting elements 6b that is irradiated through the lens units 6c to be
20 transmitted without being obstructed.

[0023]

The rear cover 6g is a component that covers the entire circuit board 6a including the heaters 6d and the thermostat 6e from the rear surface side of the circuit board 6a, and is fastened to the base portion 4 via the gaskets 6h. Together with the

gaskets 6h, this rear cover 6g prevents external liquids from penetrating the interior of the rear cover 6g. As is described above, the gaskets 6h are inserted between the front cover 6f and the base portion 4, and between the rear cover 6g and the base portion 4, and prevent external liquids from penetrating the interiors of the front cover 6f and the rear cover 6g.

[0024]

These body portion units 6 are each supported at an attitude that enables the optical axis of the lens units 6c to be horizontal in order that the irradiation direction is a horizontal direction. Additionally, the two body portion units 6 are aligned with each other in the vertical direction with a space S between them. This space S enables the amount of heat mutually transmitted between the body portion units 6 to be restricted.

[0025]

The body portion case 7 is a case that is fixed to the base portion 4 and covers the body portion units 6.

In the present embodiment, each body portion case 7 is formed by placing a front surface side case 7a that covers a front surface side of the body portion unit 6, and a rear surface side case 7b that covers a rear surface side of the body portion unit 6.

These body portion cases 7 protect the body portion units 6.

[0026]

As is shown in FIG. 3, the lower end portion unit 8 is provided with a circuit board 8a, a light-emitting element 8b, a lens unit 8c, a heater 8d, a thermostat 8e, a lower surface cover 8f, stays 8g, an upper surface plate 8h, and a gasket 8i.

[0027]

The circuit board 8a is a board-shaped component on which are mounted the light-emitting element 8b, the lens unit 8c, the heater 8d, and the thermostat 8e, and is

fixed to the upper surface plate 8h via the stays 8g. The light-emitting element 8b is mounted on the lower side surface of the circuit board 8a. This light-emitting element 8b contains a light-emitting diode (LED), and emits light upon being supplied with power via wiring (not shown in the drawings).

5 [0028]

FIG. 6 is a cross-sectional view taken along a line C-C in FIG. 3. As is shown in FIG. 6, in the present embodiment, a single light-emitting element 8b is mounted on the circuit board 8a. As is shown in FIG. 3, the lens unit 8c is fixed to the circuit board 8a, and is disposed on the lower surface of the light-emitting element 8b so as to cover
10 the light-emitting element 8b. This lens unit 8c guides light emitted from the light-emitting element 8b towards the lower surface side.

[0029]

The heater 8d is mounted on an upper surface of the circuit board 8a. This heater 8d generates heat upon being supplied with power via wiring (not shown in the
15 drawings). As is shown in FIG. 6, in the present embodiment, a single heater 8d is mounted on the circuit board 8a. The thermostat 8e is mounted on the upper surface of the circuit board 8a. This thermostat 8e is placed on the power supply line of the heater 8d, and switches the state of energization to the heater 8d by switching the state of energization of the power supply line. Note that the thermostat 8e switches this state of
20 energization between a power supply state in which power is supplied to the heater 8d, and a power shut-off state in which power is not supplied to the heater 8d. Note also that, in the same way as the thermostats 6e of the body portion units 6, the thermostat 8e also switches the power supply state to the heater 8d such that the surrounding temperature is maintained at the temperature at which the light emission efficiency of the
25 light-emitting element 8b is the highest.

[0030]

The lower surface cover 8f is a component that covers the entire circuit board 8a including the light-emitting element 8b and the lens unit 8c from the lower surface side of the circuit board 8a, and is fastened to the lower end portion case 9 via the gasket 8i.

5 Together with the gasket 8i, this lower surface cover 8f prevents external liquids such as LNG and the like from penetrating the interior of the lower surface cover 8f.

Furthermore, the lower surface cover 8f also has a viewing port 8f1 that contains a transparent component in an area thereof opposite the lens unit 8c. This viewing port 8f1 enables light from the light-emitting element 8b that is irradiated through the lens

10 unit 8c to be transmitted without being obstructed.

[0031]

The stays 8g are components that connect the circuit board 8a to the upper surface plate 8h and, as is shown in FIG. 6, four stays 8g are provided so as to encircle the light-emitting element 8b and the lens unit 8c. The upper surface plate 8h is a

15 substantially circular plate-shaped component and, as is shown in FIG. 3, is fastened to the lower portion flange 4b of the base portion 4. The gasket 8i is interposed between the lower surface cover 8f and the lower end portion case 9, and prevents liquid from penetrating the interior of the lower end portion case 9.

