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Power supply device, and electric vehicle and electrical storage device each equipped with same

Abstract

Provided is a power supply device that is configured to dispose each of battery cells at an ideal position while stacking the battery cells to form a battery stack, the power supply device including: battery cells each having an outer covering can in a prismatic shape and having a constant cell thickness; end plates paired for covering both side end surfaces of the battery stack in which battery cells are stacked; and bind bars that are disposed on opposite side surfaces of the battery stack and coupled to the end plates. Bind bar includes pressing piece for pressing an upper surface of each of battery cells adjacent to each other. The power supply device further includes elastomer molding disposed between pressing piece and an upper surface of battery cell, and pressing piece elastically presses the upper surface of battery cell with elastomer molding.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS
(1) This application is a U.S. national stage application of the PCT International Application No. PCT/JP2020/028030 filed on Jul. 20, 2020, which claims the benefit of foreign priority of Japanese patent application No. 2019-152167 filed on Aug. 22, 2019, the contents all of which are incorporated herein by reference.
TECHNICAL FIELD
(2) The present invention relates to a power supply device, and an electric vehicle and an electrical storage device that are equipped with the power supply device.
BACKGROUND ART
(3) The power supply device is used as a power supply device for driving an electric vehicle, a power supply device for storing power, and the like. In such a power supply device, rechargeable battery cells are stacked. As illustrated in a perspective view of FIG. **22**, power supply device **900** typically includes battery stack **910** that is obtained by alternately stacking battery cells **901** each with an outer covering can in a rectangular shape and insulating spacers **902**, and that has both end surfaces on which respective end plates **903** are disposed, end plates **903** being joined to each other with bind bars **904** made of metal.
(4) It is important for a power supply device with stacked battery cells to dispose each of the battery cells at a predetermined position. The power supply device of FIG. **22** includes the bind bars that are each provided on both upper and lower sides with respective bent pieces to prevent positional displacement of each battery cell in the vertical direction in the drawing. This power supply device is configured such that a battery cell in a rectangular shape is disposed at a predetermined position by holding both sides of the battery cell with the respective bent pieces provided up and down in the bind bar. Although this structure can prevent vertical positional displacement of the battery stack with the bind bar, there is a disadvantage that each battery cell is less likely to be always disposed at an optimum position. In particular, a battery cell in a rectangular shape cannot eliminate a dimensional error generated in a manufacturing process, and thus causing a change in dimension of each battery cell.
(5) When the battery cell repeats charging and discharging, the outer covering can expands and contracts. In recent years, particularly capacity of the battery cell has been increased, and as a result, the amount of expansion tends to increase. The battery stack with a large number of battery cells as described above that are stacked and joined has a problem that each battery cell is less likely to be disposed at an ideal position for a long period of time due to difference in the amount of expansion of each battery cell.
CITATION LIST
Patent Literature
(6) PTL 1: Unexamined Japanese Patent Publication No. H09-120808

SUMMARY OF THE INVENTION

(7) It is an object of the present invention to provide a power supply device capable of disposing each of battery cells at an ideal position in a battery stack formed by stacking the battery cells, and an electric vehicle and an electrical storage device using the power supply device.

(8) A power supply device according to an aspect of the present invention includes: battery cells **1** each having outer covering can **1***a* in a prismatic shape and having a constant cell thickness; end plates **20** paired for covering both respective side end surfaces of battery stack **10** in which battery cells **1** are stacked; and bind bars **15** that are disposed on respective opposite side surfaces of battery stack **10** and coupled to respective end plates **20**. Bind bar **15** includes pressing piece **15***l* for pressing an upper surface of each of battery cells **1** adjacent to each other. The power supply device further includes elastomer molding **18** disposed between pressing piece **15***l* and an upper surface of battery cell **1**, and pressing piece **15***l* elastically presses the upper surface of battery cell **1** with elastomer molding **18**.

(9) An electric vehicle according to an aspect of the present invention includes: power supply device **100**; running motor **93** that receives electric power from power supply device **100**; vehicle body **91** on which power supply device **100** and running motor **93** are mounted; and wheels **97** that are driven by running motor **93** to cause vehicle body **91** to travel.

