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**Fujisaki et al.**

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(54) **POWER SUPPLY DEVICE**

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(73) Assignee: **TDK Corporation** (JP)

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***H05K 5/00*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***H05K 5/0017*** (2013.01)

(58) **Field of Classification Search**
CPC .... H05K 5/0017; H05K 7/142; H05K 7/1417
USPC ..... 361/601, 622, 760, 761, 752, 730, 796; 362/310; 345/39, 82, 102
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,801,345 A * 9/1998 Mikula-Curtis ..... H01H 13/702 200/314
8,419,203 B1 * 4/2013 Walker ..... G02F 1/133603 362/243
2006/0114678 A1 * 6/2006 Shimonishi ..... G02B 3/14 362/296.02
2008/0101049 A1 * 5/2008 Casto ..... G06F 1/18 361/788
2008/0298072 A1 * 12/2008 Chang ..... F21V 13/10 362/308
2010/0053955 A1 * 3/2010 Vissenberg ..... G02B 6/0021 362/235
2010/0091488 A1 * 4/2010 Ijzerman ..... G02B 6/0021 362/235

FOREIGN PATENT DOCUMENTS

JP 05-276736 10/1993
JP 2006-210516 A 8/2006

* cited by examiner

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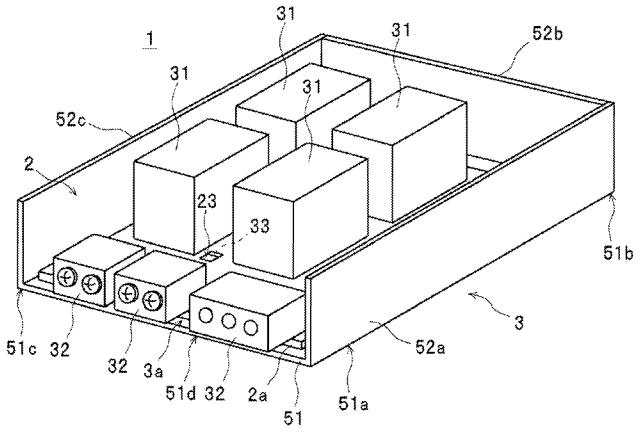
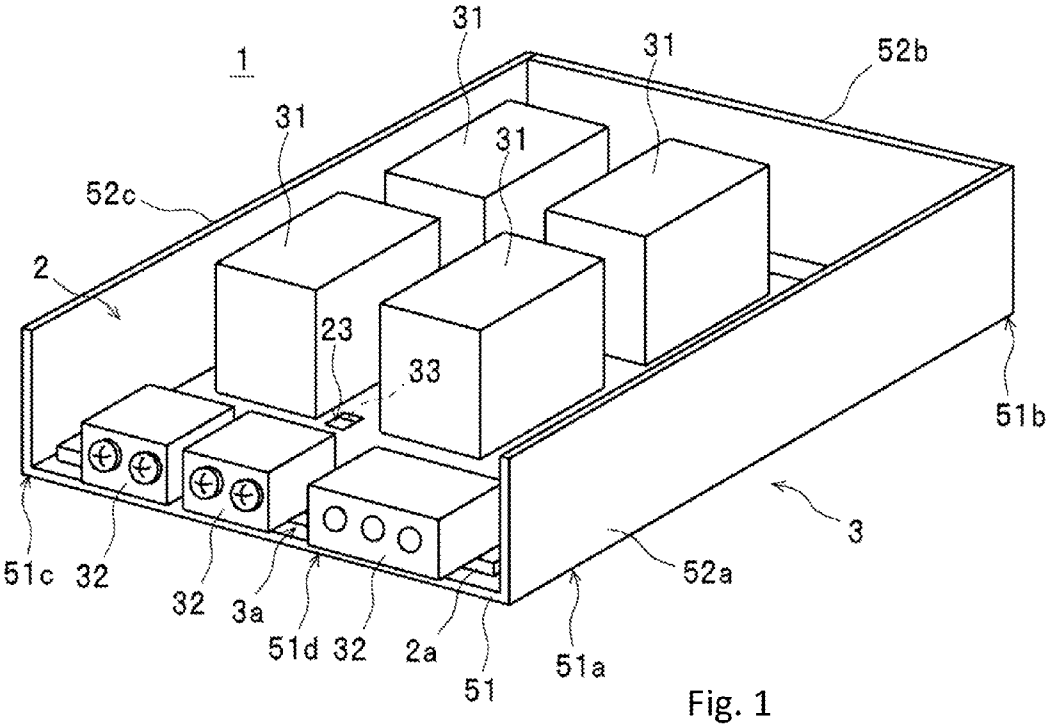
(57) **ABSTRACT**

A power supply device includes a circuit board that has an arrangement surface and a rear surface opposite to the arrangement surface and that has a through hole. An insertion mounted circuit component, a connector and a surface mounted light emitting component that is provided for confirming an operation of the power supply device are assembled on the arrangement surface. A chassis holds the circuit board from the sides and the rear surface of the circuit board and has an opening to expose the connector. The surface mounted light emitting component is surface mounted on the rear surface of the circuit board. The through hole is provided near the surface mounted light emitting component so as to guide light emitted from the surface mounted light emitting component toward the opening of the chassis.

**3 Claims, 9 Drawing Sheets**

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52b
52c
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51d
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2a
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51a
52a

Fig. 1

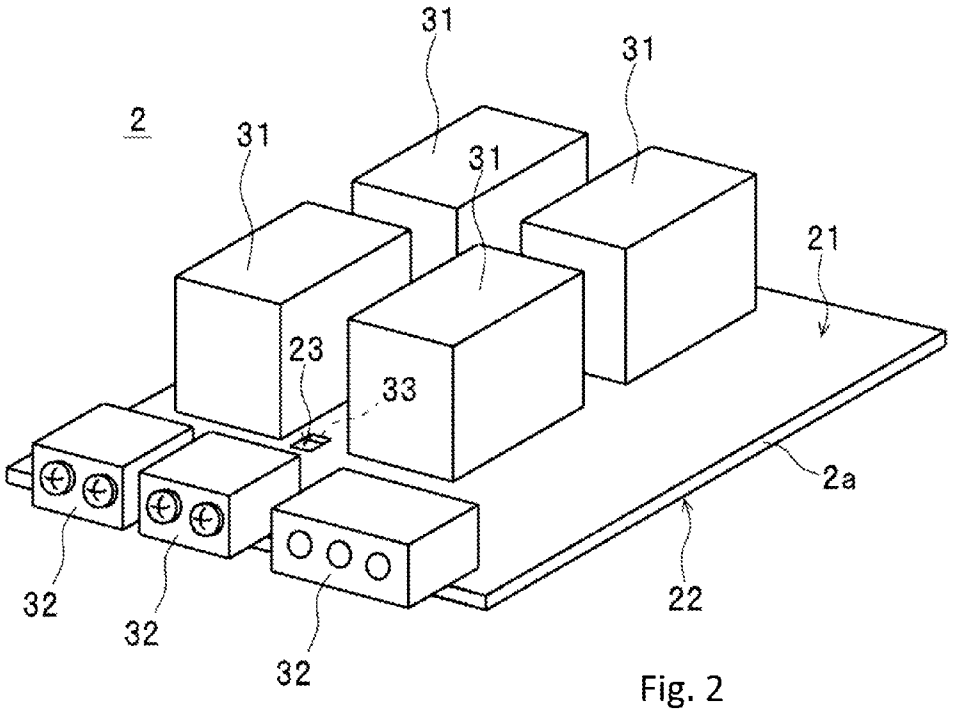
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Fig. 2

