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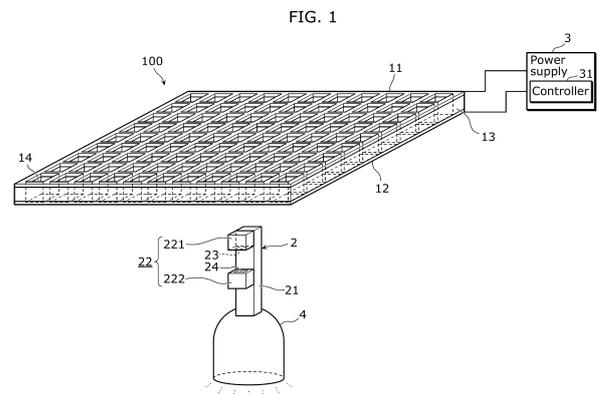
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(54) **DIRECT-CURRENT DISTRIBUTION SYSTEM**

(57) A DC distribution system (100) includes a panel (1), a power supply (3), and a connector (2). The panel (1) includes a pair of conductors (11, 12) arranged spaced apart from each other in one direction, the pair of conductors each having a planar shape; and a plurality of attachment portions (14) that penetrate through the pair of conductors (11, 12). The power supply (3) supplies DC power to the pair of conductors (11, 12). The connector (2) is provided to a load (4) and includes a pair of electrodes (23, 24), the connector (2) being attachable to an attachment portion (14) of the plurality of attachment portions (14). Connector (2) supplies the DC power output from the power supply (3) to the load (4) via the pair of electrodes (23, 24) and the pair of conductors (11, 12), with the connector (2) being attached to the attachment portion (14).



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**Description**

[Advantageous Effects of Invention]

[Technical Field]

**[0001]** The present invention relates to a direct-current (DC) distribution system that supplies DC power.

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**[0006]** The DC distribution system according to the present invention has an advantage of being capable of easily increasing the flexibility in the attachment position of a load.

[Background Art]

[Brief Description of Drawings]

**[0002]** Patent Literature (PTL) 1 discloses a lighting system. In this lighting system, first electric supply lines and second electric supply lines each including a wire material having electrical conductivity are disposed with a space therebetween, and crossed one above the other and provided on a ceiling. A lighting fixture is mounted to hook across these first electric supply lines and second electric supply lines, and the power supply terminals of the lighting fixture are connected to the respective first and second electric supply lines. The lighting fixture is cased to emit light with a voltage applied between the first and second electric supply lines.

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**[0007]**

[FIG. 1]

FIG. 1 is a schematic diagram illustrating a configuration of a DC distribution system according to Embodiment 1.

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[FIG. 2]

FIG. 2 is a diagram illustrating a method of attaching a connector according to Embodiment 1 to a panel.

[FIG. 3]

FIG. 3 is a schematic diagram illustrating a configuration of a DC distribution system according to Embodiment 2.

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[FIG. 4]

FIG. 4 is a diagram illustrating a connection relationship between a power supply and surrounding panels in the DC distribution system according to Embodiment 2.

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[FIG. 5]

FIG. 5 is a diagram illustrating an output characteristic of the power supply in the DC distribution system according to Embodiment 2.

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[FIG. 6]

FIG. 6 is a schematic diagram illustrating a configuration of a connector according to Variation 1.

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[FIG. 7]

FIG. 7 is a schematic diagram illustrating a configuration of a connector according to Variation 2.

[FIG. 8]

FIG. 8 is a cross-sectional view illustrating a configuration of a DC distribution system according to Variation 3.

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[FIG. 9]

FIG. 9 is a block diagram illustrating a configuration of a power supply in a DC distribution system according to Variation 4.

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[Citation List]

[Patent Literature]

**[0003]** [PTL 1] Japanese Unexamined Patent Application Publication No. 2002-008430

[Summary of Invention]

[Technical Problem]

**[0004]** The present invention provides a DC distribution system that can easily increase the flexibility in the attachment position of a load.

[Solution to Problem]

**[0005]** A direct-current (DC) distribution system according to one aspect of the present invention includes: a panel, a power supply, and a connector. The panel includes: a pair of conductors arranged spaced apart from each other in one direction; and a plurality of attachment portions that penetrate through the pair of conductors in the one direction, each conductor in the pair of conductors having a planar shape. The power supply supplies DC power to the pair of conductors. The connector is provided to a load and includes a pair of electrodes, and the connector is attachable to an attachment portion of the plurality of attachment portions. The connector supplies the DC power output from the power supply to the load via the pair of electrodes and the pair of conductors, with the connector being attached to the attachment portion.

[Description of Embodiments]

**[0008]** The following specifically describes one or more embodiments with reference to the drawings. Each of the one or more embodiments described below illustrates a general or specific example. The numerical values, shapes, materials, structural elements, the arrangement and connection of the structural elements, steps, processing order of the steps, etc. described in the following one or more embodiments are mere examples, and do not intend to limit the present invention. Furthermore, among the structural elements in the following one or more

embodiments, structural elements not recited in any one of the independent claims are described as optional structural elements.

**[0009]** Note that each figure is a schematic diagram, and not necessarily a precise depiction. Moreover, in the figures, structural elements that are essentially the same share like reference signs and overlapping description may be omitted or simplified.

[Embodiment 1]

**[0010]** The following describes DC distribution system 100 according to Embodiment 1 with reference to FIG. 1. FIG. 1 is a schematic diagram illustrating a configuration of DC distribution system 100 according to Embodiment 1. As illustrated in FIG. 1, DC distribution system 100 includes panel 1, power supply 3, and connector 2.

**[0011]** Note that, although in the example illustrated in FIG. 1, DC distribution system 100 includes one panel 1, one power supply 3, and one connector 2, the present invention is not limited to this configuration. For example, DC distribution system 100 may include a plurality of panels 1, a plurality of power supplies 3, and a plurality of connectors 2. The following describes DC distribution system 100 by focusing on one panel 1, one power supply 3, and one connector 2.

**[0012]** Panel 1 has a plate-like shape as a whole, and disposed on a ceiling of a facility. For example, panel 1 is disposed as a part of the ceiling by replacing part of the component material included in the ceiling of the facility. Moreover, for example, panel 1 is disposed on the ceiling by being hanged from the ceiling of the facility. Note that, panel 1 is disposed not only on the ceiling of a facility, but also disposed as part of a floor, a wall, or an article of furniture, for example. Panel 1 includes a pair of conductors 11 and 12, insulator 13, and a plurality of attachment portions 14.

**[0013]** The pair of conductors 11 and 12 include a material having electrical conductivity. Each conductor in the pair of conductors 11 and 12 has a planar shape (specifically, planar shape in a plan view in one direction) and arranged spaced apart from each other in the one direction. In Embodiment 1, the "one direction" corresponds to a thickness direction of panel 1, and is the vertical direction. In the following, one of the pair of conductors 11 and 12 is also referred to as first conductor 11, and the other conductor is also referred to as second conductor 12. First conductor 11 is electrically connected to one electrode (here, the positive electrode) of the pair of electrodes on the output side of power supply 3. Second conductor 12 is electrically connected to the other electrode (here, the negative electrode) of the pair of electrodes on the output side of power supply 3.

**[0014]** Insulator 13 includes a material having insulating properties. Insulator 13 has a planar shape (specifically, planar shape in a plan view in the one direction) and disposed between the pair of conductors 11 and 12 in the one direction. Moreover, insulator 13 electrically insu-

lates between the pair of conductors 11 and 12. In Embodiment 1, first conductor 11 is disposed on a first surface (upper surface in FIG. 1) of insulator 13 and second conductor 12 is disposed on a second surface (lower surface in FIG. 1) of insulator 13 in the thickness direction of insulator 13 (i.e., the one direction). Note that second conductor 12 may be disposed on the first surface of insulator 13, and first conductor 11 may be disposed on the second surface of insulator 13.

**[0015]** Attachment portion 14 includes a hole penetrating through the pair of conductors 11 and 12 in the one direction. In Embodiment 1, attachment portion 14 includes a rectangle hole in a plane view in the one direction. Note that the shape of the hole included in attachment portion 14 in the plan view is not limited to the rectangle shape, and may be other shapes, for example, a circular shape, etc. Moreover, in Embodiment 1, since insulator 13 is disposed between the pair of conductors 11 and 12, attachment portion 14 includes a hole penetrating through the pair of conductors 11 and 12 and insulator 13 in the one direction.