(10) An electrical storage device according to an aspect of the present invention includes: power supply device **100**; and power supply controller **88** configured to control charging and discharging of power supply device **100**, wherein power supply controller **88** enables charging of battery cells **1** with electric power supplied from an outside and is configured to control charging to battery cells **1**.

(11) The power supply device described above has a feature in that each of the battery cells can be disposed at an ideal position in the battery stack formed by stacking the battery cells.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a perspective view illustrating a power supply device according to a first exemplary embodiment.

(2) FIG. **2** is an exploded perspective view of the power supply device illustrated in FIG. **1**.

(3) FIG. **3** is an enlarged perspective view of a main part of the power supply device of FIG. **1**.

(4) FIG. **4** is a plan view of the power supply device of FIG. **1**.

(5) FIG. **5** is a plan view and an enlarged plan view of a main part of the power supply device of FIG. **4** in which an insulating sheet is not illustrated.

(6) FIG. **6** is a horizontal sectional view taken along line VI-VI of the power supply device of FIG. **1**.

(7) FIG. **7** is a vertical sectional view taken along line VII-VII of the power supply device of FIG. **1**.

(8) FIG. **8** is a side view of the power supply device of FIG. **1**.

(9) FIG. **9** is a perspective view illustrating a bind bar of FIG. **2**.

(10) FIG. **10** is a perspective view of the bind bar in FIG. **9** as viewed from its back surface.

(11) FIG. **11** is an exploded perspective view of the bind bar of FIG. **10**.

(12) FIG. **12** is an enlarged plan view of a main part of a power supply device according to a second exemplary embodiment in which an insulating sheet is not illustrated.

(13) FIG. **13** is an enlarged sectional view of a main part of the power supply device of FIG. **7**.

(14) FIG. **14** is a perspective view illustrating the power supply device according to the second exemplary embodiment.

(15) FIG. **15** is an exploded perspective view of the power supply device of FIG. **14**.

(16) FIG. **16** is an enlarged sectional view taken along line XVI-XVI of the power supply device of FIG. **14**.
(17) FIG. **17** is an enlarged sectional view taken along line XVII-XVII of the power supply device of FIG. **14**.
(18) FIG. **18** is an enlarged perspective view illustrating an example of an elastomer unit.
(19) FIG. **19** is a block diagram illustrating an example of a power supply device mounted in a hybrid automobile that travels by an engine and a motor.
(20) FIG. **20** is a block diagram illustrating an example of a power supply device mounted in an electric vehicle that travels only using a motor.
(21) FIG. **21** is a block diagram illustrating an example of application to a power supply device for power storage.
(22) FIG. **22** is an exploded perspective view illustrating a conventional power supply device.

DESCRIPTION OF EMBODIMENTS

(23) Exemplary embodiments of the present invention will be described below with reference to the drawings. However, the exemplary embodiments described below are examples that allow a technical idea of the present invention to be embodied, and the present invention is not limited to the exemplary embodiments described below. In the present description, components described in the scope of claims are not limited to the components of the exemplary embodiments. Unless otherwise specified, particulars including dimensions, materials, shapes, and relative positions of the components described in the exemplary embodiments are described as being mere examples and not as being restrictive of the present invention. The sizes and positional relationships of the members illustrated in the respective drawings may be exaggerated to clarify the explanation. In the following description, the same names or the same reference marks denote the same components or components of the same type, and detailed description is appropriately eliminated. Each element constituting the present invention may be configured such that a plurality of elements is composed of one member to allow the one member to serve as the plurality of elements, or conversely, a function of one member may be achieved by sharing with the plurality of members. Contents described in some examples or exemplary embodiments can be used, for example, in other examples or exemplary embodiments.
(24) A power supply device according to a first exemplary embodiment of the present invention includes: battery cells each having an outer covering can in a prismatic shape and having a constant cell thickness; end plates paired for covering both side end surfaces of a battery stack in which the battery cells are stacked; bind bars that are disposed on respective opposite side surfaces of the battery stack and coupled to the respective end plates, the bind bars each including a pressing piece for pressing an upper surface of each of the battery cells adjacent to each other; and an elastomer molding disposed between the pressing piece and an upper surface of each of the battery cells, the pressing piece elastically pressing the upper surface of each of the battery cells with the elastomer molding.
(25) The power supply device described above is configured such that the bind bars each include the pressing piece that presses the battery cell, and the pressing piece presses the upper surface of the battery cell with the elastomer molding, which is elastically deformable and interposed therebetween, to dispose the battery cell at a predetermined position, without directly pressing the upper surface of the battery cell. This structure has a feature in that the pressing piece for pressing the upper surface of each of the battery cells constituting the battery stack presses the upper surface of the battery cell with the elastomer molding interposed therebetween, and thus enabling the battery cells, which are repeatedly expanded and contracted due to charging and discharging and each have a dimensional error generated in the manufacturing process, to be pressed and disposed at respective predetermined positions. In particular, the pressing piece for pressing the upper surface of the battery cell with the elastomer molding interposed therebetween has a feature in that the pressing piece can evenly press the upper surface of the battery cell in a wide area to dispose