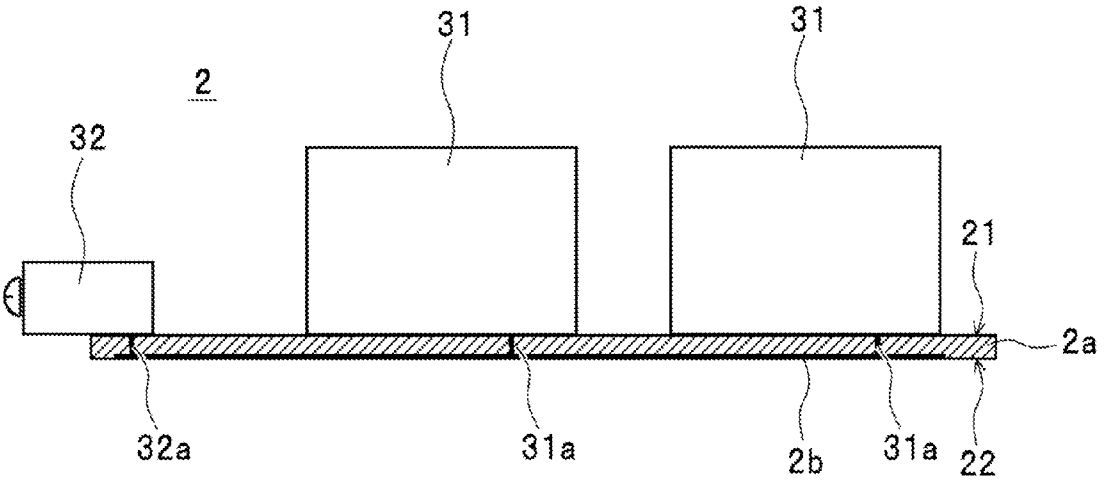



Fig. 3

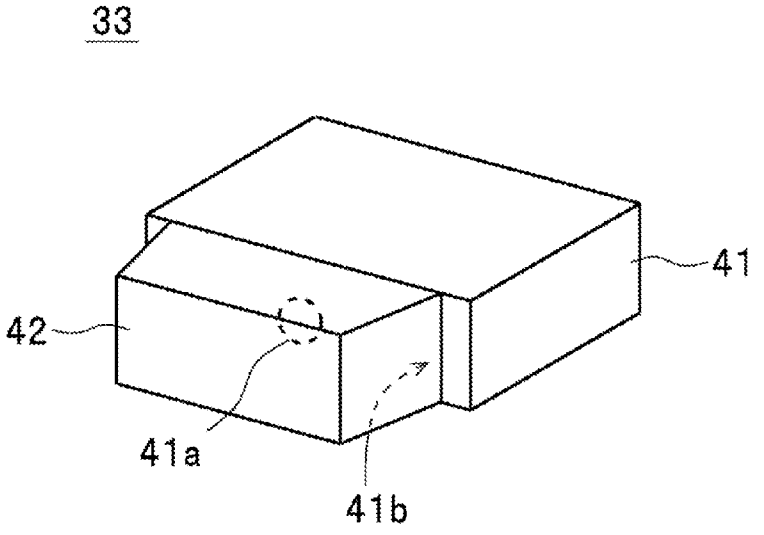



Fig. 4

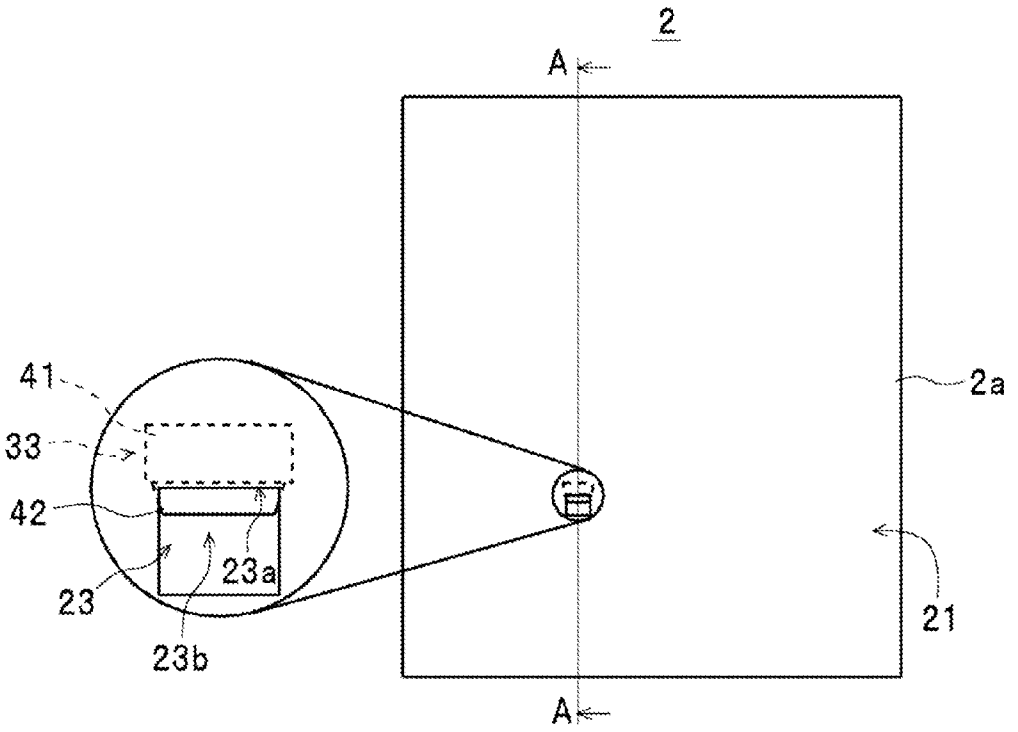



Fig. 5

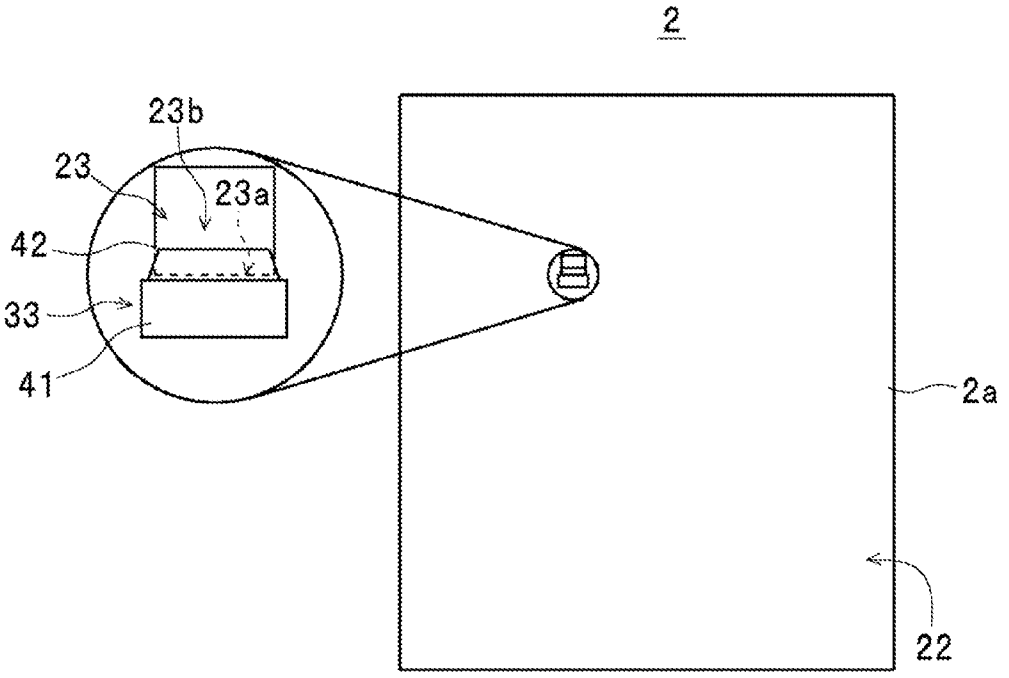



Fig. 6

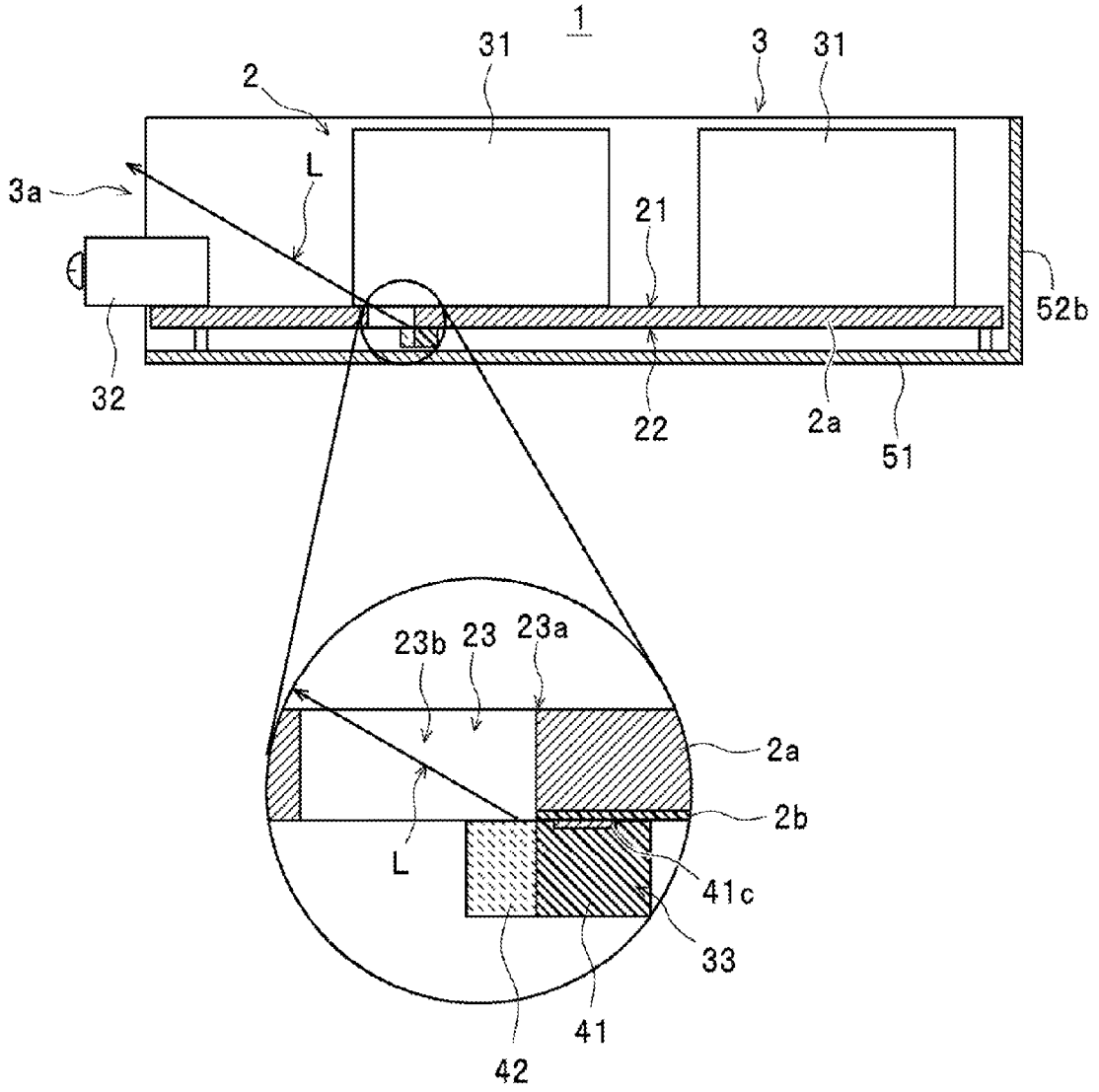
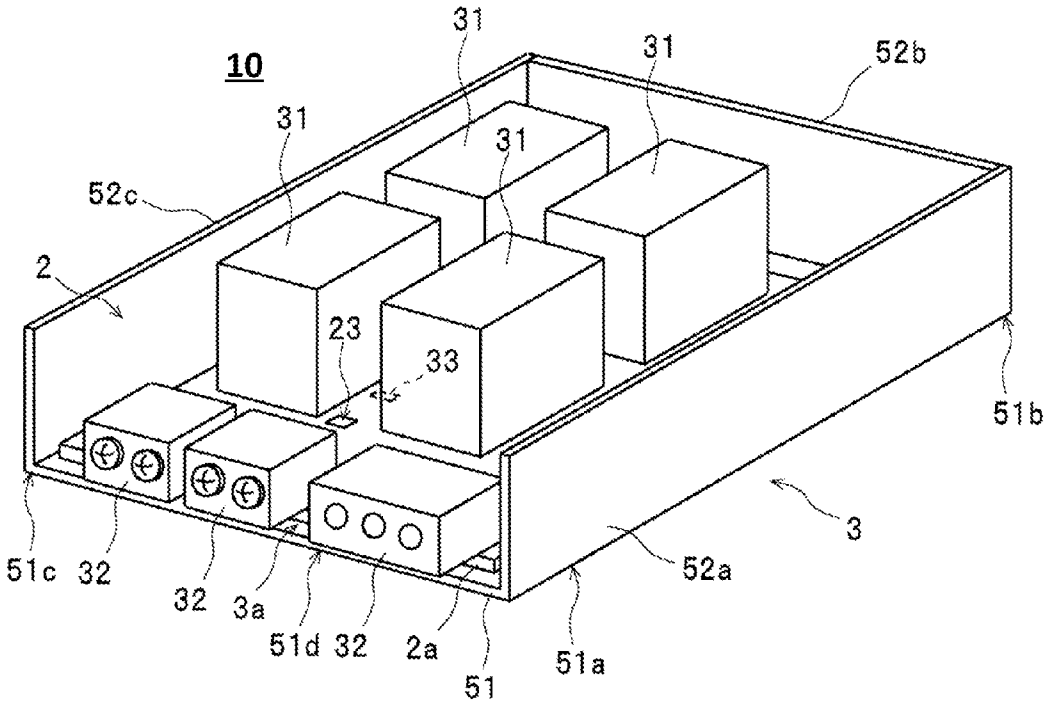



Fig. 7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31
52b
52c