**[0016]** In Embodiment 1, a plurality of attachment portions 14 are arranged in a grid-like pattern in the plan view in the one direction. Therefore, panel 1 has a mesh shape in the plan view in the one direction. Note that panel 1 may be any shape as long as panel 1 includes a plurality of attachment portions 14. Therefore, the arrangement of the plurality of attachment portions 14 is not limited to the above-mentioned arrangement, and may be any arrangement.

**[0017]** Power supply 3 supplies DC power to the pair of conductors 11 and 12. In Embodiment 1, power supply 3 includes a power converter including an AC/DC converter circuit. Power supply 3 converts alternating-current (AC) power output from an electrical grid into DC power, and outputs the converted DC power to the pair of conductors 11 and 12. Note that in Embodiment 1, power supply 3 may be any type as long as power supply 3 outputs DC power, and may be a power supply such as a distributed energy like a photovoltaic solar cell or a storage battery, or a combination of one of these power supplies and a power converter (for example, a power converter including a DC/DC converter circuit).

**[0018]** Power supply 3 include a pair of electrodes on the output side. The pair of electrodes may be disposed in any manner with respect to panel 1 as long as each of the pair of electrodes is electrically connected to one of the pair of conductors 11 and 12. For example, power supply 3 may be disposed on one of four corners of panel 1 in the plan view in the one direction.

**[0019]** Moreover, power supply 3 includes controller 31. Controller 31 may be implemented by, for example, a microcomputer, but may be implemented by a processor or a dedicated circuit. Functions of controller 31 may be implemented by hardware, such as a microcomputer or a processor included in controller 31, executing a computer program (software) stored in memory. Controller 31 controls the power converter according to, for example, a

command value from an external controller or a command value stored in advance in memory so that the output power (or output voltage) of power supply 3 matches the command value.

**[0020]** Connector 2 is provided to load 4, and includes a pair of electrodes 23 and 24 (see FIG. 2). Moreover, connector 2 is attachable to one attachment portion 14 of the plurality of attachment portions 14. Furthermore, connector 2 supplies the DC power output from power supply 3 to load 4 via the pair of electrodes 23 and 24 and the pair of conductors 11 and 12, with connector 2 being attached to attachment portion 14.

**[0021]** Connector 2 may be formed integrally with load 4 and undetachable from load 4, or may be attachable to and detachable from load 4. In the latter case, connector 2 may be attached to any load 4 as long as load 4 has a structure to which connector 2 can be attached. Moreover, in the latter case, connector 2 and load 4 are electrically connected to each other by using, for example, a universal serial bus (USB) cable, etc.

**[0022]** Connector 2 includes main body 21 and fixing portion 22, as illustrated in FIG. 1 and FIG. 2. FIG. 2 is a diagram illustrating a method of attaching connector 2 according to Embodiment 1 to panel 1. In FIG. 2, (a) illustrates a state in which main body 21 of connector 2 is inserted into attachment portion 14. In FIG. 2, (b) illustrates a state in which main body 21 is rotated 90 degrees clockwise around an axis in the one direction with main body 21 of connector 2 being inserted into attachment portion 14. In FIG. 2, (c) illustrates a state in which connector 2 is attached to attachment portion 14.

**[0023]** Main body 21 is insertable into attachment portion 14. In Embodiment 1, main body 21 has a cuboid shape and its width and depth are both smaller than the width and the depth of the hole included in attachment portion 14. Note that the shape of main body 21 is not limited to the cuboid shape, and may be any other shape as long as main body 21 has a size that is insertable into attachment portion 14.

**[0024]** Fixing portion 22 is a portion for fixing the pair of electrodes 23 and 24 in contact with the pair of conductors 11 and 12, respectively, with main body 21 being inserted into attachment portion 14 and sandwiching the pair of conductors 11 and 12 in the one direction.

**[0025]** Specifically, fixing portion 22 includes a pair of protrusions 221 and 222. Hereafter, among the pair of protrusions 221 and 222, protrusion 221 located above in the one direction is also referred to as first protrusion 221, and protrusion 222 located below in the one direction is also referred to as second protrusion 222. First protrusion 221 and second protrusion 222 both protrude from a side surface of main body 21. In a plan view in the one direction, first protrusion 221 (or second protrusion 222) and main body 21 each have a size that can pass through attachment portion 14 with their longitudinal direction being along the longitudinal direction of attachment portion 14 (see (a) in FIG. 2). On the other hand, in the plan view in the one direction, first protrusion 221 (or

second protrusion 222) and main body 21 each have a size that cannot pass through attachment portion 14 with their longitudinal direction intersecting with the longitudinal direction of attachment portion 14 (see (b) in FIG. 2).

**[0026]** At least one of first protrusion 221 or second protrusion 222 can move by sliding in the one direction. In Embodiment 1, sliding a lever (not illustrated) provided to main body 21 in the one direction allows first protrusion 221 to move by sliding. Moreover, first protrusion 221 is biased by a spring (not illustrated) in a direction to narrow the space between first protrusion 221 and second protrusion 222.

**[0027]** First protrusion 221 includes electrode 23 (hereafter, also referred to as first electrode 23), which is one of the pair of electrodes 23 and 24. Specifically, first electrode 23 is attached on a surface (the lower surface in (a) in FIG. 2) of first protrusion 221 that faces first conductor 11 with main body 21 being inserted into attachment portion 14. Moreover, second protrusion 222 includes electrode 24 (hereafter, also referred to as second electrode 24), which is the other one of the pair of electrodes 23 and 24. Specifically, second electrode 24 is attached on a surface (the upper surface in (a) in FIG. 2) of second protrusion 222 that faces second conductor 12 with main body 21 being inserted into attachment portion 14.

**[0028]** The pair of electrodes 23 and 24 are each electrically connected to load 4 via wiring passing through the inside of fixing portion 22 and main body 21. Therefore, electrical connection of the pair of electrodes 23 and 24 to the pair of conductors 11 and 12 of panel 1, respectively, allows for provision of power to load 4 from power supply 3 via the pair of conductors 11 and 12 and the pair of electrodes 23 and 24.

**[0029]** Here, a method of attaching connector 2 to attachment portion 14 will be described with reference to FIG. 2. First, as illustrated in (a) in FIG. 2, a user inserts connector 2 into attachment portion 14 in a direction in which the longitudinal direction of first protrusion 221 (or second protrusion 222) and main body 21 is along the longitudinal direction of attachment portion 14. Here, the user operates the lever provided on connector 2 to insert connector 2 into attachment portion 14 while maintaining the state in which first protrusion 221 is moved upward. The user then inserts conductor 2 into attachment portion 14 to a position in which the pair of conductors 11 and 12 are placed between first protrusion 221 and second protrusion 222.

**[0030]** Next, as illustrated in (b) in FIG. 2, the user rotates connector 2 a predetermined degree (here, 90 degrees) around an axis in the one direction. In the example illustrated in (b) in FIG. 2, connector 2 is rotated clockwise, but connector 2 may be rotated counterclockwise. Moreover, the predetermined degree is not limited to 90 degrees, and may be any degree as long as first protrusion 221 (or second protrusion 222) of the rotated connector 2 and main body 21 cannot pass through attachment portion 14.

**[0031]** After that, the user releases the lever provided on connector 2. Then, as illustrated in (c) in FIG. 2, first protrusion 221 that is moved upward against the elastic force of the spring moves toward second protrusion 222 to return to the original position by the elastic force of the spring. With this, first protrusion 221 and second protrusion 222 sandwich the pair of conductors 11 and 12 and insulator 13, thereby fixing connector 2 to attachment portion 14. As described above, rotation of fixing portion 22 around an axis in the one direction enables fixing portion 22 to move between (i) a first position (see (a) in FIG. 2) from which fixing portion 22 is movable in the one direction inside attachment portion 14 and (ii) a second position (see (c) in FIG. 2) in which fixing portion 22 is fixed to the pair of conductors 11 and 12 by sandwiching the pair of conductors 11 and 12.

**[0032]** Load 4 is driven by the power supplied from power supply 3 by being electrically connected to the pair of conductors 11 and 12 of panel 1 via connector 2. In Embodiment 1, load 4 is a lighting fixture, but may be, for example, a loudspeaker, a camera, a sensor, or a USB power delivery (PD). In other words, load 4 may be a device other than a lighting fixture as long as load 4 can be driven by receiving power. Moreover, in Embodiment 1, load 4 that is electrically connected to the pair of conductors 11 and 12 is a lighting fixture of one type, but a plurality of types of loads 4 may be electrically connected to the pair of conductors 11 and 12. For example, a lighting fixture, a loudspeaker, a camera, a sensor, and USB PD may be connected to the pair of conductors 11 and 12.