the battery cell at a predetermined position. Although pressing with a strong force can prevent positional displacement of the battery cell, an excessively strong pressing force, particularly a forcibly strong pressing force, causes deformation or damage of the battery cell. The elastomer molding can come into surface contact with a surface of the battery cell to evenly press the battery cell in a wide area, so that the battery cell can be disposed at a predetermined position. This enables preventing damage to the battery cell due to a strong pressing force while disposing the battery cell at the predetermined position.

(26) Additionally, the elastomer molding consumes large energy to deform itself, and thus has an extremely high ability to absorb vibration. The power supply device described above, in which the elastomer molding having the unique physical properties always holds the upper surface of the battery cell in a pressed state, has a feature in that the battery cell can be protected from vibration and impact in an environment under vibration and impact. The vibration and impact applied to the power supply device damage various parts of the battery cell, such as a fixing part of an electrode terminal of the battery cell, and a coupling part with a thick metal sheet fixed to the electrode terminal for connecting the battery cell in series or in parallel. The battery cell can be disposed at a predetermined position by pressing an upper surface of the battery cell with an elastic arm such as a metal sheet or a plastic sheet. However, such an elastic arm consumes only a small amount of energy to deform itself, i.e., the elastic arm has a large Q value, and thus has insufficient attenuation characteristics of vibration. As a result, vibration and impact of the battery cell cannot be effectively suppressed. The power supply device described above includes the elastomer molding having excellent attenuation characteristics of vibration and pressing the upper surface of the battery cell, so that the battery cell can be disposed at a predetermined position while vibration and impact of the battery cell are absorbed. Thus, the power supply device described above has a feature in that even when the power supply device is used for supplying power to a running motor of a vehicle, the battery cell can be used for a long period of time by being protected from vibration and impact.

(27) A power supply device according to a second exemplary embodiment of the present invention includes elastomer moldings that independently press respective battery cells.

(28) The power supply device described above has a feature in that the elastomer moldings independently press the respective battery cells to enable all the battery cells to be disposed at accurate positions even in a state where the battery cells have upper surfaces at ununiform positions due to a dimensional error, or an unbalanced amount of expansion caused by charging and discharging.

(29) A power supply device according to a third exemplary embodiment of the present invention includes the bind bars each provided with pressing pieces that independently press respective battery cells.

(30) The power supply device described above has a feature in that the pressing pieces independently press the respective battery cells to enable all the battery cells to be disposed at accurate positions even in a state where the battery cells have upper surfaces at ununiform positions due to a dimensional error, or an unbalanced amount of expansion caused by charging and discharging.

(31) A power supply device according to a fourth exemplary embodiment of the present invention includes the elastomer molding that has a rubbery pressing part in a columnar shape or a plate shape protruding toward the upper surface of the battery cell.

(32) The power supply device described above has a feature in that the pressing piece presses the upper surface of the battery cell with the rubbery pressing part in a columnar shape or a plate shape interposed therebetween by using a restoring force caused by deforming the rubbery pressing part into a short crushed shape, and deforming the columnar shape or the plate shape into a bent shape, so that a pressing force changes a little even when the amount of displacement of the battery cell increases, whereby the battery cell can be disposed at a predetermined position by constantly

