

DESCRIPTION

BATTERY DEVICE AND BATTERY SYSTEM

5 CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is national stage application of International Application No. PCT/JP2017/027084, filed July 26, 2017, incorporated herein by reference, and which claims the benefit of priority from Japanese Patent
10 Application No. 2016-150793, filed July 29, 2016, the entire contents of which are incorporated herein by reference.

FIELD

15 [0002] Embodiments described herein relate generally to a battery device and a battery system.

BACKGROUND

[0003] Conventionally, battery devices incorporating a
20 plurality of battery cells and modules in a casing are known. In such a battery device, for example, the battery cells and modules are cooled for longer longevity.

25 [0004] It is hard to assemble a battery device in a configuration such that cells and modules are uniformly cooled, which may increase manufacturing cost.

BRIEF DESCRIPTION OF DRAWINGS

30 [0005] FIG. 1 is a perspective view schematically illustrating a vehicle according to a first embodiment.

FIG. 2 is an exploded perspective view illustrating a battery device according to the first embodiment.

FIG. 3 is a cross-sectional view illustrating the

battery device according to the first embodiment.

FIG. 4 is a perspective view schematically illustrating an inside of the battery device according to the first embodiment.

5 FIG. 5 is a perspective view illustrating a battery module according to the first embodiment.

FIG. 6 is an exploded perspective view illustrating the battery module according to the first embodiment.

FIG. 7 is a cross-sectional view illustrating part of
10 the battery device according to the first embodiment.

FIG. 8 is a perspective view illustrating a first fixing member according to the first embodiment.

FIG. 9 is a perspective view schematically illustrating a battery device according to a second
15 embodiment.

FIG. 10 is a cross-sectional view illustrating the battery device according to the second embodiment.

FIG. 11 is an exploded perspective view illustrating a battery unit according to the second embodiment.

20 FIG. 12 is an exploded side view illustrating the battery unit according to the second embodiment.

FIG. 13 is a cross-sectional view illustrating part of the battery device according to the second embodiment.

FIG. 14 is a perspective view schematically illustrating an inside of the battery device according to
25 the second embodiment.

FIG. 15 is a cross-sectional view of a battery device according to a third embodiment.

FIG. 16 is a perspective view schematically illustrating a plurality of battery devices according to a
30 fourth embodiment.

FIG. 17 is a plan view illustrating a plurality of battery devices according to a fifth embodiment.

DETAILED DESCRIPTION

[0006] In general, according to one embodiment, a battery device includes a casing, a second wall, a plurality of battery modules, a support, a plurality of
5 fixing parts and cooling unit. The casing includes a first wall. The second wall is detachably attached to the casing apart from the first wall in a first direction. The plurality of battery modules are arranged in a second direction inside a chamber of the casing, the second
10 direction intersecting with the first direction, the chamber located between the first wall and the second wall, the battery modules each including a first surface facing the first wall, a second surface facing the second wall, and a first positioner provided on the first surface, the
15 first positioner including one of a protrusion and a recess. The support extends in the second direction inside the chamber, supports the battery modules, and is provided with a plurality of second positioners that is fitted to the first positioners to hold the battery modules in the second
20 direction, the second positioners each including the other of the protrusion and the recess. The plurality of fixing parts are provided on the second surface or in a location closer to the second surface than to the first surface, and fix the battery modules and the casing to each other. The
25 cooling unit is configured to allow a refrigerant to flow into an interval between the battery modules.

[0007] The following describes a first embodiment with reference to FIGS. 1 to FIG. 8. In the present
30 description, basically, a vertically upward direction is defined as an upward direction, and a vertically downward direction is defined as a downward direction. In the present description, a plurality of expressions may be used for a

component according to the embodiment and description of the component. The component and description expressed in a plurality of ways may be expressed in a different way that is not described herein. In addition, a component and description that are not expressed in a plurality of ways may also be expressed in a different way that is not described herein.

[0008] FIG. 1 is a perspective view schematically illustrating a vehicle 10 according to the first embodiment. The vehicle 10 is an example of a battery system. The battery system may be, for example, another battery system such as a solar power generation system or a household power storage system.

[0009] Examples of the vehicle 10 include an electric vehicle such as a bus illustrated in FIG. 1. The vehicle 10 may be, for example, another vehicle such as a car, a light-rail train, an electric train, or a streetcar. The vehicle 10 includes a vehicle body 11, a plurality of wheels 12, and a plurality of battery devices 13.

[0010] As illustrated in the drawings, in the present description, X-axis, Y-axis, and Z-axis are defined. The X-axis, the Y-axis, and the Z-axis are orthogonal to each other. The X-axis extends along the width of the vehicle 10. The Y-axis extends along the length of the vehicle 10. The Z-axis extends along the height of the vehicle 10.

[0011] The vehicle body 11 extends in a Y-axis direction, and includes a front part 11a, a rear part 11b, and side parts 11c. The front part 11a faces in a traveling direction of the vehicle 10. The rear part 11b is opposite the front part 11a.

[0012] Each of the side parts 11c of the vehicle body 11 faces in an X-axis direction. The side parts 11c are provided with ventilation slits 11d. The ventilation slits

11d are holes for communicating between inside and outside of the vehicle body 11.

[0013] The battery devices 13 are housed inside the vehicle body 11, and supply electric power to a motor and/or an electric system, for example. The battery devices 13 are, for example, detachably fixed to a beam inside the vehicle body 11 by screwing or insertion. The battery devices 13 are not limited thereto.

[0014] FIG. 2 is an exploded perspective view illustrating the battery device 13 according to the first embodiment. FIG. 3 is a cross-sectional view illustrating the battery device 13 according to the first embodiment. As illustrated in FIGS. 2 and 3, the battery device 13 includes a casing 21, a lid member 22, a plurality of battery modules 23, and a plurality of first fixing members 24. The lid member 22 is an example of a second wall. The first fixing members 24 are an example of fixing parts.

[0015] The casing 21 is made of metal. The casing 21 may be, for example, made of other materials such as resin. As illustrated in FIG. 3, the casing 21 includes a bottom wall 31, two first side walls 32, and two corner walls 33. The bottom wall 31 is an example of a first wall. Each of the first side walls 32 is an example of a third wall. Each of the corner walls 33 is an example of a fourth wall.

[0016] The bottom wall 31 is a quadrangular wall spreading across the X-Y plane, and extends in a Y-axis direction. The Y-axis direction is an example of a second direction, and includes a positive Y-axis direction (a direction indicated by the arrow of the Y-axis) and a negative Y-axis direction (a direction opposite to the arrow of the Y-axis). The Y-axis direction is a longitudinal direction of the battery device 13.

[0017] The bottom wall 31 includes an inner face 31a.

The inner face 31a is a substantially flat surface facing in a positive Z-axis direction (a direction indicated by the arrow of the Z-axis, upward direction). Each of the positive Z-axis direction and the upward direction is an example of a first direction.