#### [Advantages]

**[0033]** The following describes advantages of DC distribution system 100 according to Embodiment 1 with comparison to a DC distribution system according to a comparative example. The DC distribution system according to the comparative example is a system that uses a linear power track as a power supply line. In the DC distribution system according to the comparative example, DC power is supplied to a load by attaching the load to the power track.

**[0034]** However, in the DC distribution system according to the comparative example, the power track, which is a power supply line, is linear. Therefore, there is such a problem that the position to which the load is attached is restricted to a linear arrangement, and such an arrangement lacks flexibility. Moreover, even when the load is located closer in distance to a power supply in the DC distribution system according to the comparative example, there may be a problem that DC power is supplied from the power supply to the load over a longer distance than the distance between the power supply and the load depending on wiring conditions of the power track, which is a power supply line. Furthermore, in the DC distribution system according to the comparative example, when a plurality of power tracks are connected and connection

failure between a load and a conductor included in one of the power tracks or breakage of the conductor occur, all of the power tracks cannot be used.

**[0035]** In contrast, in DC distribution system 100 according to Embodiment 1, panel 1, which is a power supply line, has a planar shape, and connector 2 and load 4 can be freely attached to any position of attachment portion 14 as long as it is a position where attachment portion 14 is present in panel 1. In other words, DC distribution system 100 according to Embodiment 1 has an advantage of being capable of easily increasing the flexibility in the attachment position of load 4, compared with the DC distribution system according to the comparative example.

**[0036]** Moreover, DC distribution system 100 according to Embodiment 1, the pair of conductors 11 and 12 each having a planar shape form a power supply line. Therefore, DC distribution system 100 according to Embodiment 1 has an advantage that such a situation does not occur that DC power is supplied from power supply 3 to load 4 over a longer distance than a distance between power supply 3 and load 4, as in the DC distribution system according to the comparative example.

**[0037]** Moreover, in DC distribution system 100 according to Embodiment 1, the pair of conductors 11 and 12 each having a planar shape form a power supply line. Therefore, DC distribution system 100 according to Embodiment 1 has an advantage that contact failure is not likely to occur between the pair of conductors 11 and 12 and the pair of electrodes 23 and 24 of connector 2. Furthermore, DC distribution system 100 according to Embodiment 1 has an advantage that, even if the wire of any part of the pair of conductors 11 and 12 breaks due to a fracture, etc., panel 1 can be used excluding the broken part.

#### [Embodiment 2]

**[0038]** The following describes DC distribution system 100A according to Embodiment 2 with reference to FIG. 3. FIG. 3 is a schematic diagram illustrating a configuration of DC distribution system 100A according to Embodiment 2. As illustrated in FIG. 3, DC distribution system 100A according to Embodiment 2 is different from DC distribution system 100 according to Embodiment 1 in that DC distribution system 100A includes a plurality of panels 1, and power supply 3 is connected to each of four corners of one or more panels 1. In other words, when one panel 1 is focused on among the plurality of panels 1, a plurality of power supplies 3 are electrically connected to a pair of conductors 11 and 12 of panel 1.

**[0039]** Specifically, in each of power supplies 3, the pair of electrodes 23 and 24 are electrically connected to the pair of conductors 11 and 12 of each of a plurality of panels 1 located around power supply 3. In other words, each of power supplies 3 is electrically connected to (i) a pair of conductors 11 and 12 of main panel 1A, which is panel 1 for which power supply 3 serves as main power

supply 3A, and (ii) a pair of conductors 11 and 12 of sub-panel 1B, which is panel 1 for which power supply 3 does not serve as main power supply 3A.

**[0040]** Here, when one panel 1 is focused on, main power supply 3A is power supply 3 that supplies power to panel 1, among power supplies 3 that are electrically connected to the pair of conductors 11 and 12 of panel 1. In the example illustrated in FIG. 3, power supply 3 enclosed by a circle is main power supply 3A for panel 1 enclosed by a rectangular frame. Moreover, in the example illustrated in FIG. 3, when viewed from power supply 3 enclosed by the circle, among four panels 1 around power supply 3 enclosed by the circle, panel 1 enclosed by the rectangular frame is main panel 1A, and the remaining three panels 1 are sub-panels 1B.

**[0041]** Then, for each of the plurality of power supplies 3, diode D1 is provided between power supply 3 and the pair of conductors 11 and 12 of sub-panel 1B, and diode D1 includes an anode that is electrically connected to power supply 3 and a cathode that is electrically connected to the pair of conductors 11 and 12 of sub-panel 1B. FIG. 4 is a diagram illustrating a connection relationship between power supply 3 and surrounding panels 1 in DC distribution system 100A according to Embodiment 2. As illustrated in FIG. 4, diode D1 is not provided in the power supply line between power supply 3 and main panel 1A (see FIG. 3). On the other hand, diode D1 is provided in the power supply line between power supply 3 and sub-panel 1B (see FIG. 3), and the anode of diode D1 is electrically connected to power supply 3, and the cathode of diode D1 is electrically connected to the pair of conductors 11 and 12 of sub-panel 1B.

**[0042]** Moreover, in DC distribution system 100A according to Embodiment 2, each of power supplies 3 is controlled by controller 31 to have an output characteristic as illustrated in FIG. 5. FIG. 5 is a diagram illustrating an output characteristic of power supply 3 in DC distribution system 100A according to Embodiment 2. In FIG. 5, the vertical axis represents the output voltage of power supply 3, and the horizontal axis represents the output power of power supply 3. Moreover, in FIG. 5, the solid line indicates the output characteristic of main power supply 3A when one panel 1 is focused on, and the dash-dot line indicate the output characteristic of sub-power supplies 3B other than main power supply 3A. Note that the difference between the output voltage indicated by the solid line and the output voltage indicated by the dash-dot line is a decrease in voltage in diode D1.

**[0043]** As illustrated in FIG. 5, the output voltage of power supply 3 is controlled by controller 31 to be a constant voltage until the output power of power supply 3 reaches a predetermined value (here, 50% when the rated output is 100%). On the other hand, when the output power of power supply 3 exceeds the predetermined value, the output voltage of power supply 3 is controlled by controller 31 to decrease gradually as the output power increases. In other words, in DC distribution system 100A according to Embodiment 2, it can be said

that each of power supplies 3 includes controller 31 that controls power supply 3 such that the output voltage decreases when the output power is greater than the predetermined value. Controller 31 monitors the output power of power supply 3 based on, for example, a result of measurement of the current flowing through the pair of conductors 11 and 12 of main panel 1A by a current sensor (not illustrated).

**[0044]** The following describes operations of DC distribution system 100A according to Embodiment 2. In the following, description is given by focusing on one panel 1, and one power supply 3 among four power supplies 3 on the four corners of the one panel 1 is referred to as main power supply 3A, and the remaining three power supplies 3 are referred to as sub-power supplies 3B. Moreover, description is given by assuming that the output power of the other power supplies 3 has not reached to the predetermined value.

**[0045]** As illustrated in FIG. 5, the output voltage of main power supply 3A is greater than the output voltage of at least one of the other power supplies 3 until the output power of main power supply 3A reaches threshold P1. In this state, main power supply 3A alone supplies power to its corresponding panel 1. On the other hand, when the output power of main power supply 3A increases as a result of an increase in the number of loads 4 attached to panel 1 and the output power of main power supply 3A reaches threshold P1, the output voltage of main power supply 3A falls below the output voltage of at least one of sub-power supplies 3B. Then, when the electric potential of at least one of sub-power supplies 3B becomes higher than the electric potential of panel 1, power is supplied to panel 1 from at least one of sub-power supplies 3B via diode D1.

**[0046]** As described above, in DC distribution system 100A according to Embodiment 2, each of power supplies 3 functions as an auxiliary power supply that supplies power to panel 1 when output power of main power supply 3A supplying power to panel 1 exceeds threshold P1. Therefore, since power is supplied to panel 1 by a plurality of power supplies 3 by complementing each other in DC distribution system 100A according to Embodiment 2, DC distribution system 100A has an advantage of being capable of supplying power stably to load 4 that is electrically connected to panel 1.