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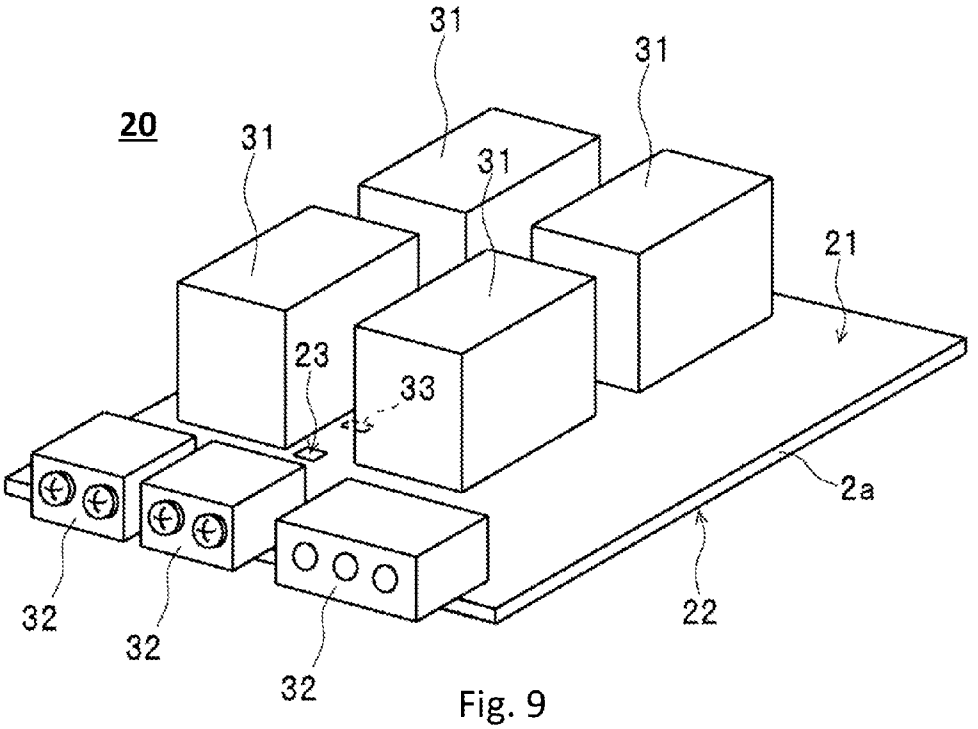
51
51a
52a

Fig. 8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31
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31
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21
23
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2a
22
32
32
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Fig. 9