[0018] The two first side walls 32 are quadrangular walls spreading across the X-Z plane, and extend in the positive Z-axis direction. The two first side walls 32 are spaced apart from each other in the Y-axis direction. The bottom wall 31 is located between the two first side walls 32 in the Y-axis direction separately from the two first side walls 32.

[0019] Each of the two corner walls 33 connects a Y-axial end of the bottom wall 31 and an end of the first side wall 32 in a negative Z-axis direction (a direction opposite to the arrow of the Z-axis, downward direction). The corner walls 33 extend in a direction that obliquely intersects with the positive Z-axis direction and the Y-axis direction.

[0020] As illustrated in FIG. 2, the casing 21 further includes two second side walls 34. The two second side walls 34 are quadrangular walls spreading across the Y-Z plane, and extend from both X-axial ends of the bottom wall 31 in the positive Z-axis direction. The two second side walls 34 are spaced apart from each other in the X-axis direction.

[0021] As illustrated in FIG. 3, the lid member 22 includes a top wall 35 and an edge wall 36. The top wall 35 is a quadrangular wall spreading across the X-Y plane, and extends in the Y-axis direction. The edge wall 36 is a quadrangular wall spreading across the X-Z plane. The edge wall 36 extends from a Y-axial end of the top wall 35 in the negative Z-axis direction.

[0022] The lid member 22 is detachably attached to the casing 21 with spacing from the bottom wall 31 of the casing 21 in the positive Z-axis direction. For example, the lid member 22 is attached to the casing 21 with bolts.

[0023] The top wall 35 includes an inner face 35a and an outer face 35b. The inner face 35a is a substantially flat surface facing in the negative Z-axis direction. The inner face 35a of the top wall 35 and the inner face 31a of the bottom wall 31 face each other with an interval. The outer face 35b is a substantially flat surface facing in the positive Z-axis direction. The outer face 35b is opposite the inner face 35a.

[0024] The casing 21 is provided with a chamber C. The chamber C is located between the bottom wall 31 of the casing 21 and the top wall 35 of the lid member 22 and between the two first side walls 32. The chamber C extends in the Y-axis direction.

[0025] The two corner walls 33 of the casing 21 are each provided with an air inlet 33a. The air inlet 33a is an example of a first vent hole. The air inlet 33a extends in a direction that obliquely intersects with the positive Z-axis direction and the Y-axis direction. For example, the air inlet 33a extends in a direction orthogonal to the direction in which the corner walls 33 extend.

[0026] The lid member 22 is provided with a hood 41. The hood 41 is provided above the outer face 35b of the top wall 35. The hood 41 includes a cover wall 42 and an end wall 43. The hood 41 may house various components such as a circuit board.

[0027] The cover wall 42 is a quadrangular wall spreading across the X-Y plane. The cover wall 42 is spaced apart from the outer face 35b of the top wall 35 in the positive Z-axis direction. The end wall 43 connects

the cover wall 42 and the top wall 35. The end wall 43 is provided with a plurality of air outlets 43a. Each of the air outlets 43a is an example of a second vent hole.

[0028] The hood 41 is provided with an inclined passage Ps. The inclined passage Ps is an example of a third passage. The hood 41 may accommodate a component such as a circuit board in isolation from the inclined passage Ps.

[0029] At least part of the inclined passage Ps is located between the cover wall 42 and the top wall 35. The inclined passage Ps is connected at one end to the chamber C and at the other end to the air outlets 43a. One end of the inclined passage Ps is connected to the center of the chamber C in the Y-axis direction.

[0030] The inclined passage Ps extends toward the air outlets 43a in a downwardly tilting direction. In other words, the inclined passage Ps has a passage extending downward from the chamber C to the inclined passage Ps.

[0031] A plurality of air-outlet covers 45 are attached to an outer face 43b of the end wall 43. Each of the air-outlet covers 45 is an example of a cover. The outer face 43b of the end wall 43 is opposite an inner face 43c of the end wall 43 facing the inclined passage Ps.

[0032] The air-outlet covers 45 cover the air outlets 43a, and extend in a downwardly tilting direction toward the outside of the air outlets 43a. In other words, the air-outlet covers 45 form a downward or obliquely downward flow channels which are connected to the air outlets 43a.

[0033] FIG. 4 is a perspective view schematically illustrating the inside of the battery device 13 according to the first embodiment. In FIG. 4, the casing 21 is indicated by a two-dot chain line. As illustrated in FIG. 4, the casing 21 includes two support frames 51 and two fixing frames 52. Each of the support frames 51 is an

example of a support.

[0034] The two support frames 51 extend in the Y-axis direction inside the casing 21. The two support frames 51 are spaced apart from each other in the X-axis direction. The support frame 51 is fixed, for example, to the bottom wall 31 and the two second side walls 34 of the casing 21 by welding. Thereby, the support frames 51 improve the rigidity of the casing 21.

[0035] The support frames 51 have a hollow pipe shape with a quadrangular frame-shaped cross section. The support frames 51 may have another shape. The support frames 51 each include a top surface 51a. The top surface 51a is a substantially flat surface facing in the positive Z-axis direction.

[0036] The support frames 51 are provided with a plurality of recesses 51b. The recesses 51b are an example of second positioners. The support frames 51 may include protrusions as second positioners. The recesses 51b are holes opening to the top surface 51a. The recesses 51b may be, for example, depressions or cutouts. The recesses 51b are arranged at intervals in the Y-axis direction.

[0037] The fixed frames 52 are spaced apart from the support frames 51 in the positive Z-axis direction. The two fixed frames 52 extend in the Y-axis direction inside the casing 21. The two fixed frames 52 are spaced apart from each other in the X-axis direction. The fixed frames 52 are fixed, for example, to the two second side walls 34 of the casing 21 by welding. Thereby, the fixed frames 52 improve the rigidity of the casing 21.

[0038] The fixed frames 52 have a hollow pipe shape having a quadrangular frame-shaped cross section. The fixed frames 52 may have another shape. The fixed frames 52 each include a top surface 52a. The top surface 52a is

a substantially flat surface facing in the positive Z-axis direction.

[0039] The fixed frame 52 are provided with a plurality of screw holes 52b. The screw holes 52b are open to the top surface 52a. The screw holes 52b may open to another location. The screw holes 52b are arranged at intervals in the Y-axis direction.

[0040] FIG. 5 is a perspective view illustrating the battery module 23 according to the first embodiment. FIG. 6 is an exploded perspective view illustrating the battery module 23 according to the first embodiment. As illustrated in FIG. 6, the battery module 23 includes a plurality of cells 61, a holder 62, and a plurality of busbars 63. The cells 61 may be, for example, referred to as electric cells. The holder 62 is an example of a holding element, and may be referred to as, for example, a casing.