[Variations]

**[0047]** Embodiments 1 and 2 have been described above, but the present invention should not be limited to Embodiments 1 and 2 described above. The following lists variations of Embodiments 1 and 2.

[Variation 1]

**[0048]** In Embodiments 1 and 2, panel 1 includes insulator 13 sandwiched by a pair of conductors 11 and 12, but the present invention is not limited to this example.

For example, panel 1 need not include insulator 13. In this case, the pair of conductors 11 and 12 may be spaced apart from each other enough to ensure electrical insulation.

**[0049]** Moreover, in this case, the connector may include a configuration that can replace insulator 13. FIG. 6 is a schematic diagram illustrating a configuration of connector 2A according to Variation 1. As illustrated in FIG. 6, connector 2A according to Variation 1 further includes insulation portion 25. Insulation portion 25 includes a material having an electrical insulating property, and protrudes from a side surface of main body 21 to locate between a pair of protrusions 221 and 222 in the one direction. Furthermore, as illustrated in FIG. 6, insulation portion 25 electrically insulates between a pair of conductors 11 and 12 by being inserted between the pair of conductors 11 and 12, with main body 21 being inserted into attachment portion 14, i.e., a pair of electrodes 23 and 24 being in contact with the pair of conductors 11 and 12, respectively.

**[0050]** This provides an advantage that a short circuit between the pair of conductors 11 and 12 can be prevented by insulation portion 25, with connector 2A being attached to attachment portion 14. In other words, it is advantageous in that electrical insulation between the pair of conductors 11 and 12 can be ensured by connector 2A even when panel 1 does not include insulator 13.

[Variation 2]

**[0051]** In Embodiments 1 and 2 described above, the connector may further include an abrading portion. FIG. 7 is a schematic diagram illustrating a configuration of connector 2B according to Variation 2. As illustrated in FIG. 7, connector 2B according to Variation 2 further includes insulation portion 25, as with connector 2A according to Variation 1. Furthermore, in connector 2B according to Variation 2, a lower surface of first protrusion 221 and an upper surface of insulation portion 25 that are opposite to each other are inclined to reduce a distance between the lower surface of first protrusion 221 and the upper surface of insulation portion 25 toward main body 21. Similarly, a lower surface of insulation portion 25 and an upper surface of second protrusion 222 that are opposite to each other are inclined to reduce a distance therebetween toward main body 21. Moreover, the pair of protrusions 221 and 222 each include a material having a degree of hardness higher than the degrees of hardness of the pair of conductors 11 and 12. A lower surface of first protrusion 221 and an upper surface of second protrusion 222 form abrading portion 26. Stated differently, fixing portion 22 includes abrading portion 26.

**[0052]** Connector 2B according to Variation 2 is rotated a predetermined degree with connector 2B being inserted into attachment portion 14, the lower surface of first protrusion 221 moves while being in contact with first conductor 11, and the upper surface of second protrusion 222 moves while being in contact with second conductor

12. With this, the surface of first conductor 11 is abraded by friction with the lower surface of first protrusion 221. Moreover, the surface of second conductor 12 is abraded by friction with the upper surface of second protrusion 222.

**[0053]** As described above, fixing portion 22 of connector 2B according to Variation 2 includes abrading portion 26 that abrades the pair of conductors 11 and 12 by friction during a movement of fixing portion 22 from the first position to the second position. Therefore, in Variation 2, there is an advantage that abrasion of the surfaces of the pair of conductors 11 and 12 by abrading portions 26 can easily prevent the surfaces of the pair of conductors 11 and 12 from oxidizing, and contact failure between the pair of conductors 11 and 12 and the pair of electrodes 23 and 24 is less likely to occur.

[Variation 3]

**[0054]** In Embodiments 1 and 2 described above, connector 2 is attachable to panel 1 by rotating around the axis in the one direction with fixing portion 22 being inserted into attachment portion 14, but the present invention is not limited to this example. For example, the connector may be attachable to a panel without rotation.

**[0055]** FIG. 8 is a schematic diagram illustrating a configuration of DC distribution system 100B according to Variation 3. FIG. 8 is a plan view of attachment portion 14A and connector 2C as viewed in the one direction. As illustrated in FIG. 8, attachment portion 14A includes an inverted L-shaped hole in the plan view in the one direction. Specifically, in the plan view in the one direction, attachment portion 14A includes first opening 141 having a rectangular shape and second opening 142 having a side in the longitudinal direction shorter than a side of first opening 141 in the longitudinal direction, and first opening 141 and second opening 142 are connected to each other.

**[0056]** In connector 2C, first protrusion 221 (or second protrusion 222) and main body 21 each have a size that can pass through first opening 141 of attachment portion 14A in the plan view in the one direction (see (a) in FIG. 8). In contrast, only first protrusion 221 (or second protrusion 222) of connector 2C has a size that can pass through second opening 142 of attachment portion 14A in the plan view in the one direction (see (b) in FIG. 8).

**[0057]** Here, a method of attaching connector 2C to attachment portion 14A will be described with reference to FIG. 8. Note that the operation for the lever provided to connector 2C is the same as in Embodiment 1, and therefore description thereof is omitted. First, as illustrated in (a) in FIG. 8, a user inserts connector 2C into first opening 141 of attachment portion 14A in a direction in which the longitudinal direction of first protrusion 221 (or second protrusion 222) and main body 21 is along the longitudinal direction of first opening 141 of attachment portion 14A. The user then inserts conductor 2C into first opening 141 of attachment portion 14A to a position in

which the pair of conductors 11 and 12 are placed between first protrusion 221 and second protrusion 222.

**[0058]** Next, as illustrated in (b) in FIG. 8, the user slides connector 2C in a direction from first opening 141 to second opening 142. With this, main body 21 of connector 2C is inserted into second opening 142. In this state, as with Embodiment 1, first protrusion 221 and second protrusion 222 sandwich the pair of conductors 11 and 12 and insulator 13, thereby fixing connector 2C to attachment portion 14A.

[Variation 4]

**[0059]** Embodiment 2 described above implements supplying power to panel 1 from at least one of other power supplies 3 different from main power supply 3A by using diodes D1, but the present invention is not limited to this example. For example, each of power supplies 3 may communicate with the other power supplies 3 different from power supply 3, and when power supply 3 obtains information indicating that output power of another power supply 3 exceeds a threshold, power supply 3 supplies power to panel 1 (main panel 1A) to which the other power supply 3 is supplying power as main power supply 3A.

**[0060]** FIG. 9 is a block diagram illustrating a configuration of power supply 3 in DC distribution system 100C according to Variation 4. DC distribution system 100C according to Variation 4 is different from DC distribution system 100A according to Embodiment 2 in that each of the plurality of power supplies 3 of DC distribution system 100C includes, instead of the plurality of diodes D1, communicator 32 that communicates with the other power supplies 3 different from power supply 3. Moreover, in DC distribution system 100C according to Variation 4, each of power supplies 3 does not have an output characteristic (see FIG. 5) as with Embodiment 2. The following describes DC distribution system 100C by focusing on one of power supplies 3. This power supply 3 functions as sub-power supply 3B when another power supply 3 functions as main power supply 3A.

**[0061]** Communicator 32 communicates with the other communicators 32 of the other power supplies 3, for example, through power line communication (PLC). Note that communicator 32 may communicate with the other communicators 32 of the other power supplies 3 through wired communication other than PLC, or wireless communication.

**[0062]** Communicator 32 obtains information related to output power of at least one of the other power supplies 3, i.e., information related to output power of another power supply 3 as main power supply 3A. Communicator 32 obtains information related to output power of at least one of the other power supplies 3 by, for example, obtaining a result of measurement of current flowing through a pair of conductors 11 and 12 of panel 1 (main panel 1A) to which another power supply 3 is supplying power as main power supply 3A.

**[0063]** When the output power of the other power

supply 3 (main power supply 3A) obtained by communicator 32 reaches threshold P1, controller 31 controls the output voltage of at least one of power supplies 3 (sub-power supplies 3B) to be higher than the output voltage of the other power supply 3 (main power supply 3A). With this, power is supplied to panel 1 (main panel 1A) from the at least one of power supplies 3 (sub-power supplies 3B).

**[0064]** The scope of the present invention may also include embodiments as a result of adding various modifications to the embodiments that may be conceived by those skilled in the art, and embodiments obtained by combining structural elements and functions in the embodiments in any manner as long as the combination does not depart from the teaching of the present invention.