pressing the upper surface of the battery cell with a predetermined pressing force. This prevents the battery cell from being pressed and damaged by the elastomer molding with an excessively strong force even in a state where the battery cell expands and increases in the amount of displacement. Thus, there is a feature in that the battery cell can be disposed at a predetermined position while being prevented from being damaged.
(33) A power supply device according to a fifth exemplary embodiment of the present invention includes the elastomer molding that has rubbery pressing parts different in protrusion height.
(34) This power supply device has a feature in that the rubbery pressing parts different in protrusion height press the upper surfaces of the respective battery cells, so that the battery cells each having a large dimensional error can be reliably disposed at respective predetermined positions. This is because the rubbery pressing part with a high height presses the upper surface of the battery cell with a wide gap between the pressing piece and the upper surface of the battery cell, and many rubbery pressing parts press the upper surface of the battery cell with a narrow gap between the pressing piece and the upper surface of the battery cell, thereby disposing the battery cells at respective predetermined positions. In particular, the rubbery pressing part protruding high has a columnar shape and deforms itself in a bent manner to press the upper surface of the battery cell, so that the rubbery pressing part with a high height deforms in a bent manner even for the battery cell with a narrow gap between the pressing piece and the upper surface of the battery cell to dispose the battery cell at a predetermined position without pressing and damaging the battery cell under too strong pressure.
(35) A power supply device according to a sixth exemplary embodiment of the present invention includes rubbery pressing parts that are disposed apart from each other in a longitudinal direction of the upper surface of the battery cell.
(36) A power supply device according to a seventh exemplary embodiment of the present invention includes rubbery pressing parts in which at least one rubbery pressing part has a length at which the at least one rubbery pressing part buckles in a pressed state on the upper surface of the battery cell.
(37) The power supply device described above includes the rubbery pressing part that presses the upper surface of the battery cell by deforming resulting in buckling, so that the battery cell is not pressed under too strong pressure even when the rubbery pressing part protruding high presses the upper surface of the battery cell. This enables the battery cell to be disposed at a predetermined position while preventing damage to the battery cell.
(38) A power supply device according to an eighth exemplary embodiment of the present invention includes the elastomer molding that is made of an elastomer or rubber.
(39) A power supply device according to a ninth exemplary embodiment of the present invention includes an insulating sheet disposed between the bind bar and the battery stack, and the insulating sheet is disposed between the pressing piece and the elastomer molding.
(40) A power supply device according to a tenth exemplary embodiment of the present invention includes the bind bar that is a metal sheet, and the metal sheet is bent providing the pressing piece integrally with the bind bar.
(41) The power supply device according to the exemplary embodiments of the present invention is used for various applications such as a power supply that is mounted on an electric vehicle such as a hybrid vehicle or an electric automotive and supplies power to a running motor, a power supply that stores generated power of natural energy such as solar power generation or wind power generation, and a power supply that stores midnight power, and is particularly used as a power supply suitable for an application for large power and large current. In the following example, exemplary embodiments applied to a power supply device for driving an electric vehicle will be described.
First Exemplary Embodiment
(42) FIGS. **1** to **11** each illustrate power supply device **100** according to a first exemplary embodiment of the present invention. In these drawings, FIG. **1** is a perspective view illustrating