[0041] The cells 61 are, for example, lithium ion secondary batteries. For example, the cells 61 may be another secondary batteries such as nickel hydrogen batteries, nickel cadmium batteries, and lead storage batteries. The lithium ion secondary batteries are a kind of nonaqueous electrolyte secondary batteries in which lithium ions in an electrolyte conduct electricity.

[0042] Examples of a cathode material of the lithium ion secondary batteries include various materials such as a lithium manganese complex oxide, lithium nickel complex oxide, lithium cobalt complex oxide, lithium nickel cobalt complex oxide, lithium manganese cobalt complex oxide, spinel type lithium manganese nickel complex oxide, and lithium phosphorus oxide having an olivine structure. Examples of an anode material of the lithium ion secondary batteries include various materials such as an oxide-based

material including lithium titanate (LTO), a carbonaceous material, and a silicon-based material. Examples of an electrolyte (for example, an electrolytic solution) of the lithium ion secondary batteries include sole organic solvent or combination of organic solvents such as ethylene carbonate, propylene carbonate, diethyl carbonate, ethylmethyl carbonate, and dimethyl carbonate, mixed with lithium salt such as fluorine-based complex salt (for example, LiBF_4 and LiPF_6).

[0043] The battery module 23 may include, for example, a circuit board that detects a voltage and/or a temperature of each cell 61. The battery module 23 may further include a circuit board that controls charge and discharge of the cells 61.

[0044] The cells 61 have a quadrangular box shape. For example, the cells 61 may have a cylindrical shape. Each of the cells 61 includes a first end 61a, a second end 61b, and two terminals 61c.

[0045] The first end 61a faces in the Y-axis direction. The Y-axis direction is an example of a third direction. For example, the first end 61a faces in one of the positive Y-axis direction and the negative Y-axis direction. The second end 61b is opposite the first end 61a. The two terminals 61c are located at the first end 61a.

[0046] The cells 61 are arranged in a matrix in the X-axis direction and the Z-axis direction. In other words, the cells 61 are aligned in directions intersecting with the Y-axis. The directions intersecting with the Y-axis are an example of a direction intersecting with the third direction. First ends 61a of the arranged cells 61 face in the same direction.

[0047] The holder 62 houses and holds the cells 61. The holder 62 is made of a synthetic resin. For example, the

holder 62 may be made of another material such as metal. The holder 62 includes a first member 65, a second member 66, and a third member 67.

[0048] The first member 65 is provided with a plurality of slits 65a. The slits 65a are depressions opening in the same direction. The arranged cells 61 are housed in the slits 65a. Thus, the first member 65 holds the arranged cells 61.

[0049] The second member 66 is attached to the first member 65 to cover the cells 61 housed in the slits 65a. The second member 66 is provided with a plurality of holes 66a from which the terminals 61c of the cells 61 are exposed. The third member 67 is attached to the second member 66 to cover the holes 66a.

[0050] The busbars 63 are arranged between the second member 66 and the third member 67. The busbars 63 electrically connect the terminals 61c of the cells 61 to each other. The cells 61 are electrically connected to each other in series or in parallel.

[0051] The battery module 23 includes a first end face 23a illustrated in FIG. 5 and a second end face 23b illustrated in FIG. 6. The first end face 23a is an example of a first surface. The second end face 23b is an example of a second surface.

[0052] The first member 65 includes the first end face 23a and the second end face 23b. The first end face 23a is a substantially flat surface facing in the negative Z-axis direction. The second end face 23b is a substantially flat surface facing in the positive Z-axis direction, and opposes to the first end face 23a.

[0053] The battery module 23 further includes a plurality of first protrusions 23c and a plurality of second protrusions 23d. Each of the first protrusions 23c

is an example of a first positioner. The battery module 23 may include recesses as a first positioner.

[0054] The first end face 23a is provided with the first protrusions 23c protruding from the first end face 23a. The first protrusions 23c have a substantially cylindrical shape. The first protrusions 23c may have another shape. According to the present embodiment, a pair of first protrusions 23c and another pair of first protrusions 23c are spaced apart from each other in the X-axis direction.

[0055] The second end face 23b is provided with the second protrusions 23d protruding from the second end face 23b. The second protrusions 23d have a substantially cylindrical shape. The second protrusions 23d may have another shape. According to the present embodiment, a pair of second protrusions 23d and another pair of second protrusions 23d are spaced apart from each other in the X-axis direction.

[0056] The first protrusions 23c and the second protrusions 23d have screw holes 23e inside. For example, metal cylinders with the screw holes 23e are insert-molded together with the first protrusions 23c and the second protrusions 23d. Only the second protrusions 23d may have the screw holes 23e inside.

[0057] The battery module 23 further includes two terminals 23f. The terminals 23f are located on the second end face 23b, projecting from the second end face 23b. The terminals 23f include a terminal of the battery module 23. For example, the terminals 23f include an electrode to which a connector is attached. The terminals 23f of the battery modules 23 are electrically connected to each other in series or in parallel.

[0058] As illustrated in FIG. 3, the battery modules 23 are arranged with gap G in the Y-axis direction inside the

chamber C. The battery modules 23 are arranged in a row in the Y-axis direction, and may be arranged in a plurality of rows. The battery module 23 located at the end of the row is separated from the first side wall 32 of the casing 21 with the gap G.

[0059] The first end faces 23a of the battery modules 23 face the bottom wall 31 of the casing 21 with an interval. A lower passage Pl is provided between the first end faces 23a of the battery modules 23 and the bottom wall 31. The lower passage Pl extends in the Y-axis direction, and connects the air inlets 33a and the gap G between the battery modules 23. In other words, the lower passage Pl is connected to the air inlets 33a.

[0060] The second end faces 23b of the battery modules 23 face the top wall 35 of the lid member 22 with an interval. An upper passage Pu is provided between the second end faces 23b of the battery modules 23 and the top wall 35. The upper passage Pu extends in the Y-axis direction, and connects the inclined passage Ps and the gap G between the battery modules 23. In other words, the upper passage Pu is connected to the air outlet 43a via the inclined passage Ps. The inclined passage Ps connects the central part of the upper passage Pu in the Y-axis direction and the air outlets 43a.

[0061] The two support frames 51 support the battery modules 23 apart from the bottom wall 31 in the positive Z-axis direction. For example, the first end faces 23a of the battery modules 23 are supported by the top surfaces 51a of the support frames 51. This forms the lower passage Pl between the battery modules 23 and the bottom wall 31.

[0062] FIG. 7 is a cross-sectional view illustrating part of the battery device 13 according to the first embodiment. As illustrated in FIG. 7, the first

protrusions 23c of the battery module 23 are inserted into the recesses 51b of the support frames 51 in the Z-axis direction. Thereby, the first protrusions 23c of the battery module 23 are fitted into the recesses 51b of the support frames 51.