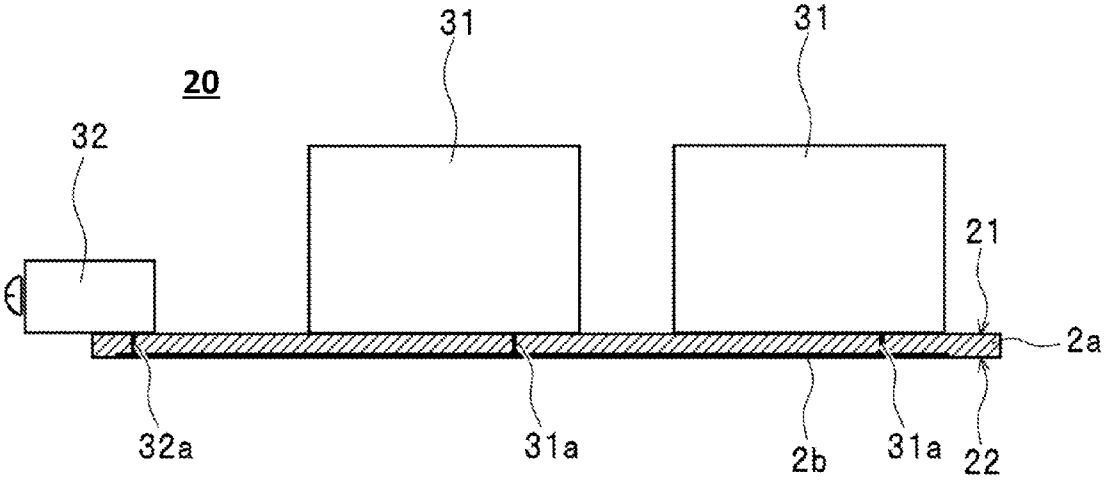


Fig. 10

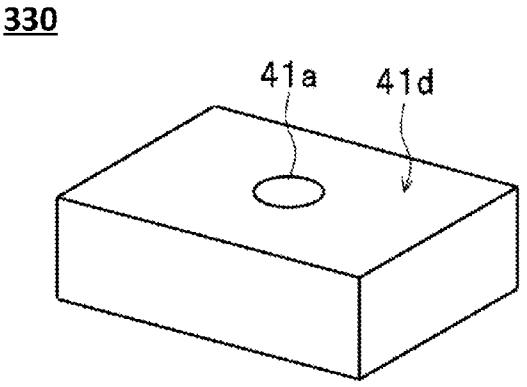


Fig. 11

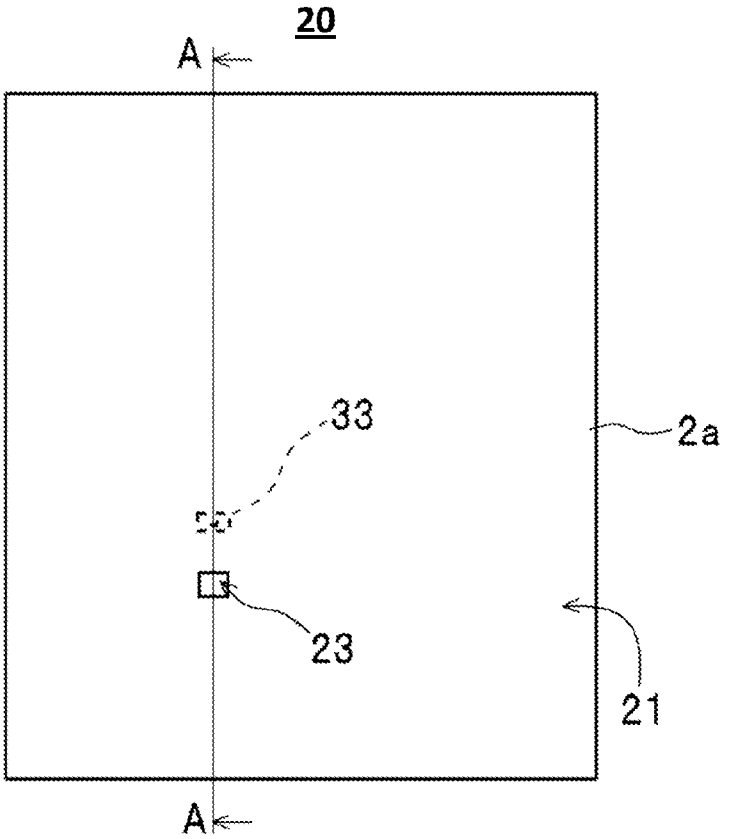


Fig. 12

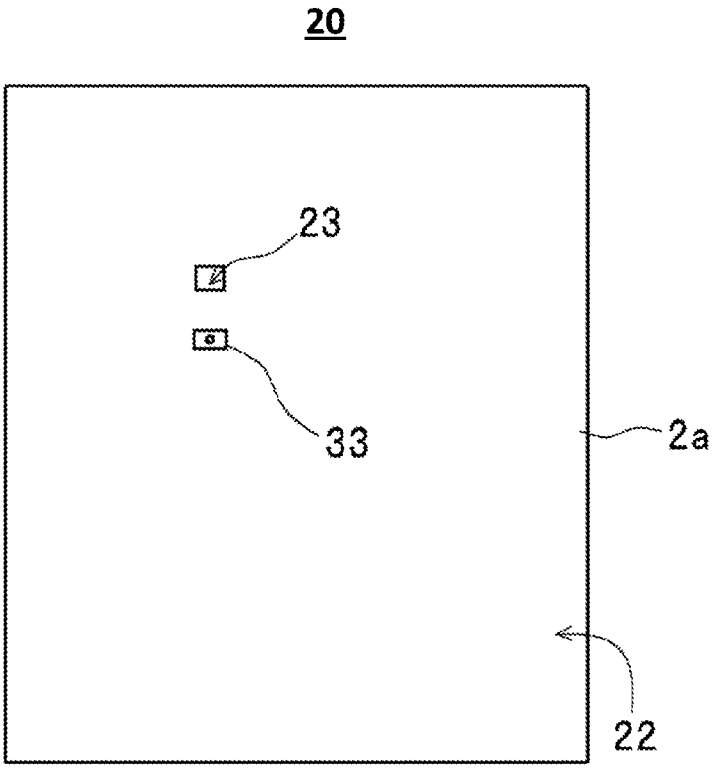


Fig. 13

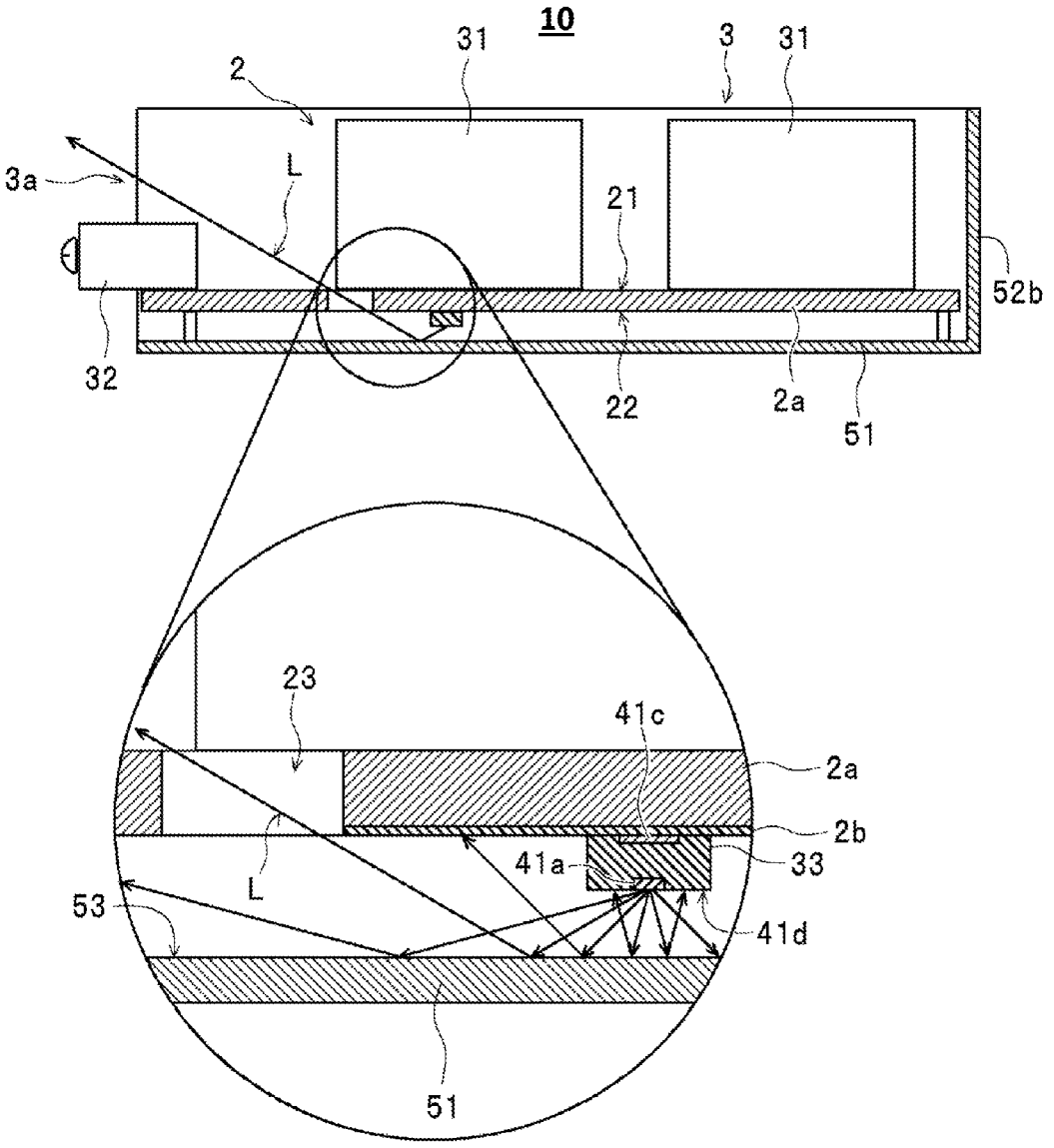


Fig. 14

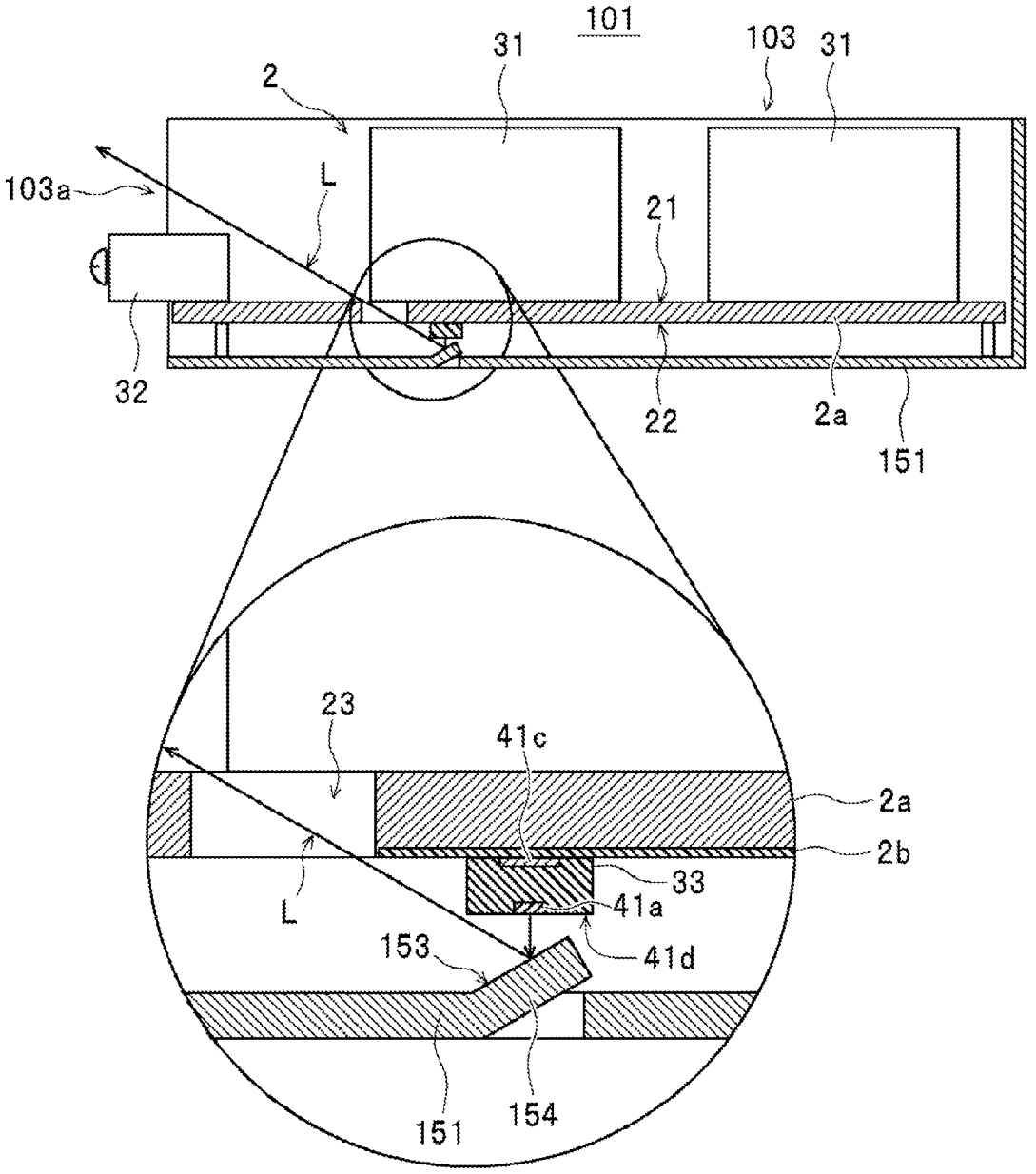
101
31
103
31
2
103a
L
21
32
22
2a
151
23
41c
2a
2b
33
41a
L
153
41d
151
154

Fig. 15

# POWER SUPPLY DEVICE

## CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to Japanese Patent Application Nos. 2013-066442 filed Mar. 27, 2013, and 2013-071131 filed Mar. 29, 2013 which are hereby expressly incorporated by reference herein in their entirety.

## BACKGROUND

The present invention relates to a power supply device that is provided with a circuit board and a chassis. Specifically, a light emitting component, such as a light emitting diode (LED), for confirming/displaying an operation state (operation state confirmation) of the power supply device is mounted on the circuit board. The chassis holds the circuit board.

As disclosed in Japanese Patent Publication Number 2002-315307, a power supply device, in which a LED for displaying an operation state is provided, is known. The power supply device is configured with a DC-DC converter module that has a wiring board on which an electric component is mounted and a shield housing that contains the wiring board. In this case, the LED for displaying an operation state is provided on the wiring board of the DC-DC converter module. This power supply device enables confirmation of an operation state of the DC-DC converter module because the LED emits light.

However, the above conventional power supply device has the following problems. An insertion mounted LED is used as the LED for displaying an operation state in this power supply device. Specifically, a connection terminal that is formed by a metal wire material is attached to a base end of a light emitting member of the insertion mounted LED. Further, in this power supply device, many insertion mounted electric components are used in addition to the insertion mounted LED for displaying an operation state. Therefore, the insertion mounted electric components need to be replaced with surface mounted electric components to miniaturize the power supply device. Further, when the insertion mounted electric component is attached to the wiring board, a connection terminal needs to be inserted into an insertion hole that is formed on the wiring board from a front surface side to a rear surface side. Further, a tip of the connection terminal, which passes through the insertion hole, located on the rear surface side needs to be fixed to a wiring pattern by soldering. Therefore, the insertion mounted electric components need to be replaced with the surface mounted electric components to improve assembling efficiency. In consideration of the above described matters, a configuration in which a surface mounted LED is used and attached to the rear surface side instead of using the insertion mounted LED can be adopted. However, when this configuration is adopted, a problem of deterioration in visibility occurs. That is, because light that is emitted from the surface mounted LED is shaded by the wiring board, the light cannot be visually recognized from the front surface side of the wiring board.

## SUMMARY

Embodiments of the present invention attempt to solve the problems explained above. An object of the present invention is to provide a power supply device that can improve manufacturing efficiency while fully securing the visibility of light that is emitted from a light emitting component.



To achieve the above object, a power supply device according to one aspect of the present invention includes: a circuit board that has an arrangement surface and a rear surface opposite to the arrangement surface and that has a through hole, the circuit board having an insertion mounted circuit component, a connector and a surface mounted light emitting component that is provided for confirming an operation of the power supply device are assembled thereon; and a chassis that holds the circuit board from sides and the rear surface of the circuit board and that has an opening to expose the connector. The surface mounted light emitting component is assembled on the rear surface of the circuit board. The through hole is provided adjacent (in a vicinity of) the surface mounted light emitting component so as to guide light emitted from the surface mounted light emitting component toward the opening of the chassis.