power supply device **100** according to the first embodiment, FIG. **2** is an exploded perspective view of power supply device **100** in FIG. **1**, FIG. **3** is an enlarged perspective view of a main part of power supply device **100** in FIG. **1**, FIG. **4** is a plan view of power supply device **100** in FIG. **1**, FIG. **5** is a plan view and an enlarged plan view of a main part of power supply device **100** in FIG. **4** in which insulating sheet **30** is not illustrated, FIG. **6** is a horizontal sectional view taken along line VI-VI of power supply device **100** in FIG. **1**, FIG. **7** is a vertical sectional view taken along line VII-VII of power supply device **100** in FIG. **1**, FIG. **8** is a side view of power supply device **100** in FIG. **1**, FIG. **9** is a perspective view illustrating bind bar **15** in FIG. **2**, FIG. **10** is a perspective view illustrating bind bar **15** in FIG. **9** viewed from the rear, and FIG. **11** is an exploded perspective view of bind bar **15** in FIG. **10**. Power supply device **100** illustrated in these drawings includes battery stack **10** in which battery cells **1** are stacked, end plates **20** paired covering both side end surfaces of battery stack **10**, bind bars **15** for joining end plates **20** to each other, and insulating sheet **30** that is insulative and interposed between each of bind bars **15** and battery stack **10**.
(43) (Battery Stack **10**)
(44) As illustrated in FIGS. **1** and **2**, battery stack **10** includes battery cells **1** each including positive and negative electrode terminals **2**, and bus bars (not illustrated) connected to respective electrode terminals **2** of each of battery cells **1** to connect battery cells **1** in parallel and in series. Battery cells **1** are connected in parallel or in series through these bus bars. Battery cells **1** are each a chargeable and dischargeable secondary battery. Power supply device **100** includes battery cells **1** that are connected in parallel to form a parallel battery group, and parallel battery groups are connected in series to allow many battery cells **1** to be connected in parallel and in series. FIGS. **1** to **3** each illustrates power supply device **100** that includes battery stack **10** formed by stacking battery cells **1**. Battery stack **10** has opposite end surfaces on which respective end plates **20** paired are disposed. End plates **20** are each fixed to end portions of respective bind bars **15** to fix battery cells **1** stacked in a pressed state. Bind bars **15** each include pressing piece **15***l* for disposing battery cell **1** at a predetermined position, and this pressing piece **15***l* presses an upper surface of battery cell **1** with elastomer molding **18** interposed therebetween to dispose battery cell **1** at the predetermined position.
(45) (Battery Cell **1**)
(46) Battery cell **1** is a prismatic battery that has a main surface in a prismatic outer shape, which is a wide surface, and that has a constant cell thickness while being smaller in thickness than in width. Battery cell **1** is a secondary battery that can be charged and discharged, and is a lithium ion secondary battery. However, the battery cell is not particularly limited to a prismatic battery in the present invention, and is also not particularly limited to a lithium ion secondary battery. As the battery cell, all rechargeable batteries such as a non-aqueous electrolyte secondary battery other than the lithium ion secondary battery, and a nickel hydride battery cell can also be used.
(47) As illustrated in FIGS. **2** to **7**, battery cell **1** includes outer covering can **1***a* that accommodates an electrode assembly formed by stacking positive and negative electrode plates, and that is filled with an electrolyte solution and hermetically sealed. Exterior can **1***a* is formed into a rectangular tubular shape with a closed bottom, and has an upper opening that is airtightly closed by sealing plate **1***b* of a metal sheet. Exterior can **1***a* is formed by deep drawing using a metal sheet made of aluminum, an aluminum alloy, or the like. Sealing plate **1***b* is formed using a metal sheet made of aluminum, an aluminum alloy, or the like, as with outer covering can **1***a*. Sealing plate **1***b* is inserted into the upper opening of outer covering can **1***a*, and then a boundary between an outer periphery of sealing plate **1***b* and an inner periphery of outer covering can **1***a* is irradiated with laser light to fix sealing plate **1***b* to outer covering can **1***a* in an airtight manner by laser welding.
(48) (Electrode Terminal **2**)
(49) As illustrated in FIGS. **3** to **5**, for example, battery cell **1** includes sealing plate **1***b* serving as a top surface that is used as terminal surface **1**X, and terminal surface **1**X has opposite end portions

to which respective positive and negative electrode terminals **2** are fixed. Electrode terminals **2** each has a protrusion in a cylindrical columnar shape. However, the protrusion is not necessarily in a columnar shape, and may be in a polygonal columnar shape or an elliptic columnar shape.

(50) Positive and negative electrode terminals **2** are fixed to sealing plate **1***b* of battery cell **1** at respective positions to allow a positive electrode and a negative electrode to be bilateral symmetry. As illustrated in FIGS. **3** to **5**, for example, this placement enables adjacent battery cells **1** to be connected in series by alternately and laterally inverting battery cells **1** and stacking them, and connecting electrode terminals **2** of the positive electrode and the negative electrode that are adjacent and close to each other with a bus bar. The present invention does not specify the number of battery cells constituting the battery stack and a connection state of the battery cells. The number of battery cells constituting the battery stack and the connection state of the battery cells may be modified in various manners, inclusive of other exemplary embodiments to be described later.