[0063] The recesses 51b and the first protrusions 23c hold the battery modules 23 with gap G in the Y-axis direction. The recesses 51b and the first protrusions 23c work to limit relative movement of the battery modules 23 in the Y-axis direction and the X-axis direction.

[0064] The first protrusions 23c of the battery module 23 may be fitted into the recesses 51b of the support frames 51 with spacing. That is, it can be said that when the first protrusions 23c are located inside the recesses 51b, the first protrusions 23c are fitted into the recesses 51b.

[0065] The recesses 51b and the first protrusions 23c maintain a Y-axial length (width) of the gap G between the battery modules 23. The Y-axial length of the gap G between the battery modules 23 may be slightly variable. As illustrated in FIG. 3, the first end 61a and the second end 61b of each cell 61 are directed to the gap G.

[0066] FIG. 8 is a perspective view illustrating the first fixing members 24 according to the first embodiment. As illustrated in FIG. 8, the first fixing members 24 each include a first plate 71, a second plate 72, a third plate 73, and bolts 75 and 76 in FIG. 7.

[0067] The first plate 71 and the second plate 72 are plate-like parts extending across the X-Y plane. The first plate 71 is provided with a plurality of holes 71a. The second plate 72 is provided with a plurality of holes 72a. The third plate 73 is a plate-like part extending across the Y-Z plane. The third plate 73 connects the end of the

first plate 71 and the end of the second plate 72.

[0068] As illustrated in FIG. 7, the first plates 71 are supported by the second protrusions 23d of the battery module 23. For example, the distal ends of the second protrusions 23d are inserted into depressions in the first plate 71 and positioned.

[0069] The bolts 75 are screwed into the screw holes 23e of the second protrusions 23d through the holes 71a in FIG. 8. Thereby, the first plates 71 are fixed to the second protrusions 23d of the battery module 23. The first plates 71 may be welded onto the second protrusions 23d.

[0070] The second plates 72 are supported by the top surface 52a of the fixing frame 52. The bolts 76 are screwed into the screw holes 52b of the fixing frame 52 through the holes 72a in FIG. 8. Thereby, the second plates 72 are fixed to the fixing frame 52. The second plate 72 may be welded onto the fixing frame 52.

[0071] As described above, the first fixing members 24 are located on the second protrusions 23d of the second end face 23b of the battery module 23. The first fixing members 24 fix the battery module 23 and the fixing frame 52 of the casing 21 to each other.

[0072] As illustrated in FIG. 3, a fan 78 is provided between the upper passage Pu and the inclined passage Ps. The fan 78 is an example of a cooling unit and a fan. For example, the fan 78 may be located at a different position such as a position adjacent to the air inlets 33a.

[0073] When driven, the fan 78 blows a gaseous refrigerant M from the two air inlets 33a to the air outlets 43a. The gaseous refrigerant M is, for example, air. Air is supplied from the outside of the vehicle 10 through the ventilation slits 11d in FIG. 1, for example. In FIG. 3, the arrows indicate a flow of the refrigerant M.

The fan 78 may blow the gaseous refrigerant M from the air outlets 43a to the two air inlets 33a.

[0074] The refrigerant M is sucked from the air inlets 33a and flows into the gap G between the battery modules 23 or the gap G between the battery module 23 and the first side wall 32 through the lower passage Pl. That is, the fan 78 blows the refrigerant M into the gap G among the battery modules 23.

[0075] The refrigerant M cools the first end 61a and the second end 61b of each cell 61 facing the gap G while flowing through the gap G. The cells 61 that generate heat during charge and discharge are cooled by the refrigerant M. The refrigerant M flows into the inclined passage Ps through the gap G and the upper passage Pu. The refrigerant M in the inclined passage Ps is exhausted from the air outlets 43a to the outside of the battery device 13.

[0076] As illustrated in FIGS. 2 and 3, the battery device 13 further includes a plurality of spacers 79. For example, the spacers 79 are made of a synthetic resin foam (sponge) such as EPT-Sealer (registered trademark). The spacer 79 may be made of another material. The battery device 13 does not necessarily include the spacers 79.

[0077] For example, the spacers 79 have a quadrangular prism shape extending in the Z-axis direction. The spacers 79 may have another shape. In the X-axis direction, the width of the spacers 79 is substantially the same as the width of the support frames 51. The spacers 79 are adhered to the battery module 23 with double-sided tape, for example, and placed in the gap G.

[0078] In each of the gaps G, two spacers 79 are arranged. The two spacers 79 are spaced apart from each other in the X-axis direction. The two spacers 79 define a flow channel in the gap G through which the refrigerant M

passes.

[0079] The spacers 79 maintain the gap G between every two adjacent battery modules 23 to separate them. This ensures that the refrigerant M flows through the gap G to cool the cells 61. The spacers 79 prevent the two adjacent battery modules 23 from contacting with each other and being damaged.

[0080] The following describes an example of an assembly method of the battery device 13 as described above. First, the battery modules 23 are stored in the casing 21 with the lid member 22 detached. Fitting the first protrusions 23c of the battery module 23 into the recesses 51b of the support frame 51 facilitates positioning of the battery modules 23 without using any tools. Thereby, the gap G is formed between the battery modules 23. The battery modules 23 are yet movable in the positive Z-axis direction.

[0081] Next, the second protrusions 23d of the battery modules 23 and the fixing frames 52 are fixed to each other with the first fixing members 24. This fixing is accompanied by, for example, screwing with the bolts 75 and 76. The second protrusions 23d and the fixing frames 52 are closer to the opened top end of the casing 21 than to the support frames 51. This can allow an operator to easily perform screwing with the bolts 75 and 76.

[0082] The battery modules 23, fixed to the fixing frames 52 with the first fixing members 24, are restricted from moving in the positive Z-axis direction. Thus, the battery modules 23 are fixed to the casing 21.

[0083] Next, the terminals 23f of the battery modules 23 are electrically connected to each other via a connector, for example. The lid member 22 is then attached to the casing 21. This completes the assembly of the battery device 13.

[0084] In the vehicle 10 according to the first embodiment described above, the support frames 51 are provided with the recesses 51b. The first protrusions 23c of the battery modules 23 are fitted into the recesses to hold the battery modules 23 with the gap G in the Y-axis direction. That is, the battery modules 23 each include the first protrusions 23c as a first positioner, and the support frame 51 includes the recesses 51b as second positioners.

[0085] In a location distant from the lid member 22 removable from the casing 21, it is typically difficult to perform work such as screwing. However, with the battery device 13 according to the present embodiment, it is made possible to easily position the battery modules 23 by fitting the first protrusions 23c in the recesses 51b, in a distant location from the lid member 22 that is removable from the casing 21.

[0086] In a position close to the lid member 22 removable from the casing 21, it is typically easier to perform the work such as screwing. In the battery device 13 according to the present embodiment, the first fixing members 24 that fix the battery module 23 to the casing 21 are located on the second end face 23b of the battery module 23 close to the lid member 22, or at a position closer to the second end face 23b than to the first end face 23a. This can facilitate the fixing of the battery module 23 to the casing 21.