Further, in the power supply device according to the aspect of the present invention, the surface mounted light emitting component is configured with a light emitting member and an optical dispersion member attached to the light emitting member. An edge of the optical dispersion member is located inside of the through hole in a plan view.

Further, in the power supply device according to the aspect of the present invention, the surface mounted light emitting component is a light emitting diode (LED).

In the power supply device according to the aspect of the present invention, a light emitting component for confirming an operation of the power supply device is composed of a surface mounted LED. The surface mounted LED is placed on a connection surface (a rear surface) of a circuit board. Unlike a configuration in which an insertion mounted LED has a connection terminal formed by a metal wire material, an automated mounting process can be used for the surface mounted LED by using, for example, a mounter. As a result, the manufacturing efficiency can be improved. Further, in the power supply device according to the aspect of the present invention, because a through hole is formed near a position on which the surface mounted LED is mounted in the circuit board, light, which is emitted from the surface mounted LED that is mounted on the connection surface of the circuit board, passes through the through hole and reaches a side of an arrangement surface (a front surface) of the circuit board. As a result, the light can be irradiated toward an open area of a chassis. Therefore, according to the power supply device, the visibility of the light that is emitted from the surface mounted LED as a light emitting component can be adequately secured. As a result, when a user looks at the circuit board from the open area of the chassis, the user can certainly and visually recognize a light emitting state of the surface mounted LED. Therefore, an operation state of the power supply device can be surely confirmed.

In the power supply device according to the aspect of the present invention, because the surface mounted LED is provided with the main body that emits the light and the optical dispersion member that is attached to the main body, the light can be dispersed by the optical dispersion member. Therefore, as compared with a configuration in which the light is emitted in only a narrow range, the dispersed light certainly passes though the through hole and reaches the side of the arrangement surface. As a result, the dispersed light can be certainly irradiated to the open area of the chassis.

Further, an edge of the optical dispersion member is located inside of the through hole in a plan view. In other words, the surface mounted LED is placed at a position in which a tip of the optical dispersion member projects toward a center of the through hole from an edge of the through hole in a state in which the circuit board is seen from the side of the

arrangement surface. Therefore, much of the light that is dispersed by the optical dispersion member can pass through the through hole and be irradiated toward the open area of the chassis. As a result, the light emitting state of the surface mounted LED can be more surely and visually recognized.

A power supply device according to another aspect of the present invention includes: a circuit board that has an arrangement surface and a rear surface opposite to the arrangement surface and that has a through hole, the circuit board having an insertion mounted circuit component, a connector and a surface mounted light emitting component that is provided for confirming an operation of the power supply device are assembled thereon; a chassis that holds the circuit board from sides and the rear surface of the circuit board, that has an opening to expose the connector and that has a reflective member facing the rear surface of the circuit board and the surface mounted light emitting component; and a gap that is provided between the rear surface of the circuit board and the reflective member. The surface mounted light emitting component is assembled on the rear surface of the circuit board so as to emit light toward the reflective member. The through hole is provided adjacent to (in a vicinity of) the surface mounted light emitting component so as to guide the light reflected by the reflective member toward the opening of the chassis.

Further, in the power supply device according to the aspect of the present invention, the surface mounted light emitting component is a light emitting diode (LED).