[0032]

20 As a result of the upper surface plate 8h being fastened to the lower portion flange 4b of the base portion 4, this lower end portion unit 8 is supported at an attitude that enables the optical axis of the lens unit 8c to be vertical in order that the irradiation direction is a vertically downward direction.

[0033]

25 The lower end portion case 9 has a substantially circular cylinder shape whose

lower end is formed as an aperture end, and is fastened to the lower portion flange 4b of the base portion 4 via a gasket 10. This lower end portion case 9 surrounds the lower end portion unit 8 from a horizontal direction, and protects the lower end portion unit 8.

[0034]

5 This illumination unit 3 is electrically connected via the turning unit 2 to an external power source, and provides illumination in a frontal direction (i.e., in a horizontal direction) using light emitted from the light-emitting elements 6b of the body portion unit 6, and also provides illumination downwards using light emitted from the light-emitting element 8b of the lower end portion unit 8.

10 [0035]

FIG. 7 is a wiring diagram schematically showing connection relationships in the illumination unit 3. As is shown in FIG. 7, in the illumination device 1 of the present embodiment, all of the light-emitting elements 6b and the light-emitting element 8b are connected in series via a single power supply line L1 to an external power supply D.

15 By connecting all of the light-emitting elements 6b and the light-emitting element 8b via a single power supply line L1 in this manner, compared with when parallel connections are employed, the number of power supply lines can be decreased. Because of this, it is possible, for example, to decrease the number of pins in the connector 5.

[0036]

20 On the other hand, the heaters 6d and the heater 8d in each body portion unit 6 and the lower end portion 8 are collectively connected via their respective body portion unit 6 or lower end portion 8 in parallel to the external power supply D. Here, the heaters 6d provided in one body portion unit 6 are connected to the external power supply D via a branch line L2, while the heaters 6d provided in the other body portion

25 unit 6 are connected to the external power supply D via a branch line L3, and the heater

8d provided in the lower end portion 8 is connected to the external power supply D via a branch line L4. Furthermore, a thermostat (i.e., the thermostats 6e and the thermostat 8e) is provided respectively for each one of the branch line L2, the branch line L3, and the branch line L4. Here, the thermostat 6e provided in one body portion unit 6 is placed on the branch line L2, the thermostat 6e provided in the other body portion unit 6 is placed on the branch line L3, and the thermostat 8e is placed on the branch line L4. By connecting a heater and thermostat in parallel to the external power supply D in this manner, the heaters and thermostat can be driven as a unit in each body portion unit 6 and in the lower end portion unit 8.

10 [0037]

The illumination device 1 of the present embodiment having the above-described structure is capable of being immersed in LNG, and power is supplied thereto from the outside via wiring that is laid along the cable K. When the illumination unit 3 of this illumination device 1 is turned, the rotation shaft portion 2b of the turning unit 2 is rotated, and the illumination unit 3 that is coupled to the rotation shaft portion 2b is turned. By turning the illumination unit 3 in this manner, it is possible to illuminate a wide area of the interior of the LNG tank.

[0038]

Here, in the illumination device 1 of the present embodiment, the thermostats 6e switch the power supply state to the heaters 6d such that the surrounding temperature is maintained at the temperature at which the light emission efficiency of the light-emitting elements 6b is the highest.

Because of this, light is emitted when the light-emitting elements 6b are in a state of maximum efficiency. Because the light emitted from these light-emitting elements 6b is irradiated in a forward direction, according to the illumination device 1 of

the present embodiment, it is possible to constantly provide bright illumination in a forward direction. Furthermore, in the illumination device 1 of the present embodiment, the thermostat 8e switches the power supply state to the heater 8d such that the surrounding temperature is maintained at the temperature at which the light emission efficiency of the light-emitting element 8b is the highest. Because of this, light is emitted when the light-emitting element 8b is in a state of maximum efficiency. Because the light emitted from this light-emitting element 8b is irradiated in a downward direction, according to the illumination device 1 of the present embodiment, it is possible to constantly provide bright illumination in a downward direction.