[0087] As described above, the battery modules 23 can be easily arranged with the gap G through which the refrigerant M can flow. This facilitates the assembly of the battery device 13 that can be cooled by the refrigerant M. Easier assembly of the battery device 13 leads to preventing increase in manufacturing cost of the battery

device 13. In addition, the battery modules 23 are cooled by the refrigerant M flowing through the gap G among the battery modules 23, which can prevent deterioration of the cells 61 and decrease in the longevity of the battery device 13.

[0088] The terminals 23f are provided on the second end face 23b. That is, the terminals 23f are located closer to the lid member 22 around which work is easily carried out. This further facilitates electric connection between the terminals 23f of the two battery modules 23 to each other.

[0089] The cells 61 are arranged in the X-axis direction and the Z-axis direction that intersect with the Y-axis direction in which the first end 61a faces. At least one of the first end 61a and the second end 61b of each cell 61 is directed to the gap G between the battery modules 23. Thereby, the refrigerant M blown by the fan 78, while flowing through the gap G among the battery modules 23, cools at least one of the first ends 61a and the second ends 61b of the cells 61. Thus, the cells 61 of the battery modules 23 are uniformly cooled.

[0090] The fan 78 blows the refrigerant M from the air inlets 33a to the air outlets 43a. The air inlets 33a are connected to the lower passage Pl, and the air outlets 43a are connected to the upper passage Pu. Thus, the refrigerant M flows from the lower passage Pl to the upper passage Pu through the gap G among the battery modules 23. Thereby, the battery modules 23 are cooled by the gaseous refrigerant M, and the battery modules 23 and the cells 61 are prevented from deteriorating in their performance due to temperature change.

[0091] The corner walls 33 provided with the air inlets 33a extend in the direction that obliquely intersects with the positive Z-axis direction and the Y-axis direction.

That is, the direction in which the refrigerant M flows from the air inlets 33a into the lower passage Pl obliquely intersects with the Y-axis direction. Thus, even with a large output of the fan 78, the refrigerant M easily passes through the gap G between the first side walls 32 and the battery modules 23, for example, and cools the battery module 23 closest to the first side wall 32. In addition, if multiple battery devices 13 are aligned in contact with each other, the air inlets 33a are prevented from being closed by the first side wall 32 of another battery device 13.

[0092] The inclined passage Ps connecting the upper passage Pu and the air outlets 43a extends in a downwardly tilting direction toward the air outlets 43a. This helps discharge, for example, rainwater which has entered the inclined passage Ps through the air outlets 43a, from the air outlets 43a by gravity. That is, the rainwater is prevented from entering the chamber C through the inclined passage Ps.

[0093] The air-outlet covers 45 partially cover the air outlets 43a, and extend in a downwardly tilting direction toward the outside of the air outlets 43a. Thereby, the air-outlet covers 45 prevent rainwater from entering the air outlets 43a.

[0094] The following describes a second embodiment with reference to FIGS. 9 to 14. In the following embodiments, elements having same or like function as the previously described elements are denoted by common reference numerals, and description thereof may be omitted. The elements denoted by the common reference numerals do not necessarily have all the same functions and properties, and may have different functions and properties depending on the respective embodiments.

[0095] FIG. 9 is a perspective view schematically illustrating a battery device 13 according to the second embodiment. FIG. 10 is a cross-sectional view illustrating the battery device 13 according to the second embodiment. As illustrated in FIG. 9, the battery device 13 according to the second embodiment includes a liquid cooler 81. The liquid cooler 81 is an example of a cooling unit, and may be referred to as a water cooler, for example. The liquid cooler 81 includes a plurality of liquid cooling members 82, two supply devices 83A and 83B, and a plurality of pipes 84. Each of the pipes 84 is an example of a tubular channel.

[0096] FIG. 11 is an exploded perspective view illustrating a battery unit U according to the second embodiment. FIG. 12 is an exploded side view illustrating the battery unit U according to the second embodiment. In the second embodiment, the battery device 13 includes a plurality of battery units U.

[0097] The battery units U each include one liquid cooling member 82 and one or two battery modules 23. Each battery unit U may include three or more battery modules 23. The battery modules 23 according to the second embodiment are the same as the battery modules 23 according to the first embodiment.

[0098] The following describes the battery unit U including two battery modules 23. The liquid cooling member 82 is made of metal such as aluminum or copper. The liquid cooling member 82 may be made of another material. The liquid cooling member 82 includes a cooling unit 91, a first mounting part 92, a second mounting part 93, and two projections 94.

[0099] The cooling unit 91 has a quadrangular plate shape, for example. The cooling unit 91 may have another shape. As illustrated in FIGS. 11 and 12, the cooling unit

91 includes a bottom end 91a, a top end 91b, two side ends 91c, and two connecting surfaces 91d.

[0100] The bottom end 91a is an end of the cooling unit 91 in the negative Z-axis direction. The top end 91b is an end of the cooling unit 91 in the positive Z-axis direction, and opposite the bottom end 91a. The two side ends 91c are X-axial ends of the cooling unit 91. The two connecting surfaces 91d face in the Y-axis direction.

[0101] The first mounting part 92 projects from the top end 91b of the cooling unit 91 in the positive Z-axis direction. The first mounting part 92 is provided with a plurality of screw holes 92a. The screw holes 92a are open in the Y-axis direction.

[0102] The second mounting part 93 projects from the bottom end 91a of the cooling unit 91 in the negative Z-axis direction. The second mounting part 93 is provided with a plurality of screw holes 93a. The screw holes 93a are open in the Y-axis direction.

[0103] The two projections 94 project from the two side ends 91c of the cooling unit 91 in the X-axis direction. The end of each projection 94 in the positive Z-axis direction is continuous with the top end 91b of the cooling unit 91. The end of each projection 94 in the negative Z-axis direction is separated from the bottom end 91a of the cooling unit 91. The projections 94 may be located at different positions.

[0104] The liquid cooling member 82 has a flow channel 97 inside. A liquid refrigerant M can flow through the flow channel 97. The flow channel 97 is in a substantially U-form, for example. The flow channel 97 may be in another form.

[0105] Both ends of the flow channel 97 are open to the end of the first mounting part 92 in the positive Z-axis

direction. Both ends of the flow channel 97 may be open to another location. The liquid cooling member 82 provided with the flow channel 97 is formed by brazing a grooved member and another member together, for example.

[0106] FIG. 13 is a cross-sectional view illustrating part of the battery device 13 according to the second embodiment. As illustrated in FIGS. 11 to 13, the battery module 23 includes a second fixing member 86. The second fixing member 86 includes a first plate 101, a second plate 102, a third plate 103, a fourth plate 104, and bolts 105, 106, and 107.