Further, in the power supply device according to the aspect of the present invention, the reflective member is a surface of the chassis.

In the power supply device according to the aspect of the present invention, a light emitting component for confirming an operation of the power supply device is composed of a surface mounted LED. The surface mounted LED is placed on a connection surface (a rear surface) of a circuit board. Unlike a configuration in which an insertion mounted LED has a connection terminal formed by a metal wire material, an automated mounting process can be used for the surface mounted LED by using, for example, a mounter. As a result, the manufacturing efficiency can be improved. Further, in the power supply device according to the aspect of the present invention, because a through hole is formed in the circuit board, light, which is emitted from the surface mounted LED that is mounted on the connection surface of the circuit board, is reflected by the reflective member so as to pass the reflected light through the through hole. Therefore, the reflected light reaches a side of an arrangement surface (a front surface) of the circuit board. As a result, the light can be irradiated toward an open area of a chassis. Therefore, according to the power supply device, the visibility of the light that is emitted from the surface mounted LED as a light emitting component can be adequately secured. As a result, when a user looks at the circuit board from the open area of the chassis, the user can certainly and visually recognize a light emitting state of the surface mounted LED. Therefore, an operation state of the power supply device can be surely confirmed.

In the power supply device according to the aspect of the present invention, the reflective member is a bottom surface of the chassis. Thus, as compared with a configuration in which the reflective member is formed by a separate member that is different from the bottom surface of the chassis, it is possible to reduce a manufacturing cost of the power supply device because the separate reflective member is not necessary.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view that shows a configuration of a power supply device **1** according to an embodiment of the present invention.

FIG. **2** is a perspective view that shows a configuration of a power supply circuit mounting body **2** according to an embodiment of the present invention.

FIG. **3** is a cross sectional view that shows a mounting state of a circuit component **31** in the power supply circuit mounting body **2** according to an embodiment of the present invention.

FIG. **4** is a perspective view of a surface mounted LED **33** according to an embodiment of the present invention.

FIG. **5** is a plan view of a circuit board **2***a* and the surface mounted LED **33** viewed from a side of an arrangement surface **21** according to an embodiment of the present invention.

FIG. **6** is a plan view of the circuit board **2***a* and the surface mounted LED **33** viewed from a side of a connection surface **22** according to an embodiment of the present invention.

FIG. **7** is a cross sectional view of the power supply device **1** along line A-A in FIG. **5** according to an embodiment of the present invention.

FIG. **8** is a perspective view that shows a configuration of a power supply device **10** according to an embodiment of the present invention.

FIG. **9** is a perspective view that shows a configuration of the power supply circuit mounting body **20** according to an embodiment of the present invention.

FIG. **10** is a cross sectional view that shows a mounting state of the circuit component **31** in the power supply circuit mounting body **20** according to an embodiment of the present invention.

FIG. **11** is a perspective view of a surface mounted LED **330** according to an embodiment of the present invention.

FIG. **12** is a plan view of the circuit board **2***a* and the surface mounted LED **330** viewed from a side of an arrangement surface **21** according to an embodiment of the present invention.

FIG. **13** is a plan view of the circuit board **2***a* and the surface mounted LED **330** viewed from a side of a connection surface **22** according to an embodiment of the present invention.

FIG. **14** is a cross sectional view of the power supply device **10** along line A-A in FIG. **12** according to an embodiment of the present invention.

FIG. **15** is a cross sectional view of a configuration of the power supply device **101** according to an embodiment of the present invention.

## DESCRIPTION OF EXEMPLARY EMBODIMENTS

First Embodiment

A power supply device according to a first embodiment of the present invention will be explained below with reference to the drawings. First, a configuration of a power supply device **1** will be explained below.

The power supply device **1** shown in FIG. **1** is, for instance, a device that supplies power to electronic equipment such as a measurement device. The power supply device **1** is configured so as to be suitable for use by being attached to a cabinet or a rack. Specifically, the power supply device **1** is provided with a power supply circuit mounting body **2** and a chassis **3**.

As shown in FIG. **2**, the power supply circuit mounting body **2** is configured with a circuit board **2***a* on which circuit components **31**, which configure a power supply circuit, a

connector (connectors) **32** and a surface mounted LED **33** are mounted. In this case, as shown in FIG. **3**, body portions of the circuit components are placed on a front surface side of the circuit board **2***a* (also referred to as "an arrangement surface **21**" below). Because terminals **31***a* are inserted in insertion holes that are formed in the circuit board **2***a* and are soldered on a rear surface side (also referred to as "a connection surface **22**" below) of the arrangement surface **21**, the circuit components **31** are mounted on the circuit board **2***a*. Therefore, solder connection sections in which the terminals **31***a* are soldered to the circuit board **2***a* are formed on the connection surface **22** of the circuit board **2***a*. Further, each drawing roughly shows an outer shape of each of the circuit components **31**.

The connector **32** corresponds to a terminal that is used for connecting to a power source circuit that is configured with the power supply circuit mounting body **2**. As shown in FIG. **2**, the connector **32** is mounted on one end of the circuit board **2***a*. Further, as shown in FIG. **3**, a body portion of the connector **32** is placed on a side of the arrangement surface **21** of the circuit board **2***a*. Because a terminal **32***a* is inserted in an insertion hole that is formed in the circuit board **2***a* and is soldered on a side of the connection surface **22**, the connector **32** is mounted on the circuit board **2***a*.

The surface mounted LED **33** corresponds to a light emitting component for confirming an operation of the power supply device **1**. As shown in FIGS. **6** and **7**, the surface mounted LED **33** is placed on the connection surface **22** of the circuit board **2***a* and emits light according to an operation state of the power supply device **1** (specifically, a power source circuit that is configured with the power supply circuit mounting body **2**). Further, as shown in FIG. **4**, the surface mounted LED **33** is provided with a main body (a light emitting member) **41** and an optical dispersion member **42**.

As shown in FIG. **4**, the main body **41** is provided with a LED element **41***a* that emits light L (refer to FIG. **7**) and is formed in a box shape. Further, as shown in FIG. **7**, a connection terminal **41***c* that is in a plate shape is placed on a bottom surface of the main body **41**. Because the connection terminal **41***c* is soldered to the solder connection section that is provided on the connection surface **22** of the circuit board **2***a*, the surface mounted LED **33** is electrically connected to a wiring pattern **2***b* that is provided on the connection surface **22** of the circuit board **2***a*. Further, the surface mounted LED **33** is configured as a side view type and emits the light L from a side **41***b* (refer to FIG. **4**) of the main body **41**.

As shown in FIG. **4**, the optical dispersion member **42** is attached to the side **41***b* of the main body **41**. The optical dispersion member **42** is, as an example, formed with transparent (or translucent) resin and has a function to make the light L reflect, scatter and disperse. Specifically, the light L is emitted from the side **41***b* of the main body **41**. In this case, the optical dispersion member **42** that is formed with a colored resin can also be adopted.

As shown in FIGS. **5-7**, in the power supply device **1**, a through hole **23** is formed to pass through from the arrangement surface **21** to the connection surface **22** of the circuit board **2***a* near a mounting position of the surface mounted LED **33** on the circuit board **2***a*. In this case, as shown in FIGS. **5** and **6**, the through hole **23** is, as an example, formed in a rectangular shape in a plan view. Further, as shown in FIG. **7**, the through hole **23** is regulated with respect to its size and position so as to make the light L that is emitted from the surface mounted LED **33** pass through from the connection surface **22** to the arrangement surface **21** of the circuit board **2***a*. As a result, it is possible to irradiate the light L toward an open area **3***a* of the chassis **3** as explained below.

As shown in FIG. **5**, in the power supply device **1**, when seen from above toward the arrangement surface of the circuit board **2***a*, the surface mounted LED **33** is placed at a position in which a tip of the optical dispersion member **42** of the surface mounted LED **33** projects toward a center **23***b* of the through hole **23** from an edge **23***a* of the through hole **23** that is formed in the circuit board **2***a*.

In this case, in the power supply device **1**, the surface mounted LED **33** is used as the light emitting component for confirming an operation of the power supply device **1**. As a result, mounting can be effectively performed with a mounter for mounting a surface mounted component. Therefore, the manufacturing efficiency can be improved as compared with a case in which an insertion mounted LED that has a connection terminal formed with a metal wire material is used.

As shown in FIG. **1**, the chassis **3** is provided with a main plate **51** and side walls **52***a*-**52***c* that are respectively established on three outer circumference edges **51***a*-**51***c* of the main plate **51**. Further, the chassis **3** is configured so as to be able to hold the power supply circuit mounting body **2** on which the circuit components **31**, the connectors **32** and the surface mounted LED **33** are mounted. In this case, a circumference edge **51***d* of the main plate **51** corresponds to the open area **3***a* that is open without a side wall. In a state in which the power supply circuit mounting body **2** is held by the chassis **3**, the connector **32** that is mounted on the circuit board **2***a* is exposed at the open area **3***a*. The main plate **51** and the side walls **52***a*-**52***c* explained above are, as an example, integrally formed as the chassis **3** by pressing a steel plate that is coated by galvanization.