10 [0039]

According to the illumination device 1 of the above-described present embodiment, multiple light source units (i.e., the body portion units 6 and the lower end portion unit 8) that are provided with light-emitting elements (i.e., the light emitting elements 6b or the light emitting element 8b) that include light-emitting diodes are provided, and heaters (i.e., the heaters 6d or the heater 8d) and a thermostat (i.e., the thermostat 6e or the thermostat 8e) are placed in each body portion unit 6 and in the lower end portion unit 8. Because of this, it is possible to control the state of energization in accordance with the temperature in each one of the body portion units 6 and the lower end portion unit 8. Accordingly, it is possible to prevent an uneven temperature distribution from being generated in the longitudinal direction (in other words, in the vertical direction) of the illumination device 1, and it is additionally possible to appropriately heat each light-emitting element (i.e., the light-emitting elements 6b and the light-emitting element 8b) to a temperature at which the light emission efficiency is the highest.

25 [0040]

Moreover, as the illuminance from the light-emitting diodes increases, the amount of heat generated thereby also increases. Because of this, once the light emitting elements 6b and the light emitting element 8b are heated for a short period by the heaters 6d or the heater 8d, the amount of heat generated as a result of the increased
5 illuminance also increases, and the surrounding environment is warmed by this self-generated heat. Because of this, once the light emitting elements 6b and the light emitting elements 8b are heated by the heaters 6d or the heater 8d, the amount of heat generated by the heaters 6d and the heater 8d can be decreased, so that a temperature that is suitable for the light-emitting elements 6b and the light-emitting element 8b can be
10 maintained using a minimal amount of power.

[0041]

Moreover, in the illumination device 1 of the present embodiment, the body portion units 6 are provided with the circuit boards 6a on which are mounted the light-emitting elements 6b. Furthermore, the heaters 6d are placed on the surface of the
15 circuit board 6a on the opposite side from the surface on which the light-emitting elements 6b are mounted. Because of this, the heaters 6d can be located close to the light-emitting elements 6b, so that all of the light-emitting elements 6b can be heated highly efficiently. Additionally, the lower end portion unit 8 is provided with the circuit board 8a on which is mounted the light-emitting element 8b. Furthermore, the heater 8d
20 is placed on the surface of the circuit board 8a on the opposite side from the surface on which the light-emitting element 8b is mounted. Because of this, the heater 8d can be located close to the light-emitting element 8b, so that the entirety of the light-emitting element 8b can be heated highly efficiently.

[0042]

25 Moreover, in the illumination device 1 of the present embodiment, multiple

heaters 6d that are placed on a single circuit board 6a, and a single thermostat 6e that alters the state of energization to the multiple heaters 6d placed on the single circuit board 6a are placed in the body portion unit 6. Because of this, switching the state of the power supply to all of the heaters 6d in a single body portion unit 6 can be
5 accomplished using a single thermostat 6e, so that a simplification of the device structure of the body portion unit 6 can be achieved.

[0043]

Moreover, in the illumination device 1 of the present embodiment, the space S is formed between the multiple light source units, in other words, between the respective
10 body portion units 6. Because of this, it is possible to prevent the heat generated by one body portion unit 6 from being transmitted to the other body portion unit 6, so that the light-emitting elements 6b placed in each body portion unit 6 can be kept at a more suitable temperature.

[0044]

15 Moreover, in the illumination device 1 of the present embodiment, all of the light-emitting elements provided in each light source unit of the multiple light source units, namely, the light-emitting elements 6b in the two body portion units 6 and the light-emitting element 8b in the lower end portion unit 8 are connected in series. Because of this, the number of wires in the wiring can be decreased and reductions in
20 both the size and weight of the illumination device 1 can be achieved.

[0045]

While a preferred embodiment of the present disclosure has been described above while referring to the drawings, it should be understood that the present disclosure is not limited to the above-described embodiment. The various configurations and
25 combinations and the like of the respective component elements shown in the

above-described embodiment are merely an example thereof, and various modifications may be made thereto based on design requirements and the like insofar as they do not depart from the scope of the present disclosure.

[0046]

5 For example, in the above described embodiment, a structure is described in which the heaters 6d are placed on a circuit board 6a on the surface on the opposite side from the surface on which the light-emitting elements 6b are mounted. However, the present disclosure is not limited to this and it is also possible for the heaters 6d to be placed on the surface of the circuit board 6a on the same side as the surface on which the
10 light-emitting elements 6b are placed. In the same way, it is also possible for the heater 8d of the lower end portion unit 8 to be placed on the surface of the circuit board 8a on which the light-emitting element 8b is mounted.