[0107] The first plate 101 and the second plate 102 are plate-like parts extending across the X-Y plane. The first plate 101 is provided with a plurality of holes 101a. The second plate 102 is provided with a plurality of holes 102a. The third plate 103 is a plate-like part extending across the Y-Z plane. The third plate 103 connects an end of the first plate 101 and an end of the second plate 102.

[0108] The fourth plate 104 is a plate-like part extending across the X-Z plane. The fourth plate 104 extends from a Y-axial end of the first plate 101 in the positive Z-axis direction. The fourth plate 104 is provided with a plurality of holes 104a.

[0109] As illustrated in FIG. 13, the first plate 101 is supported by the second protrusions 23d of the battery module 23. The bolts 105 are screwed into the screw holes 23e of the second protrusions 23d through the holes 101a in FIG. 11. Thereby, the first plate 101 is fixed to the second protrusions 23d of the battery module 23. The first plate 101 may be welded onto the second protrusions 23d.

[0110] The second plate 102 is supported by the top surfaces 52a of the fixing frames 52. The bolts 106 are screwed into the screw holes 52b of the fixing frames 52

through the holes 102a in FIG. 11. Thereby, the second plate 102 is fixed to the fixing frame 52. The second plate 102 may be welded onto the fixing frame 52.

[0111] The fourth plate 104 is attached to the first mounting part 92 of the liquid cooling member 82. The bolts 107 in FIG. 12 are screwed into the screw holes 92a of the first mounting part 92 through the holes 104a in FIG. 11. Thereby, the fourth plate 104 is fixed to the liquid cooling member 82. In this manner, the first mounting part 92 of the liquid cooling member 82 is attached to the battery module 23 via the second fixing member 86.

[0112] As illustrated in FIGS. 11 to 13, the battery module 23 includes a third fixing member 87. The third fixing member 87 includes a first plate 111, a second plate 112, a third plate 113, and bolts 115 and 116.

[0113] The first plate 111 is a plate-like part extending across the X-Y plane. The first plate 111 is provided with a plurality of holes 111a. The second plate 112 is a plate-like part extending across the Y-Z plane. The second plate 112 extends from an X-axial end of the first plate 111 in the positive Z-axis direction.

[0114] The third plate 113 is a plate-like part extending across the X-Z plane. The third plate 113 extends from a Y-axial end of the first plate 111 in the negative Z-axis direction. The third plate 113 is provided with a plurality of holes 113a.

[0115] As illustrated in FIG. 13, the first plate 111 is supported by the first protrusions 23c of the battery module 23. The bolts 115 are screwed into the screw holes 23e of the first protrusions 23c through the holes 111a in FIG. 11. Thereby, the first plate 111 is fixed to the first protrusions 23c of the battery module 23.

[0116] The third plate 113 is attached to the second

mounting part 93 of the liquid cooling member 82. The bolts 116 in FIG. 12 are screwed into the screw holes 93a of the second mounting part 93 through the holes 113a in FIG. 11. Thereby, the third plate 113 is fixed to the liquid cooling member 82. In this manner, the second mounting part 93 of the liquid cooling member 82 is attached to the battery module 23 via the third fixing member 87.

[0117] The first mounting part 92 is attached to the battery module 23, and the second mounting part 93 is also attached to the battery module 23 separately from the first mounting part 92. As illustrated in FIG. 12, the connecting surfaces 91d of the cooling unit 91 are located between the first mounting part 92 and the second mounting part 93.

[0118] The connecting surfaces 91d of the cooling unit 91 protrude toward the battery modules 23 attached to the liquid cooling members 82. In other words, the connecting surfaces 91d bulge toward the battery modules 23 attached to the liquid cooling members 82. The connecting surfaces 91d of the cooling unit 91 contact with and are thermally connected to the battery modules 23 attached to the liquid cooling members 82. Thermal grease may be, for example, interposed between the connecting surfaces 91d and the battery modules 23.

[0119] The battery module 23 is thermally connected to each of the two connecting surfaces 91d of the cooling unit 91. That is, the liquid cooling member 82 is interposed between the two battery modules 23. The battery module 23 may be thermally connected to only one of the connecting surfaces 91d of the cooling unit 91.

[0120] FIG. 14 is a perspective view schematically illustrating the inside of the battery device 13 according

to the second embodiment. As illustrated in FIG. 14, the recesses 51b of the support frames 51 according to the second embodiment are cutouts opening to the top surfaces 51a.

[0121] As illustrated in FIG. 13, the first protrusions 23c of the battery module 23 and part of the third fixing member 87 are inserted into the recesses 51b of the support frames 51 in the Z-axis direction. Thereby, the first protrusions 23c of the battery module 23 and part of the third fixing member 87 are fitted into the recesses 51b of the support frame 51. The projections 94 of the liquid cooling member 82 are then supported by the top surfaces 52a of the fixing frames 52.

[0122] The recesses 51b, the first protrusions 23c, and part of the third fixing member 87 work to hold the battery modules 23 with the gap G in the Y-axis direction. In the second embodiment, the liquid cooling member 82 is placed in the gap G between the battery modules 23. The battery module 23 of one battery unit U may be in contact with the battery module 23 of its adjacent battery unit U.

[0123] The first protrusions 23c of the battery module 23 and part of the third fixing member 87 may be fitted into the recesses 51b of the support frames 51 with a gap. That is, it can be said that, when the first protrusions 23c and part of the third fixing member 87 are located in the recesses 51b, the first protrusions 23c and part of the third fixing member 87 are fitted into the recesses 51b.

[0124] The recesses 51b and the first protrusions 23c and part of the third fixing member 87 work to limit relative movement of the battery modules 23 in the Y-axis direction and the X-axis direction. The battery modules 23 are positioned together with the liquid cooling member 82 as the battery unit U.

[0125] As illustrated in FIG. 9, the multiple battery units U include the battery unit U including two battery modules 23 and the battery unit U including one battery module 23. The battery unit U including one battery module 23 is located at about the center of the battery units U aligned in the Y-axis direction. In other words, the battery unit U including one battery module 23 is located between the two battery units U each including two battery modules 23.

[0126] As schematically illustrated in FIG. 9, the pipes 84 connect the flow channels 97 of the liquid cooling members 82 to the two supply devices 83A and 83B. Specifically, two of the pipes 84 connect the two supply devices 83A and 83B to the flow channels 97 of the liquid cooling members 82. The rest of the pipes 84 connect the flow channels 97 of the two adjacent liquid cooling members 82.

[0127] The pipes 84 connect the flow channels 97 of the liquid cooling members 82 in series. In addition, the pipes 84 connect, in parallel, the two supply devices 83A and 83B to the flow channels 97 of the liquid cooling members 82 that are connected in series. The pipes 84 may connect the flow channels 97 of the liquid cooling members 82 to the two supply devices 83A and 83B in parallel.