Next, a method of using and operating the power supply device **1** will be explained below with reference to the drawings.

The power supply device **1** is, for instance, used by being attached to a cabinet or a rack. In this case, from the point of workability when a power cable is connected to the connector **32** of the power supply device **1**, the power supply device **1** is placed and attached so as to make the connector **32** face to a front side (a near side) of the cabinet and the rack.

Next, the power supply device **1** is operated by connecting the power cable to the connector **32**. Then, the power supply device **1** starts to supply electric power. As a result, the LED element **41***a* of the main body **41** in the surface mounted LED **33** emits the light L according to an operation state of the power source circuit and the light L is emitted from the side **41***b* of the main body **41**.

In the above case, the light L that is emitted from the side **41***b* enters the optical dispersion member **42** that is attached on the side **41***b* of the main body **41** and is reflected and scattered by the optical dispersion member **42**. As a result, the light L is dispersed in each direction.

Because the through hole **23** is formed near the mounting position of the surface mounted LED **33** that is mounted on the circuit board **2***a*, the light L that is emitted from the surface mounted LED **33** that is placed on the connection surface **22** (a rear surface) of the circuit board **2***a* passes through the through hole **23** and reaches the side of arrangement surface **21** of the circuit board **2***a*. As a result, a part of the light L is irradiated toward the open area **3***a* of the chassis **3**. Further, as explained above, because the light L is dispersed by the optical dispersion member **42**, the light L passes through the through hole **23** and surely reaches the side of the arrangement surface **21**. Further, because the tip of the optical dispersion member **42** in the surface mounted LED **33** projects toward the center **23***b* from the edge **23***a* of the through hole **23**, most of the light L that is dispersed by the optical disper-

sion member **42** passes through the through hole **23** and is irradiated toward the open area **3***a* of the chassis **3**.

Next, the light L (that is, a light emitting state of the surface mounted LED **33**) emitted from the surface mounted LED **33** that is irradiated as explained above is visually recognized from the side of the open area **3***a* of the chassis **3**. As a result, the operation state of the power source circuit may be confirmed.

In the power supply device **1** according to the first embodiment of the present invention, a light emitting component for confirming an operation of the power supply device **1** is composed of the surface mounted LED **33**. The surface mounted LED **33** is placed on the connection surface **22** (a rear surface) of a circuit board **2***a*. Unlike a configuration in which an insertion mounted LED has a connection terminal formed by a metal wire material, an automated mounting process can be used for the surface mounted LED **33** by using, for example, a mounter. As a result, the manufacturing efficiency can be improved. Further, in the power supply device **1** according to the first embodiment of the present invention, because the through hole **23** is formed near a position on which the surface mounted LED **33** is mounted in the circuit board **2***a*, the light L, which is emitted from the surface mounted LED **33** that is mounted on the connection surface **22** of the circuit board **2***a*, passes through the through hole **23** and reaches the side of the arrangement surface **21** (a front surface) of the circuit board **2***a*. As a result, the light L can be irradiated toward the open area **3***a* of the chassis **3**. Therefore, according to the power supply device **1**, the visibility of the light L that is emitted from the surface mounted LED **33** as a light emitting component can be adequately secured. As a result, when a user looks at the circuit board **2***a* from the open area **3***a* of the chassis **3**, the user can certainly and visually recognize a light emitting state of the surface mounted LED **33**. Therefore, an operation state of the power supply device **1** (the power supply circuit mounting body **2**) can be surely confirmed.

Further, in the power supply device **1** according to the first embodiment, because the surface mounted LED is provided with the main body **41** that emits the light L and the optical dispersion member **42** that is attached to the main body **41**, the light L can be dispersed by the optical dispersion member **42**. Therefore, as compared with a case in which the light L is emitted in only a narrow range, a light quantity that passes through the through hole **23** and reaches the side of the arrangement surface **21** can be increased.

Further, in the power supply device **1** according to the first embodiment, when seen from above toward the arrangement surface **21** of the circuit board **2***a*, the surface mounted LED **33** is placed at the position in which the tip of the optical dispersion member **42** projects toward the center **23***b* from the edge **23***a* of the through hole **23**. As a result, much of the light L that is dispersed by the optical dispersion member **42** can pass through the through hole **23** and be irradiated toward the open area **3***a* of the chassis **3**. As a result, the light emitting state of the surface mounted LED **33** can be visually recognized more certainly.

The surface mounted LED **33** and the configuration of the through hole **23**, through which the light L that is emitted from the surface mounted LED **33** passes, are not limited to the first embodiment explained above. For instance, a configuration in which a surface mounted LED that is not provided with the optical dispersion member **42** can also be adopted instead of the surface mounted LED **33** that is provided with the optical dispersion member **42**. Further, although the through hole **23** is formed in the rectangular shape in the plan view as explained above, the shape of the through hole **23** in the plan view is not limited to the rectangular shape. The through hole **23** can be formed in an arbitrary shape such as a circular shape (or a semicircular shape), an elliptical shape (or a semielliptical shape), a square shape, a slit shape or a mesh shape.

Further, although the chassis **3** in which a top area that is opposite to the main plate **51** is open as explained above is used, a configuration in which a cover for covering the top open area can be provided, i.e., a configuration, in which a casing that has a chassis **3** and the cover are used, can also be adopted.

Second Embodiment

A power supply device according to a second embodiment of the present invention will be explained below with reference to the drawings. First, a configuration of a power supply device **10** will be explained below.

The power supply device **10** shown in FIG. **8** is, for instance, a device that supplies power to electronic equipment such as a measurement device. The power supply device **10** is configured so as to be suitable for use by being attached to a cabinet or a rack. Specifically, the power supply device **10** is provided with a power supply circuit mounting body **20** and a chassis **3**.

As shown in FIG. **9**, the power supply circuit mounting body **20** is configured with a circuit board **2***a* on which circuit components **31**, which configure a power supply circuit, a connector (connectors) **32** and a surface mounted LED **33** are mounted. In this case, as shown in FIG. **10**, body portions of the circuit components **31** are placed on a front surface side of the circuit board **2***a* (also referred to as "an arrangement surface **21**" below). Because terminals **31***a* are inserted in insertion holes that are formed in the circuit board **2***a* and are soldered on a rear surface side (also referred to as "a connection surface **22**" below) of the arrangement surface **21**, the circuit components **31** are mounted on the circuit board **2***a*. Therefore, solder connection sections in which the terminals **31***a* are soldered to the circuit board **2***a* are formed on the connection surface **22** of the circuit board **2***a*. Further, each drawing roughly shows an outer shape of each of the circuit components **31**.

The connector **32** corresponds to a terminal that is used for connecting to a power source circuit that is configured with the power supply circuit mounting body **2**. As shown in FIG. **9**, the connector **32** is mounted on one end of the circuit board **2***a*. Further, as shown in FIG. **10**, a body portion of the connector **32** is placed on a side of the arrangement surface **21** of the circuit board **2***a*. Because a terminal **32***a* is inserted in an insertion hole that is formed in the circuit board **2***a* and is soldered on a side of the connection surface **22**, the connector **32** is mounted on the circuit board **2***a*.

The surface mounted LED **33** corresponds to a light emitting component for confirming an operation of the power supply device **10**. As shown in FIGS. **13** and **14**, the surface mounted LED **33** is placed on the connection surface **22** of the circuit board **2***a* and emits light according to an operation state of the power supply device **10** (specifically, a power source circuit that is configured with the power supply circuit mounting body **20**).

Further, as shown in FIG. **11**, the surface mounted LED **33** is formed in a box shape and an LED element **41***a* that emits light L (refer to FIG. **14**) is placed in a top surface **41***d* (an upper surface in FIG. **11**). In this case, as shown in FIG. **14**, the surface mounted LED **33** is placed on the connection surface **22** in a state in which the light L is emitted toward an inner surface **53** (that corresponds to a counter-face surface and a bottom surface) of a main plate **51** of the chassis **3** that face the connection surface **22** of the circuit board **2***a*, i.e., in

a state in which the top surface **41***d* faces the inner surface **53** of the main plate **51**. Further, as shown in FIG. **14**, a connection terminal **41***c* in a plate shape is placed on a bottom surface (an upper surface in FIG. **14**) of the surface mounted LED **33**. Because the connection terminal **41***c* is soldered to the solder connection section that is provided on the connection surface **22** of the circuit board **2***a*, the surface mounted LED **33** is electrically connected to a wiring pattern **2***b* that is provided on the connection surface **22** of the circuit board **2***a*.