(51) (Battery Stack **10**)

(52) Battery cells **1** are stacked in a stacking direction to form battery stack **10**, the stacking direction being a thickness direction of each battery cell **1**. Battery stack **10** is formed by stacking battery cells **1** such that terminal surfaces **1**X each provided with positive and negative electrode terminals **2** are flush with each other, terminal surfaces **1**X being each sealing plate **1***b* in FIGS. **1** to **6**.

(53) Battery stack **10** may include insulating spacer **16** interposed between battery cells **1** stacked adjacent to each other. Insulating spacer **16** is formed in the shape of a thin plate or a sheet by using an insulating material such as resin. Insulating spacer **16** is in the shape of a plate that is substantially equal in size to an opposing surface of battery cell **1**. Stacking this insulating spacer **16** between battery cells **1** adjacent to each other enables adjacent battery cells **1** to be insulated. Available examples of the spacer disposed between adjacent battery cells include a spacer having a shape allowing a flow path of a cooling gas to be formed between the battery cell and the spacer. The surface of the battery cell can also be covered with an insulating material. For example, a shrink tube such as a polyethylene terephthalate (PET) resin may be applied by thermal welding to the surface of the outer covering can except for electrode portions of the battery cell. In this case, the insulating spacer may be eliminated. Although a power supply device including battery cells connected in parallel and series includes an insulating spacer interposed between the battery cells connected in series, the insulating spacer between the battery cells connected in parallel can be eliminated because no voltage difference occurs between adjacent outer covering cans.

(54) Power supply device **100** illustrated in FIG. **2** includes end plates **20** disposed on respective opposite end surfaces of battery stack **10**. Between each of end plates **20** and battery stack **10**, end face spacer **17** may be interposed to insulate them. End face spacer **17** can also be formed in the shape of a thin plate or a sheet by using an insulating material such as resin.

(55) Power supply device **100** according to the first exemplary embodiment includes battery stack **10** in which battery cells **1** are stacked on each other, and electrode terminals **2** of respective battery cells **1** adjacent to each other are connected by bus bars **3** to connect battery cells **1** in parallel and in series. Between battery stack **10** and each of the bus bars, a bus bar holder may be disposed. Using the bus bar holder enables the bus bars to be disposed at respective predetermined positions on an upper surface of the battery stack while insulating the bus bars from each other and insulating terminal surfaces of the respective battery cells from the bus bars.

(56) The bus bar is manufactured in a predetermined shape by cutting and processing a metal sheet. The metal sheet constituting the bus bar is made of a metal having low electrical resistance and light weight, and can be formed by using, for example, an aluminum plate, a copper plate, or an alloy thereof. As the metal sheet for the bus bar, a sheet of another metal light in weight and low in electrical resistance or a sheet of an alloy of the metal also can be used.

(57) (End Plate **20**)

(58) As illustrated in FIGS. **1** to **3**, end plates **20** are disposed at respective opposite ends of battery

stack **10** and are joined to each other using bind bars **15** that are paired right and left and are disposed along both side surfaces of battery stack **10**. End plates **20** are disposed outside end face spacers **17** on the respective opposite ends of battery stack **10** in the stacking direction of battery cells **1** to sandwich battery stack **10** from the respective opposite ends.

(59) (Step **20***b*)

(60) End plates **20** are each provided with step **20***b* to lock locking block **15***b* provided on each of bind bars **15** while being joined by bind bars **15**. Step **20***b* is formed in a size and a shape that enable locking block **15***b* of bind bar **15**, which is described later, to be locked. In the example of FIG. **2**, step **20***b* in the shape of a flange is formed allowing end plate **20** to be in a T-shape in a horizontal sectional view. Near step **20***b*, end plate screw hole **20***c* is opened.

(61) (Bind Bar **15**)

(62) Bind bars **15** each have opposite ends fixed to end plates **20** disposed on respective opposite end surfaces of battery stack **10**. End plates **20** are fixed by bind bars **15** to fasten battery stack **10** in the stacking direction. As illustrated in FIGS. **9** to **11**, for example, bind bars **15** are each made of metal having a predetermined width and a predetermined thickness along the side surface of battery stack **10**, and are disposed to face the corresponding side surfaces of battery stack **10**.