[0128] The two supply devices 83A and 83B are, for example, pumps. The supply devices 83A and 83B may be other devices. The supply devices 83A and 83B may be connected to one battery device 13 or a plurality of battery devices 13. The supply devices 83A and 83B may also serve as a radiator pump of the vehicle 10.

[0129] The supply devices 83A and 83B supply the liquid refrigerant M to the flow channels 97 of the liquid cooling members 82 via the pipes 84. The liquid refrigerant M is,

for example, antifreeze such as liquid containing ethylene glycol. The liquid refrigerant M may be another liquid.

[0130] The liquid refrigerant M is supplied from the supply devices 83A and 83B through the pipes 84 and the flow channels 97 of the liquid cooling members 82 and returned to the supply devices 83A and 83B. That is, the liquid refrigerant M circulates through the supply devices 83A and 83B, the pipes 84, and the flow channels 97 of the liquid cooling members 82.

[0131] As described above, the liquid cooler 81 allows the refrigerant M to flow into the flow channels 97 of the liquid cooling members 82 arranged in the gap G between the battery modules 23. The refrigerant M cools the first end 61a or the second end 61b of each cell 61 facing the gap G, while flowing through the flow channels 97 of the liquid cooling members 82 in the gap G.

[0132] The supply devices 83A and 83B are, for example, pumps. The two supply devices 83A and 83B supply the flow of the liquid refrigerant M in the opposite directions. One of the two supply devices 83A and 83B is operated to be able to allow the refrigerant M to flow in two directions selectively. Thus, the supply devices 83A and 83B of two systems can change the direction in which the liquid refrigerant M flows. The supply devices 83A and 83B may be reversely rotatable pumps.

[0133] For example, the supply device 83A allows a predetermined amount of refrigerant M to flow in one direction and stops, and then the supply device 83B is operated. The supply device 83B allows the refrigerant M to flow in the opposite direction to that of the supply device 83A. In other words, the two supply devices 83A and 83B are alternately operated, reversing the upstream and downstream sides of the flow of the liquid refrigerant M.

This can prevent a temperature difference from occurring between the upstream battery unit U and the downstream battery unit U.

[0134] As illustrated in FIG. 10, the corner walls 33 of the casing 21 according to the second embodiment are provided with no air inlets 33a. In addition, the lid member 22 according to the second embodiment does not include the hood 41. This can downsize the battery device 13. The battery device 13 is airtightly closed, preventing entry of water or dust into the battery device 13.

[0135] In the vehicle 10 according to the second embodiment described above, the liquid cooling members 82 of the liquid cooler 81 are arranged in the gap G among the battery modules 23, are thermally connected to at least one of the battery modules 23, and are provided with the flow channels 97 through which the liquid refrigerant M flows. Thereby, the battery modules 23 are cooled by the liquid refrigerant M, preventing the battery modules 23 and the cells 61 from deteriorating in their performance due to a temperature change.

[0136] At least one of the battery modules 23 is attached to the respective liquid cooling members 82. Thereby, the battery module 23 and the liquid cooling members 82 can be handled as one battery unit U, and the arrangement of the battery module 23 and the liquid cooling members 82 can be facilitated.

[0137] Typically, the part between the first mounting part 92 and the second mounting part 93 attached to one battery module 23 may be separated from the one battery module 23. However, the connecting surfaces 91d between the first mounting part 92 and the second mounting part 93 according to the present embodiment protrude toward the battery modules 23. This prevents the connecting surfaces

91d from being separated from the battery modules 23, ensuring that the liquid cooling members 82 cool the battery modules 23.

[0138] The supply devices 83A and 83B can change the direction in which the liquid refrigerant M is supplied. Thereby, the upstream and downstream sides of the connected flow channels 97 of the liquid cooling members 82 can be changed, resulting in more uniformly cooling the liquid cooling members 82 and the battery modules 23. Thereby, the battery modules 23 and the cells 61 are prevented from deteriorating in their performance due to temperature change.

[0139] Both ends of the flow channel 97 are open to the end of the first mounting part 92 in the positive Z-axis direction. This facilitates connection of the pipes 84 to the flow channel 97. Both ends of the flow channel 97 may be provided at the projections 94, for example. In this case, the terminals 23f are prevented from being short-circuited by the liquid refrigerant M.

[0140] The battery unit U including one battery module 23 is placed at about the center of the battery units U aligned in the Y-axis direction. Thereby, weight of the battery device 13 is well balanced. The cells 61 of the battery module 23 located at the substantial center is difficult to cool. However, the battery module 23 located at the substantial center is thermally connected to the liquid cooling member 82 independently, and is therefore more efficiently cooled.

[0141] The following describes a third embodiment with reference to FIG. 15. FIG. 15 is a cross-sectional view of a battery device 13 according to the third embodiment. As illustrated in FIG. 15, the battery device 13 according to the third embodiment includes a plurality of battery units

U, as in the second embodiment. The battery units U are arranged with gap G.

[0142] The battery device 13 according to the third embodiment includes a fan 78 as with the first embodiment. When being driven, the fan 78 blows a gaseous refrigerant M from the two air inlets 33a to the air outlets 43a.

[0143] The refrigerant M is suctioned from the air inlets 33a and flows into the gap G between the battery units U (battery modules 23) or the gap G between the battery modules 23 and the first side walls 32 through the lower passage Pl. That is, the fan 78 blows the gaseous refrigerant M into the gap G between the battery modules 23.

[0144] While flowing through the gap G, the refrigerant M cools the first end 61a and the second end 61b of each cell 61 facing the gap G between the battery units U. The refrigerant M flows into the inclined passage Ps through the gap G and the upper passage Pu. The refrigerant M in the inclined passage Ps is exhausted from the air outlets 43a to the outside of the battery device 13.

[0145] The liquid refrigerant M flows into the flow channel 97 of the liquid cooling member 82. Flowing through the flow channel 97 of the liquid cooling member 82 in the gap G, the refrigerant M cools the first end 61a or the second end 61b of each cell 61 facing the gap G.

[0146] In the vehicle 10 according to the third embodiment described above, the fan 78 blows the gaseous refrigerant M into the gap G among the battery modules 23, and the liquid refrigerant M flows into the flow channels 97 of the liquid cooling members 82 in the gap G among the battery modules 23. Thereby, the battery modules 23 are cooled more efficiently. Thus, the battery modules 23 and the cells 61 are prevented from deteriorating in their performance due to temperature change.

[0147] The following describes a fourth embodiment with reference to FIG. 16. FIG. 16 is a perspective view schematically illustrating a plurality of battery devices 13 according to the fourth embodiment. As illustrated in FIG. 16, the vehicle 10 includes a plurality of battery devices 13.

[0148] The battery devices 13 include common battery modules 23. In other words, one of the battery devices 13 and another one of the battery devices 13 share the battery module 23.