As shown in FIGS. **12-14**, in the power supply device **10**, a through hole **23** that is formed to pass through from the arrangement surface **21** to the connection surface **22** of the circuit board **2***a* near a mounting position of the surface mounted LED **33** on the circuit board **2***a*. In this case, as shown in FIGS. **12** and **13**, the through hole **23** is, as an example, formed in a rectangular shape in a plan view. Further, as shown in FIG. **14**, the light L is emitted from the surface mounted LED **33** and is reflected by the inner surface **53** (that corresponds to a reflective member) of the main plate **51** of the chassis **3**. The through hole **23** is regulated with respect to its size and position so as to make the light L pass through from the connection surface **22** to the arrangement surface **21** of the circuit board **2***a*. As a result, it is possible to irradiate the light L toward an open area **3***a* of the chassis **3** as explained below.

In this case, in the power supply device **10**, the surface mounted LED **33** is used as the light emitting component for confirming an operation of the power supply device **10**. As a result, mounting can be effectively performed with a mounter for mounting a surface mounted component. Therefore, the manufacturing efficiency can be improved as compared with a case in which an insertion mounted LED that has a connection terminal formed with a metal wire material is used.

As shown in FIG. **8**, the chassis **3** is provided with the main plate **51** and side walls **52***a*-**52***c* that are respectively established on three outer circumference edges **51***a*-**51***c* of the main plate **51**. Further, the chassis **3** is configured so as to be able to hold the power supply circuit mounting body **2** on which the circuit components **31**, the connectors **32** and the surface mounted LED **33** are mounted. In this case, a circumference edge **51***d* of the main plate **51** corresponds to the open area **3***a* that is open without a side wall. In a state in which the power supply circuit mounting body **2** is held by the chassis **3**, the connector **32** that is mounted on the circuit board **2***a* is exposed at the open area **3***a*.

The main plate **51** and the side walls **52***a*-**52***c* explained above are, as an example, integrally formed as the chassis **3** by pressing a steel plate. In the power supply device **10**, as shown in FIG. **14**, the inner surface of the main plate **51** works as the reflective member that makes the light L, which is emitted from the surface mounted LED, reflect. Therefore, as a metal plate that forms the chassis **3**, it is preferred that the chassis **3** that is made of, for example, a steel plate that is plated by high-light reflective plating processes (for instance, a zinc luster chromate plating process, a luster tin plating process, a nickel plating process or a chrome plating process) is used.

In this case, in the power supply device **10**, the main plate **51** of the chassis **3** works as the reflective member. Therefore, as compared with a configuration in which the reflective member, which is separately formed as another member that is different from the main plate **51**, is provided on the inner surface of the main plate **51**, it is possible to reduce the manufacturing costs of the power supply device **10**, because the additional reflective member is not used.

Next, a method of using and operating the power supply device **10** will be explained below with reference to the drawings.

The power supply device **10** is, for instance, used by being attached to a cabinet or a rack. In this case, from the point of workability when a power cable is connected to the connector **32** of the power supply device **10**, the power supply device **10** is placed and attached so as to make the connector **32** face to a front side (a near side) of the cabinet and the rack.

Next, the power supply device **10** is operated by connecting the power cable to the connector **32**. Then, the power supply device **10** starts to supply electric power. As a result, the LED element **41***a* of the surface mounted LED **33** emits the light L according to an operation state of the power source circuit and the light L is emitted from the top surface **41***d*.

In the above case, the light that is emitted from the top surface **41***d* is reflected by the inner surface **53** of the main plate **51** of the chassis **3** that faces the connection surface **22** of the circuit board **2***a* on which the surface mounted LED **33** is placed.

The light L is emitted from the surface mounted LED **33** that is mounted on the connection surface **22** (a rear surface) of the circuit board **2***a* and is reflected by the inner surface **53** of the main plate **51** of the chassis **3**. Because the through hole **23** is formed in the circuit board **2***a*, a part of the light L passes through the through hole **23** and reaches a side of the arrangement surface **21** (a front surface) of the circuit board **2***a*. Then, the light L is irradiated toward the open area **3***a* of the chassis **3**.

Next, the light L (that is, a light emitting state of the surface mounted LED **33**) emitted from the surface mounted LED **33** that is irradiated as explained above is visually recognized from the side of the open area **3***a* of the chassis **3**. As a result, the operation state of the power source circuit may be confirmed.

As discussed above, in the power supply device according to the second embodiment of the present invention, a light emitting component for confirming an operation of the power supply device is composed of the surface mounted LED **33**. The surface mounted LED **33** is placed on the connection surface **22** (a rear surface) of the circuit board **2***a*. Unlike a configuration in which an insertion mounted LED has a connection terminal formed by a metal wire material, an automated mounting process can be used for the surface mounted LED **33** by using, for example, a mounter. As a result, the manufacturing efficiency can be improved. Further, in the power supply device **10** according to the second embodiment of the present invention, because the through hole **23** is formed in the circuit board **2***a*, the light L, which is emitted from the surface mounted LED **33** that is mounted on the connection surface **22** of the circuit board **2***a*, is reflected by the reflective member (the inner surface **53** of the main plate **51**) so as to pass the reflected light L through the through hole **23**. Therefore, the reflected light L reaches the side of the arrangement surface **21** (a front surface) of the circuit board **2***a*. As a result, the light L can be irradiated toward the open area **3***a* of the chassis **3**. Therefore, according to the power supply device **10**, the visibility of the light L that is emitted from the surface mounted LED **33** as a light emitting component can be adequately secured. As a result, when a user looks at the circuit board **2***a* from the open area **3***a* of the chassis **3**, the user can certainly and visually recognize a light emitting state of the surface mounted LED **33**. Therefore, an operation state of the circuit board **2***a* on which the power supply device and/or the power source circuit are mounted can be surely confirmed.

In the power supply device **10** according to the second embodiment, the reflective member is the inner surface **53** of the main plate **51** in the chassis **3**. Thus, as compared with a configuration in which the reflective member is formed by a

separate member that is different from the inner surface **53** of the main plate **51** in the chassis **3**, it is possible to reduce the manufacturing costs of the power supply device **10** because the separate reflective member is not necessary.

The above configurations of the reflective member and the through hole **23** through which the light that is reflected by the reflective member passes are not limited to the embodiment explained above. For instance, a power supply device **101** shown in FIG. **15** can also be adopted. A repeated explanation is omitted by using the same reference numerals for the same parts as in the power supply device **10**. In the power supply device **101**, as shown in FIG. **15**, a part of a main plate **151** of a chassis **103** is cut off and is bent so as to tilt from other parts of the main plate **151**. Further, an inner surface **153** of the bent part explained above (also referred to as "a tilt part **154**" below) functions as the reflective member. In this case, the most of the light L that is emitted from the surface mounted LED **33** can be reflected toward the through hole **23** by adjusting an angle of the tilt part **154**. Therefore, much of the light L can be irradiated toward an open area **103***a* of the chassis **103**. As a result, the light emitting state of the surface mounted LED **33** can be visually recognized more certainly. Further, in the power supply device **101**, the inner surface **153** of the tilt part **154** that corresponds to a part of the chassis **103** functions as the reflective member. Therefore, as explained above, it is preferred that the chassis **103** is made of a steel plate that is plated with a high-light reflective plating process.

Instead of the configuration in which the main plates **51** and **151** function as the reflective member as explained above, a configuration in which a reflective member that is separately formed and that is different from the main plates **51** and **151** is placed on a side of the inner surfaces **53** and **153** of the main plates **51** and **151**, can also be adopted.

Further, although the through hole **23** is formed in the rectangular shape in the plan view as explained above, the shape of the through hole **23** in the plan view is not limited to the rectangular shape. The through hole **23** can be formed in an arbitrary shape such as a circular shape (or a semicircular shape), an elliptical shape (or a semielliptical shape), a square shape, a slit shape or a mesh shape.

Further, although the chassis **103** in which a top area that is opposite to the main plate **51** is open as explained above is used, a configuration in which a cover for covering the top open area can be provided, i.e., a configuration, in which a casing that has a chassis **103** and the cover are used, can also be adopted.

The power supply device being thus described, it will be apparent that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be apparent to one of ordinary skill in the art are intended to be included within the scope of the following claims.

What is claimed is:

**1**. A power supply device, comprising:

a circuit board including:

an arrangement surface;

a rear surface on an opposite side of the circuit board as the arrangement surface;

a through hole extending from the arrangement surface to the rear surface; and

an insertion mounted circuit component, a connector and a surface mounted light emitting component that is provided for confirming an operation state of the power supply device mounted thereon; and

a chassis that holds the circuit board from sides and the rear surface of the circuit board, the chassis having an opening that exposes the connector, wherein

the surface mounted light emitting component is surface mounted on the rear surface of the circuit board,

the through hole is provided adjacent to the surface mounted light emitting component so as to guide light emitted from the surface mounted light emitting component toward the opening of the chassis,

the surface mounted light emitting component is configured with a light emitting member and an optical dispersion member operably associated with the light emitting member, and

an edge of the optical dispersion member is located inside the through hole in a plan view.

**2**. The power supply device according to claim **1**, wherein the surface mounted light emitting component is a light emitting diode.

**3**. The power supply device according to claim **1**, wherein the light emitting member is a light emitting diode.

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