(Conclusion)

**[0065]** As described above, each of DC distribution systems 100, 100A, 100B, and 100C according to a first aspect includes: panel 1, power supply 3, and one of connectors 2, 2A, 2B, and 2C. Panel 1 includes: a pair of conductors 11 and 12 arranged spaced apart from each other in one direction; and a plurality of attachment portions 14 or 14A that penetrate through the pair of conductors 11 and 12 in the one direction, each conductor in the pair of conductors 11 and 12 having a planar shape. Power supply 3 supplies DC power to the pair of conductors 11 and 12. Each of connectors 2, 2A, 2B, and 2C is provided to load 4 and includes a pair of electrodes 23 and 24, connectors 2, 2A, 2B, and 2C being attachable to attachment portion 14 or 14A of the plurality of attachment portions 14 and 14A. Each of connectors 2, 2A, 2B, and 2C supplies the DC power output from power supply 3 to load 4 via the pair of electrodes 23 and 24 and the pair of conductors 11 and 12, with connectors 2, 2A, 2B, and 2C being attached to attachment portion 14 or 14A.

**[0066]** This provides an advantage that the flexibility in the attachment position of load 4 can be easily increased.

**[0067]** Moreover, in DC distribution system 100, 100A, 100B, and 100C according to a second aspect, in the first aspect, connector 2, 2A, 2B, and 2C includes: main body 21 that is insertable into attachment portion 14 or 14A; and fixing portion 22. Fixing portion 22 sandwiches the pair of conductors 11 and 12 in the one direction with main body 21 being inserted into attachment portion 14 or 14A to fix the pair of electrodes 23 and 24, with one electrode of the pair of electrodes being in contact with one conductor of the pair of conductors 11 and 12 and an other electrode of the pair of electrodes 23 and 24 being in contact with an other conductor of the pair of conductors 11 and 12.

**[0068]** This provides an advantage that fixing connectors 2, 2A, 2B, and 2C to attachment portions 14 or 14A and electrically connecting the pair of conductors 11 and 12 to the pair of electrodes 23 and 24 can be performed in one process.

**[0069]** Moreover, each of DC distribution system 100, 100A, 100B, and 100C according to a third aspect, further includes, in the first or second aspect, insulator 13 having a planar shape. Insulator 13 is located between the pair of conductors 11 and 12 in the one direction and electrically insulates between the pair of conductors 11 and 12.

**[0070]** This provides an advantage that a short circuit between the pair of conductors 11 and 12 can be prevented by insulator 13, with connectors 2, 2B, and 2C being attached to attachment portion 14 or 14A.

**[0071]** Moreover, in each of DC distribution systems 100, 100A, 100B, and 100C according to a fourth aspect, in the second aspect, connector 2A further includes insulation portion 25. Insulation portion 25 electrically insulates between the pair of conductors 11 and 12 by being inserted between the pair of conductors 11 and 12, with the pair of electrodes 23 and 24 being in contact with the pair of conductors 11 and 12.

**[0072]** This provides an advantage that a short circuit between the pair of conductors 11 and 12 can be prevented by insulation portion 25, with connector 2A being attached to attachment portion 14 or 14A.

**[0073]** Moreover, in each of DC distribution systems 100, 100A and 100C according to a fifth aspect, in the second aspect, rotation of fixing portion 22 around an axis in the one direction enables fixing portion 22 to move between (i) a first position from which fixing portion 22 is movable in the one direction inside attachment portion 14 and (ii) a second position in which fixing portion 22 is fixed to the pair of conductors 11 and 12 by sandwiching the pair of conductors 11 and 12.

**[0074]** This provides an advantage that connectors 2, 2A, and 2B can be easily attached to attachment portion 14 because only rotating connectors 2, 2A, and 2B can switch the states of connectors 2, 2A, and 2B between a state in which connectors 2, 2A, and 2B are insertable into attachment position 14 and a state in which connectors 2, 2A, and 2B can be fixed to attachment portion 14.

**[0075]** Moreover, in each of DC distribution systems 100, 100A, 100B, and 100C according to a sixth aspect, in the fifth aspect, fixing portion 22 includes abrading portion 26 that abrades the pair of conductors 11 and 12 by friction during a movement of fixing portion 22 from the first position to the second position.

**[0076]** This provides an advantage that abrasion of the surfaces of the pair of conductors 11 and 12 by abrading portions 26 can easily prevent the surfaces of the pair of conductors 11 and 12 from oxidizing, and contact failure between the pair of conductors 11 and 12 and the pair of electrodes 23 and 24 is less likely to occur.

**[0077]** Moreover, in each of DC distribution system 100A and 100C according to a seventh aspect, in any one of the first to sixth aspects, a plurality of power supplies 3 are electrically connected to the pair of conductors 11 and 12 of panel 1, the plurality of power supplies 3 each being power supply 3. The plurality of power supplies 3 each supply power to panel 1 when output power of main power supply 3A, among the plur-

ality of power supplies 3, supplying power to panel 1 exceeds threshold P1.

**[0078]** With this, since power is supplied to panel 1 by the plurality of power supplies 3 by complementing each other, this provides an advantage that power can be supplied stably to load 4 that is electrically connected to panel 1.

**[0079]** Moreover, in DC distribution system 100A according to an eight aspect, in the seventh aspect, each of the plurality of power supplies 3 includes controller 31 that controls power supply 3 to reduce an output voltage when the output power exceeds a predetermined value. Each of the plurality of power supplies 3 is electrically connected to (i) the pair of conductors 11 and 12 of main panel 1A and (ii) a pair of conductors 11 and 12 of sub-panel 1B, main panel 1A being panel 1 in which power supply 3 serves as the main power supply 3A, sub-panel 1B being panel 1 in which power supply 3 does not serve as main power supply 3A. For each of the plurality of power supplies 3, diode D1 is provided between power supply 3 and the pair of conductors 11 and 12 of sub-panel 1B, and diode D1 includes an anode that is electrically connected to power supply 3 and a cathode that is electrically connected to the pair of conductors 11 and 12 of sub-panel 1B.

**[0080]** This provides an advantage that a simple configuration of providing diode D1 in a power supply line can achieve the configuration in which power is supplied to panel 1 by the plurality of power supplies 3 by complementing each other.

**[0081]** Moreover, in DC distribution system 100C according to a ninth aspect, in the seventh aspect, each of the plurality of power supplies 3 includes communicator 32 that communicates with an other power supply 3 different from power supply 3. Communicator 32 obtains information related to the output power of main power supply 3A.

**[0082]** This provides an advantage that a configuration can be achieved in which each of the plurality of power supplies 3 knows the output power of main power supply 3A through communicator 32 and thus the plurality of power supplies 3 can supply power to panel 1 by complementing each other.

[Reference Signs List]

**[0083]**

100, 100A, 100B, 100C direct-current (DC) distribution system  
 1 panel  
 11 first conductor (conductor)  
 12 second conductor (conductor)  
 13 insulator  
 14, 14A attachment portion  
 1A main panel  
 1B sub-panel  
 2, 2A, 2B, 2C connector

21 main body  
 22 fixing portion  
 221 first protrusion  
 222 second protrusion  
 23 first electrode (electrode)  
 24 second electrode (electrode)  
 25 insulation portion  
 26 abrading portion  
 3 power supply  
 31 controller  
 32 communicator  
 3A main power supply  
 4 load  
 D1 diode  
 P1 threshold

### Claims

1. A direct-current (DC) distribution system comprising:

a panel including: a pair of conductors arranged spaced apart from each other in one direction; and a plurality of attachment portions that penetrate through the pair of conductors in the one direction, each conductor in the pair of conductors having a planar shape;  
 a power supply that supplies DC power to the pair of conductors; and  
 a connector that is provided to a load and includes a pair of electrodes, the connector being attachable to an attachment portion of the plurality of attachment portions, wherein the connector supplies the DC power output from the power supply to the load via the pair of electrodes and the pair of conductors, with the connector being attached to the attachment portion.

2. The DC distribution system according to claim 1, wherein the connector includes:

a main body that is insertable into the attachment portion; and  
 a fixing portion that sandwiches the pair of conductors in the one direction with the main body being inserted into the attachment portion to fix the pair of electrodes, with one electrode of the pair of electrodes being in contact with one conductor of the pair of conductors and an other electrode of the pair of electrodes being in contact with an other conductor of the pair of conductors.

3. The DC distribution system according to claim 1 or 2, further comprising:  
 an insulator that is located between the pair of con-

ductors in the one direction and electrically insulates between the pair of conductors, the insulator having a planar shape.