[0149] The battery devices 13 include a plurality of battery devices 13 each including different numbers of battery modules 23. In other words, the number of the battery modules 23 in one of the battery devices 13 is different from the number of the battery modules 23 in another one of the battery devices 13. In this case, the dimensions of the casing 21 and the lid member 22 of the one of the battery devices 13 is different from the dimensions of the casing 21 and the lid member 22 of another one of the battery devices 13. The battery devices 13 including different numbers of the battery modules 23 may include a common casing 21 and a common lid member 22.

[0150] The battery devices 13 include at least one of the battery devices 13 according to the first embodiment, the second embodiment, and the third embodiment. That is, the battery devices 13 may include mutually different battery devices 13.

[0151] In the vehicle 10 according to the fourth embodiment described above, the battery devices 13 include the two battery devices 13 including different numbers of battery modules 23. That is, the number of the battery modules 23 connected in series is changeable due to a change in the dimensions of the casing 21. A battery

system having desired voltage can be easily configured by combining battery devices 13 including different numbers of battery modules 23.

[0152] The following describes a fifth embodiment with reference to FIG. 17. FIG. 17 is a plan view illustrating a plurality of battery devices 13 according to the fifth embodiment. The battery devices 13 according to the fifth embodiment include at least one of the battery devices 13 according to the first embodiment and the third embodiment. That is, the battery devices 13 may include mutually different battery devices 13.

[0153] The battery devices 13 include a common casing 21. In other words, one of the battery devices 13 and another one of the battery devices 13 share the casing 21.

[0154] The battery devices 13 include a plurality of battery devices 13 including different lid members 22. Specifically, the air outlets 43a of one of the battery devices 13 and the air outlets 43a of another one of the battery devices 13 are open in different directions. Thus, the inclined passage Ps of the one of the battery devices 13 and the inclined passage Ps of another one of the battery devices 13 extend in different directions.

[0155] For example, the air outlets 43a of one of the battery devices 13 are open in a direction away from the adjacent battery device 13. This can prevent another battery device 13 from blocking the flow of the gaseous refrigerant M exhausted from the air outlets 43a.

[0156] In the vehicle 10 according to the fifth embodiment described above, the battery devices 13 include two battery devices 13 including the respective air outlets 43a opening in different directions. That is, by changing the lid member 22, the direction in which the air outlets 43a open can be changed. Combining the battery devices 13

including the respective air outlets 43a opening in different directions further improves the degree of freedom in arrangement of the battery devices 13.

[0157] According to at least one of the embodiments described above, a support is provided with a plurality of second positioners to be fitted to first positioners of battery modules to hold the battery modules in a second direction. In addition, fixing parts, which fix the battery modules and a casing to each other, is provided on a second surface of the battery module close to a second wall or at a position closer to the second surface than to a first surface. This facilitates the assembly of the battery device that can be cooled by a refrigerant.

[0158] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

CLAIMS

1. A battery device comprising:
 - a casing including a first wall;
 - 5 a second wall that is detachably attached to the casing apart from the first wall in a first direction;
 - a plurality of battery modules arranged in a second direction inside a chamber of the casing, the second direction intersecting with the first direction, the
 - 10 chamber located between the first wall and the second wall, the battery modules each including a first surface facing the first wall, a second surface facing the second wall, and a first positioner provided on the first surface, the first positioner including one of a protrusion and a
 - 15 recess;
 - a support that extends in the second direction inside the chamber, supports the battery modules, and is provided with a plurality of second positioners that is fitted to the first positioners to hold the battery modules in the
 - 20 second direction, the second positioners each including the other of the protrusion and the recess;
 - a plurality of fixing parts that are provided on the second surface or in a location closer to the second surface than to the first surface, and fix the battery
 - 25 modules and the casing to each other; and
 - a cooling unit configured to allow a refrigerant to flow into an interval between the battery modules, wherein
 - the casing is provided with a first vent hole that is connected to a first passage between the battery modules
 - 30 and the first wall,
 - the second wall is provided with a second vent hole that is connected to a second passage between the battery modules and the second wall,

the cooling unit includes a fan configured to blow a gaseous refrigerant from the first vent hole to the second vent hole or from the second vent hole to the first vent hole,

5 the casing includes a third wall and a fourth wall, the third wall extending in the first direction, the fourth wall that connects an end of the first wall to an end of the third wall, and extends in a direction obliquely intersecting with the first direction and the second
10 direction,

the third wall and the battery modules are disposed with an interval, and

the fourth wall is provided with the first vent hole.

15 2. The battery device according to claim 1, wherein the battery modules each include a terminal on the second surface, and the terminals of two battery modules are electrically connected to each other.

20 3. The battery device according to claim 1 or 2, wherein the battery modules each include a plurality of cells and a holding element,

25 the cells each include a first end facing in a third direction, a second end opposite the first end, and a terminal placed at the first end,

the holding element holds the cells aligned in a direction intersecting with the third direction, and

30 at least one of the first end and the second end is directed to the interval between the battery modules.

4. The battery device according to any one of claims 1 to 3, wherein

the second wall is provided with a third passage that connects the second passage and the second vent hole, and

the third passage extends in a downwardly tilting direction toward the second vent hole.

5

5. The battery device according to any one of claims 1 to 4, further comprising

a cover that is attached to the second wall, partially covers the second vent hole, and extends in a downwardly
10 tilting direction toward outside the second vent hole.

6. The battery device according to any one of claims 1 to 5, wherein the cooling unit includes a plurality of liquid cooling members, each of the liquid cooling members being
15 placed in the interval between the battery modules, thermally connected to at least one of the battery modules, and provided with a flow channel through which a liquid refrigerant flows.

20 7. The battery device according to claim 6, wherein at least one of the battery modules is attached to each of the liquid cooling members.

8. The battery device according to claim 7, wherein
25 the liquid cooling members each include a first mounting part, a second mounting part, and a connecting surface, the first mounting part that is attached to one of the battery modules, the second mounting part that is attached to the one of the battery modules apart from the
30 first mounting part, the connecting surface that is located between the first mounting part and the second mounting part and is thermally connected to the one of the battery modules, and

the connecting surface protrudes toward the one of the battery modules.

9. The battery device according to any one of claims 6 to
5 8, wherein

the cooling unit includes

a supply device that supplies the liquid refrigerant to the flow channel; and

a tubular channel that connects the flow channels
10 of the liquid cooling members to the supply device,
and

the supply device is able to change a direction in which the liquid refrigerant is supplied.

15 10. A battery system comprising:

the battery devices according to any one of claims 1 to 9, wherein

one of the battery devices and another one of the battery devices include the same battery module, and

20 the number of the battery modules in the one of the battery devices is different from the number of the battery modules in the another one of the battery devices.

11. A battery system comprising:

25 the battery devices according to any one of claims 1 to 9, wherein

one of the battery devices and another one of the battery devices include the same battery module and the same casing, and

30 the second vent hole of the one of the battery devices and the second vent hole of the another one of the battery devices are open in different directions.