[0047]

Moreover, in the above-described embodiment, a structure is described in which
15 the multiple heaters 6d and the single thermostat 6e are placed on a single circuit board 6a. However, the present disclosure is not limited to this, and it is also possible to place only one heater 6d on a single circuit board 6a, or to place multiple thermostats 6e on a single circuit board 6a.

[0048]

20 Moreover, in the above-described embodiment, a structure is described in which the space S is provided between the body portion units 6. However, the present disclosure is not limited to this and it is also possible for a thermal insulating material to be placed between the body portion units 6.

[0049]

25 Moreover, it is also possible to attach an image capturing unit (not shown in the

drawings) to the illumination device 1 of the above-described embodiment, and to use this image capturing unit as an observation device. In other words, the present disclosure is not limited to being applied to illumination devices, and may also be applied to observation devices that includes a function as an illumination device.

5 [0050]

Moreover, in the illumination device 1 of the above-described embodiment, it is also possible to place temperature sensors (not shown in the drawings) inside the body portion case 7 and the lower end portion unit 8, and to measure the temperature of the environment surrounding the light-emitting elements 6b and the light-emitting element 10 8b using these temperature sensors. Moreover, if, when using these temperature sensors, the temperature inside the illumination device 1 exhibits an abnormal value, then an emergency shutdown of the illumination device 1 may be performed.

[Industrial Applicability]

[0051]

15 According to the present disclosure, it is possible to provide an illumination device that is capable of controlling the temperature of each light source unit, and preventing an uneven temperature distribution from occurring, and that additionally is able to heat each light-emitting element appropriately to a temperature at which the light emission efficiency is increased.

20 [Reference Signs List]

[0052]

- | | |
|--------|---------------------|
| 1 | Illumination device |
| 2 | Turning unit |
| 2a | Body portion |
| 25 2a1 | Connecting portion |

	2b	Rotation shaft portion
	3	Illumination unit
	4	Base portion
	4a	Upper portion flange
5	4b	Lower portion flange
	4c	Aperture
	5	Connector
	6	Body portion unit (Light source unit)
	6a	Circuit board
10	6b	Light-emitting element
	6c	Lens unit
	6d	Heater
	6e	Thermostat
	6f	Front cover
15	6fl	Viewing port
	6g	Rear cover
	6h	Gasket
	7	Body portion case
	7a	Front surface side case
20	7b	Rear surface side case
	8	Lower end portion unit (light source unit)
	8a	Circuit board
	8b	Light-emitting element
	8c	Lens unit
25	8d	Heater

	8e	Thermostat
	8f	Lower surface cover
	8fl	Viewing port
	8g	Stay
5	8h	Upper surface plate
	8i	Gasket
	9	Lower end portion case
	10	Gasket
	D	External power source
10	K	Cable
	L	Vertical axis
	L1	Power supply line
	L2	Branch line
	L3	Branch line
15	L4	Branch line
	S	Space

[CLAIMS]

[Claim 1]

An illumination device configured to be immersed in low-temperature liquefied gas, comprising:

- 5 a base portion; and
- a plurality of light source units disposed in the base portion, wherein each light source unit of the plurality of light source units includes:
- a light-emitting element containing a light-emitting diode;
- a heater configured to generate heat by being supplied with power; and
- 10 a thermostat placed on a power supply line to the heater and configured to alter energization state of the heater in accordance with the temperature.

[Claim 2]

The illumination device according to claim 1, wherein each light source unit of the plurality of light source units is provided with a circuit board on which the

- 15 light-emitting element is mounted, and
- the heater is placed on a surface of the circuit board which is on an opposite side from a surface of the circuit board on which the light-emitting element is mounted.

[Claim 3]

- The illumination device according to claim 2 comprising a plurality of the
- 20 heaters, wherein the plurality of the heaters and the single thermostat configured to alter energization state of the plurality of heaters mounted on the single circuit board are mounted on the single circuit board.

[Claim 4]

- The illumination device according to any one of claims 1 to 3, wherein the
- 25 plurality of light source units are arranged such that a space is provided therebetween.

[Claim 5]

The illumination device according to any one of claims 1 to 3 comprising a plurality of the light-emitting elements, wherein the plurality of the light-emitting elements provided in the plurality of light source units are connected together in series.

5 [Claim 6]

The illumination device according to claim 4 comprising a plurality of the light-emitting elements, wherein the plurality of the light-emitting elements provided in the plurality of light source units are connected together in series.