5 4. The DC distribution system according to claim 2, wherein  
 the connector further includes an insulation portion that electrically insulates between the pair of conductors by being inserted between the pair of conductors, with the pair of electrodes being in contact with the pair of conductors.  
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5. The DC distribution system according to claim 2, wherein  
 15 rotation of the fixing portion around an axis in the one direction enables the fixing portion to move between (i) a first position from which the fixing portion is movable in the one direction inside the attachment portion and (ii) a second position in which the fixing portion is fixed to the pair of conductors by sandwiching the pair of conductors.  
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6. The DC distribution system according to claim 5, wherein  
 25 the fixing portion includes an abrading portion that abrades the pair of conductors by friction during a movement of the fixing portion from the first position to the second position.

7. The DC distribution system according to claim 1 or 2, wherein

30 a plurality of power supplies are electrically connected to the pair of conductors of the panel, the plurality of power supplies each being the power supply, and  
 35 the plurality of power supplies each supply power to the panel when output power of a main power supply, among the plurality of power supplies, supplying power to the panel exceeds a threshold.

8. The DC distribution system according to claim 7, wherein

45 each of the plurality of power supplies includes a controller that controls the power supply to reduce an output voltage when the output power exceeds a predetermined value,  
 50 each of the plurality of power supplies is electrically connected to (i) the pair of conductors of a main panel and (ii) a pair of conductors of a sub-panel, the main panel being a panel in which the power supply serves as the main power supply, the sub-panel being a panel in which the power supply does not serve as the main power supply, and  
 55 for each of the plurality of power supplies, a

diode is provided between the power supply and the pair of conductors of the sub-panel, and the diode includes an anode that is electrically connected to the power supply and a cathode that is electrically connected to the pair of conductors of the sub-panel. 5

9. The DC distribution system according to claim 7, wherein

each of the plurality of power supplies includes a communicator that communicates with an other power supply different from the power supply, and the communicator obtains information related to the output power of the main power supply. 10  
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FIG. 1

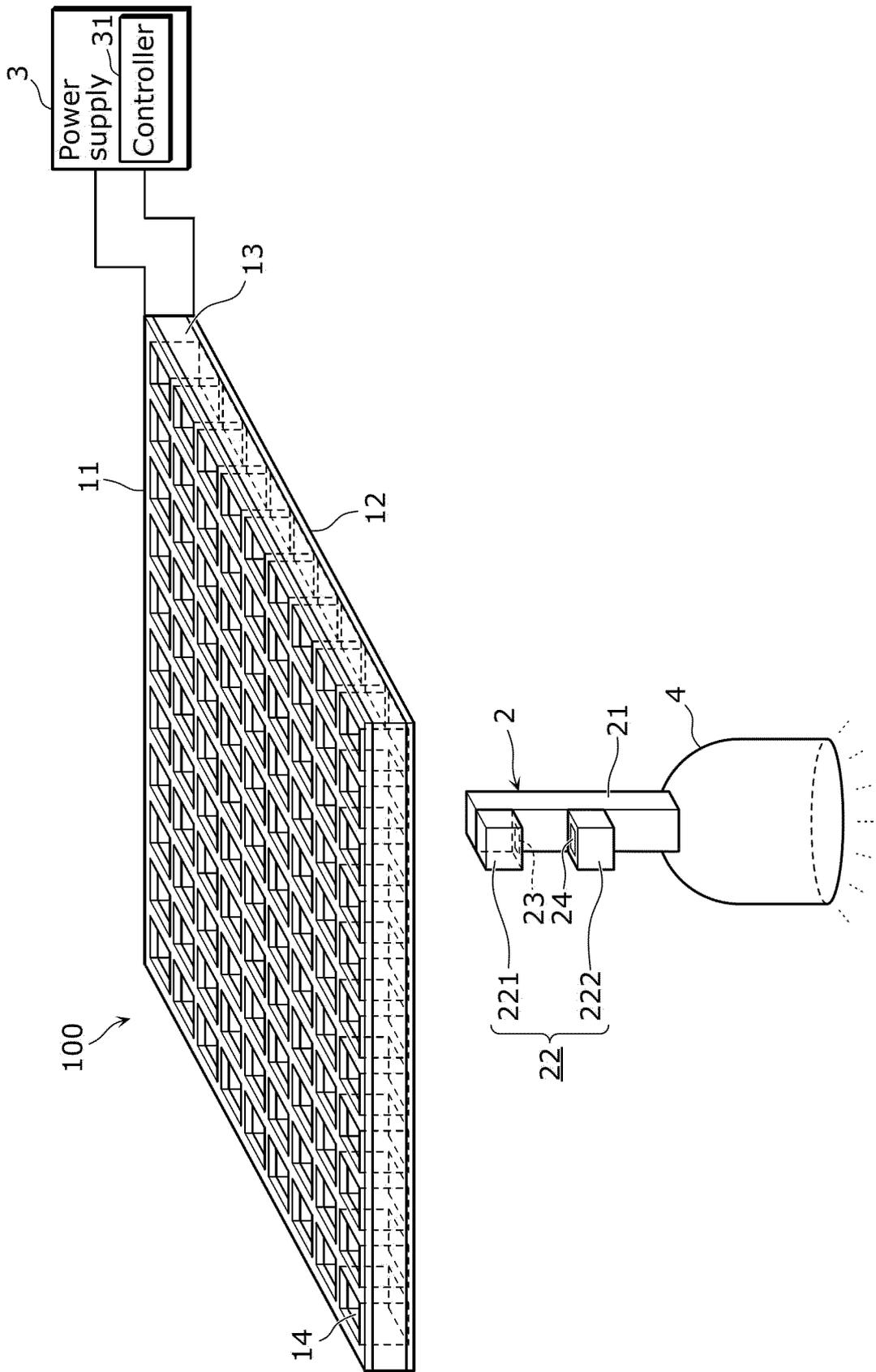


FIG. 2

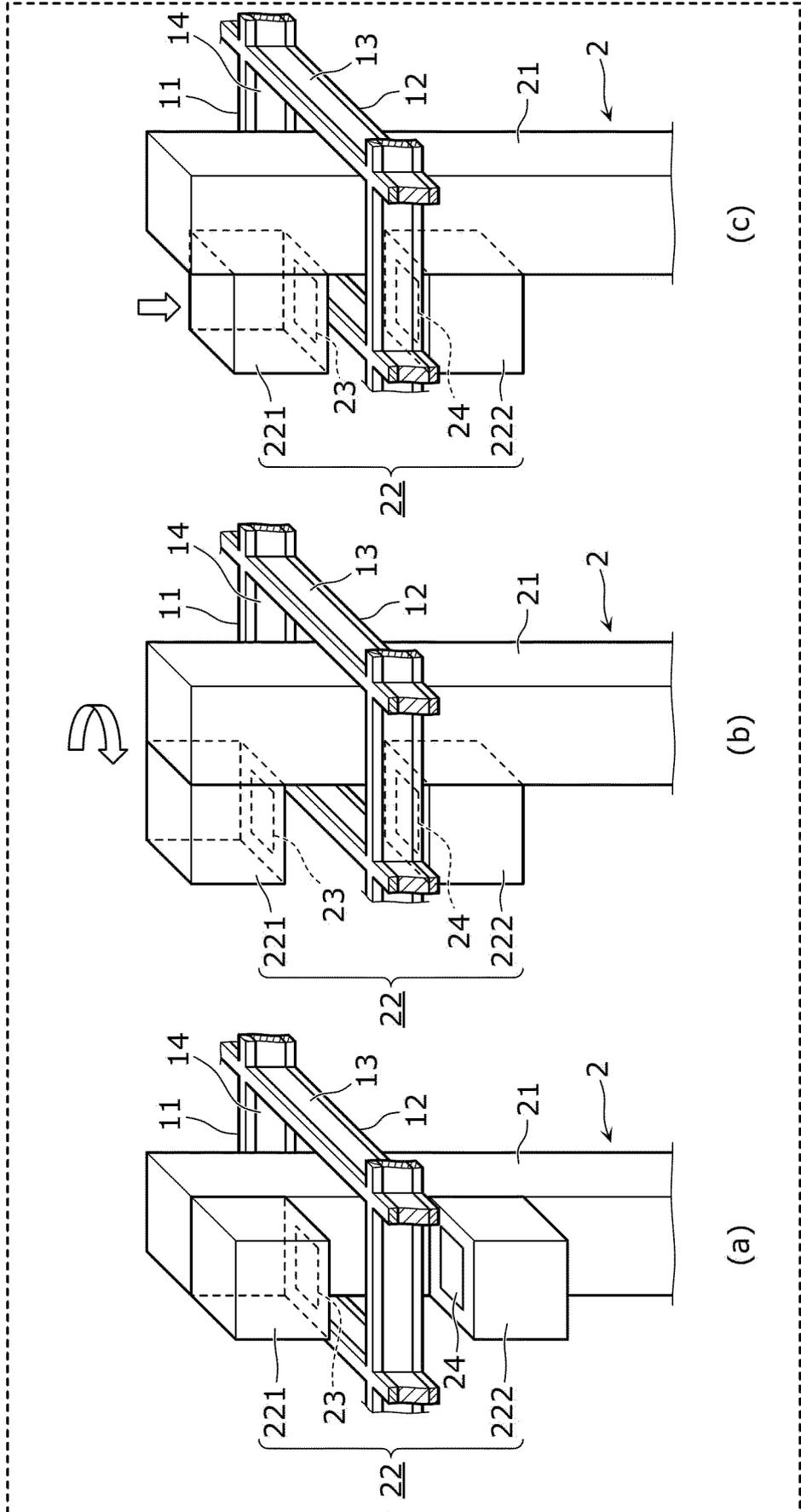


FIG. 3

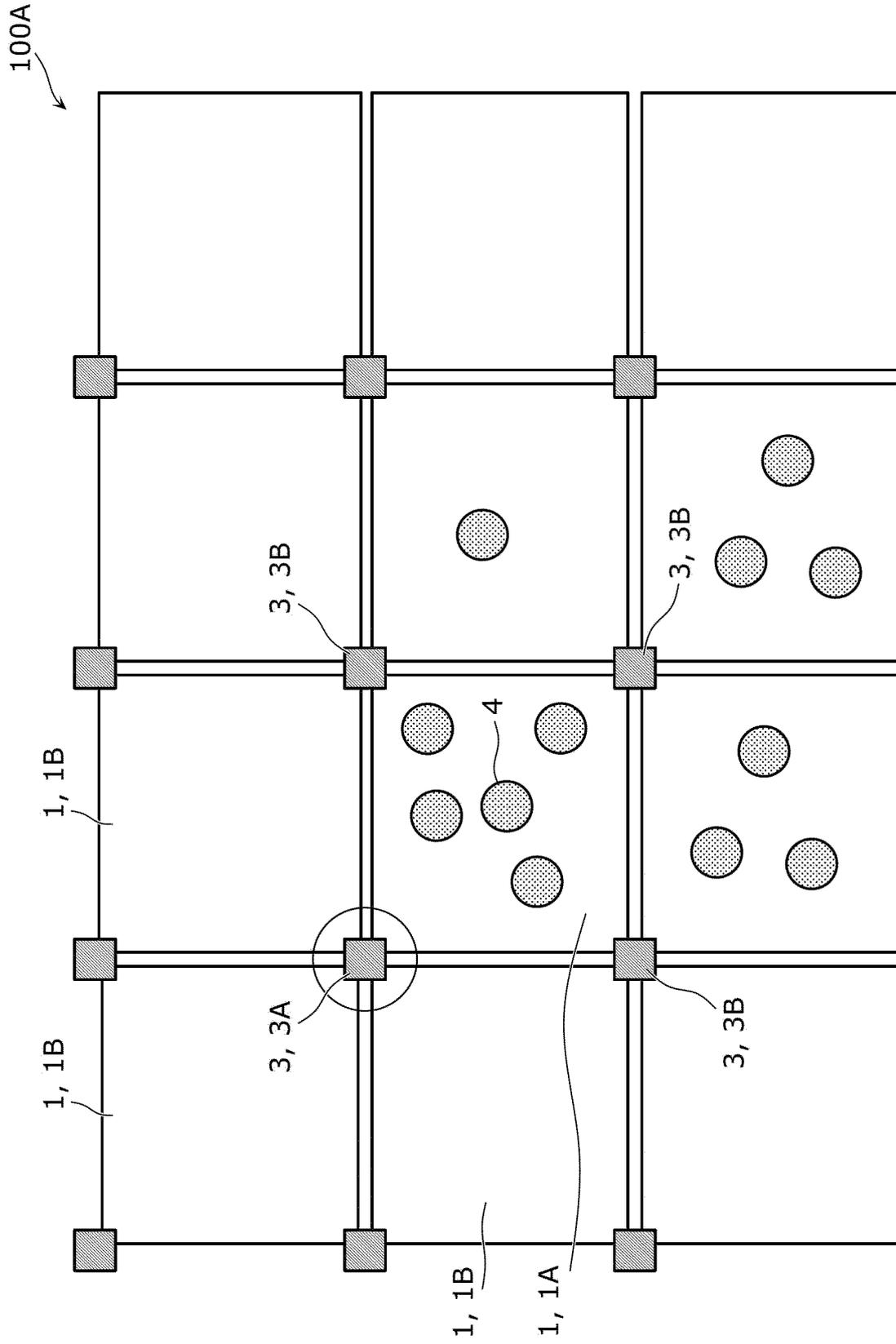


FIG. 4

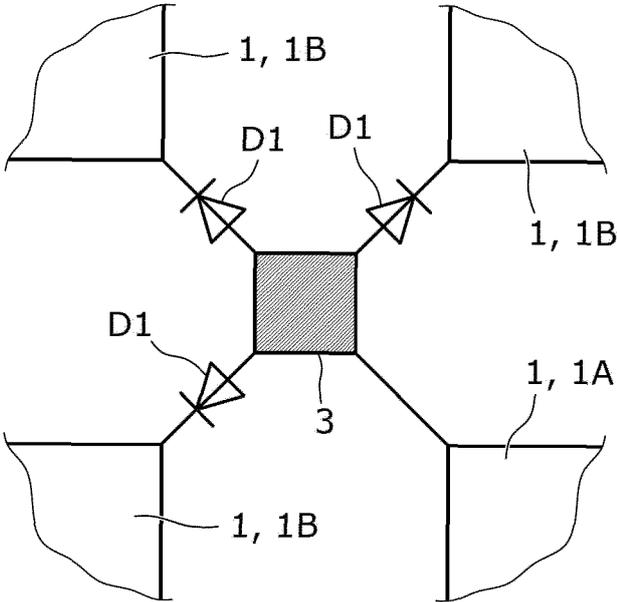


FIG. 5

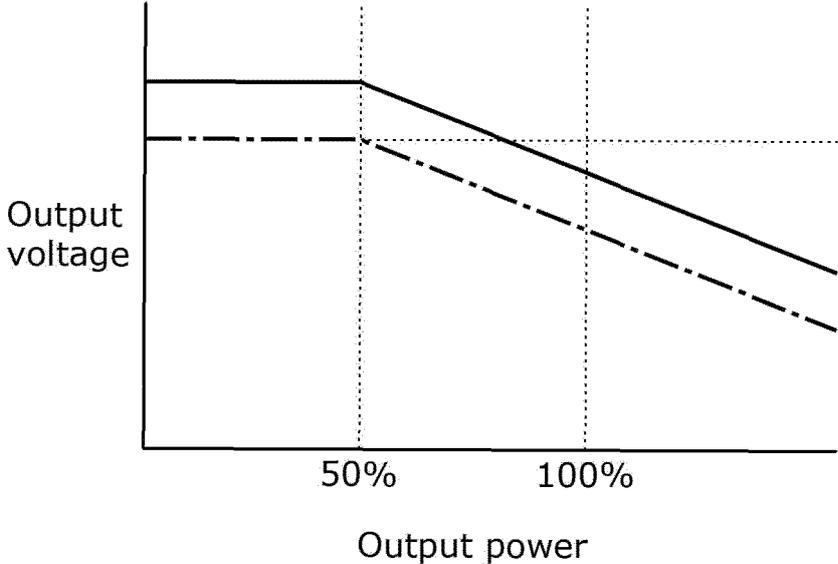


FIG. 6

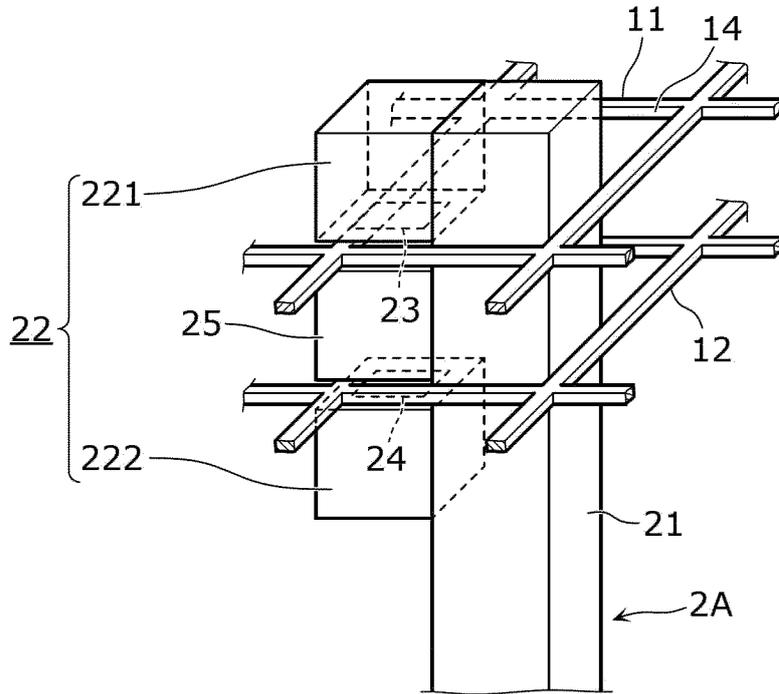


FIG. 7

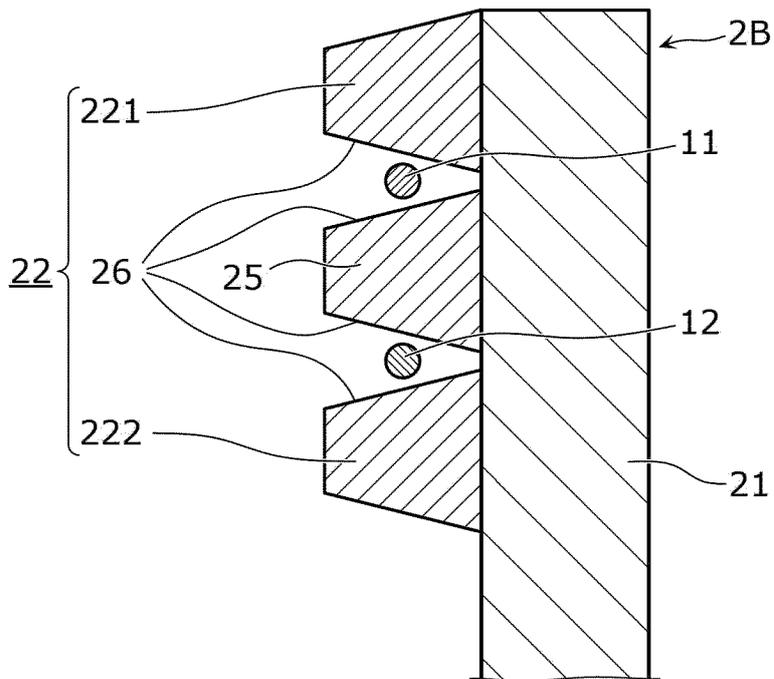


FIG. 8

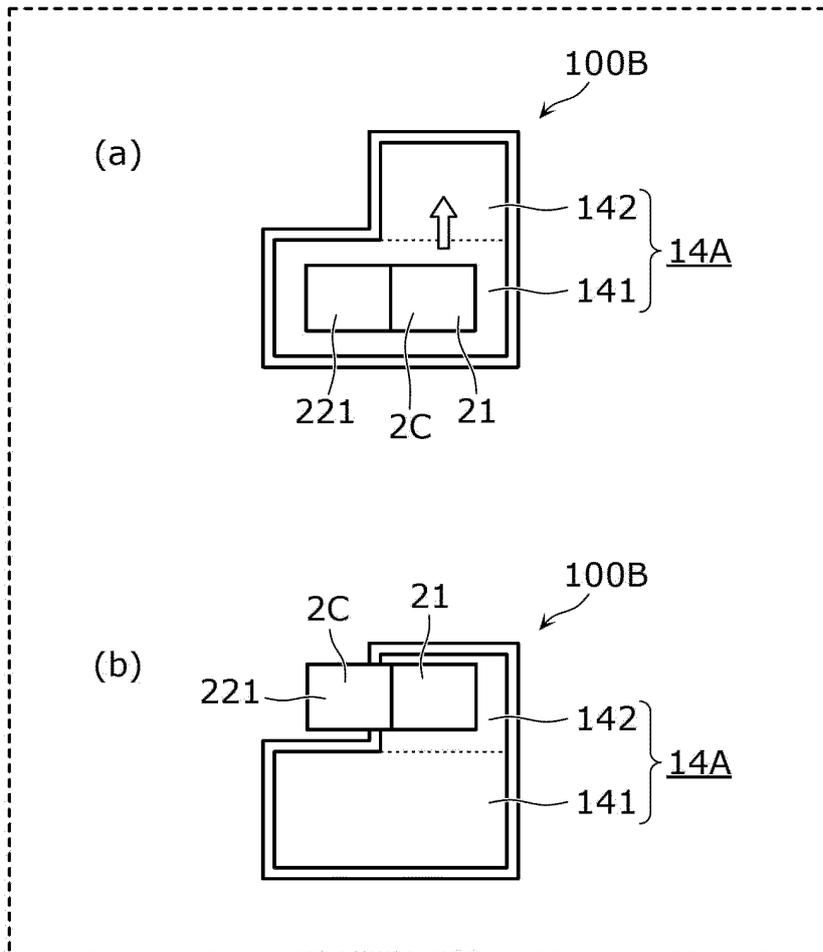
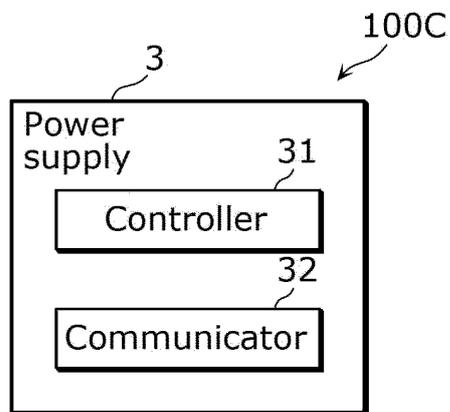


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/JP2023/022738**

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**A. CLASSIFICATION OF SUBJECT MATTER**

**F21V 21/35**(2006.01)i; **F21V 21/00**(2006.01)i; **F21V 23/06**(2006.01)i; **H01R 25/00**(2006.01)i; **H01R 41/00**(2006.01)i;  
**H05B 47/185**(2020.01)i  
FI: F21V21/35; F21V21/00 130; F21V23/06; H05B47/185; H01R25/00 N; H01R41/00 A

According to International Patent Classification (IPC) or to both national classification and IPC

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**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
F21V21/35; F21V21/00; F21V23/06; H01R25/00; H01R41/00; H05B47/185

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
Published examined utility model applications of Japan 1922-1996  
Published unexamined utility model applications of Japan 1971-2023  
Registered utility model specifications of Japan 1996-2023  
Published registered utility model applications of Japan 1994-2023

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

25

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2011-150859 A (PANASONIC ELECTRIC WORKS CO., LTD.) 04 August 2011 (2011-08-04) paragraphs [0027]-[0083], fig. 1-34	1-9
A	JP 2002-008430 A (OHBAYASHI CORP.) 11 January 2002 (2002-01-11) paragraphs [0010]-[0020], fig. 1-9	1-9

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Further documents are listed in the continuation of Box C.  See patent family annex.

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\* Special categories of cited documents:  
 "A" document defining the general state of the art which is not considered to be of particular relevance  
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 "O" document referring to an oral disclosure, use, exhibition or other means  
 "P" document published prior to the international filing date but later than the priority date claimed  
 "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention  
 "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone  
 "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art  
 "&" document member of the same patent family

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Date of the actual completion of the international search <b>06 July 2023</b>	Date of mailing of the international search report <b>18 July 2023</b>
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Name and mailing address of the ISA/JP <b>Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan</b>	Authorized officer   Telephone No.
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**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

International application No.

**PCT/JP2023/022738**

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Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2011-150859 A	04 August 2011	(Family: none)	
JP 2002-008430 A	11 January 2002	(Family: none)	

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2002008430 A [0003]