(63) Bind bar **15** includes joints **15***c* at respective opposite ends in the longitudinal direction to be fixed to respective end plates **20**, intermediate part **15***a* connecting between joints **15***c*, and pressing pieces **15***l* provided on both upper and lower edges of intermediate part **15***a*. Bind bar **15** in FIGS. **9** to **11** is provided on its both upper and lower side edges with pressing pieces **15***l*, and both sides of battery cell **1** are each vertically sandwiched between pressing pieces **15***l* to dispose battery cell **1** at a predetermined position. However, power supply device **100** of the present invention may be provided with pressing pieces **15***l* only on the upper edge of bind bar **15**, and a lower plate (not illustrated) of a thick metal sheet may be disposed below battery cells **1**. Then, battery cells **1** may be placed on the lower plate to sandwich battery cells **1** with the lower plate and pressing pieces **15***l* from below and above, so that battery cells **1** can be disposed at respective predetermined positions. The lower plate is fixed to bind bars **15** and end plates **20**, and is disposed at a predetermined position.

(64) Bind bar **15** preferably has a structure in which joint **15***c*, intermediate part **15***a*, and pressing pieces **15***l* are integrally connected to form an integrated structure with a metal sheet. In the example of FIG. **9** and the like, the metal sheet is bent to form corrugated part **15***j* in intermediate part **15***a*, and upper and lower end edges of intermediate part **15***a* are bent to form pressing pieces **15***l*. As illustrated in FIGS. **3** and **5**, for example, corrugated part **15***j* includes corrugated pieces **15***i* and flat pieces **15***k*. Corrugated pieces **15***i* are connected to each other with flat piece **15***k* interposed therebetween.

(65) Then, joint **15***c* of bind bar **15** has a part provided with locking block **15***b* as illustrated in FIG. **11**, and is increased in thickness in this part. This locking block **15***b* is locked to step **20***b* of end plate **20**, and bind bar **15** is fixed to end plate **20** by screwing or the like. The structure in which locking block **15***b* of bind bar **15** is locked to step **20***b* of end plate **20** enables bind bar **15** subjected to strong tensile stress to be firmly connected to end plate **20**. Although not illustrated, bind bar **15** can be fixed in a structure in which its opposite edges in the longitudinal direction are bent inward, and the bent edges are each screwed to an outer surface of end plate **20**.

(66) (Insulating Sheet **30**)

(67) Insulating sheet **30** is interposed between bind bar **15** and battery stack **10**. Insulating sheet **30** is made of a material having insulating properties, such as resin, and insulates bind bar **15** made of metal from battery cell **1**. Insulating sheet **30** illustrated in FIG. **2** and the like includes flat plate **31** for covering the side surface of battery stack **10**, and pressing piece supports **32** provided up and down flat plate **31**. Pressing piece support **32** is interposed between each pressing piece **15***l* of bind bar **15** and the upper surface of battery cell **1** to insulate pressing piece **15***l* from battery cell **1**. Pressing piece support **32** is provided for each of pressing pieces **15***l* formed on bind bar **15**. Thus,

pressing piece supports **32** are formed at a pitch identical to a pitch at which pressing pieces **15***l* of bind bar **15** are formed. Insulating sheet **30** may be configured to serve also as the bus bar holder described above that holds the bus bar.
(68) The insulating sheet can be unnecessary when the battery stack or the surface of the battery stack is insulated, when the battery cell is, for example, housed in an insulating case or covered with a heat-shrinkable tube made of resin, when the bind bar has a surface coated with an insulating paint or coating, or when the bind bar is made of an insulating material, for example.
(69) (Corrugated Part **15***j*)
(70) Intermediate part **15***a* has corrugated part **15***j* formed in a corrugated shape. Corrugated part **15***j* includes corrugated pieces **15***i* that are formed periodically at a pitch corresponding to the cell thickness of battery cell **1**. Even when battery stack **10** expands, forming intermediate part **15***a* in a spring shape to provide springiness to each corrugated piece **15***i* enables corrugated part **15***j* to be deformed to follow the expansion and allow intermediate part **15***a* to be displaced, and thus enabling avoidance of a situation in which stress concentrates on bind bar **15** to break bind bar **15**. When battery stack **10** returns from the expanded state, corrugated part **15***j* deforms in response to the return, and returns to an original shape. This maintains a joint state of battery stack **10** with bind bars **15**. As described above, bind bar **15** including corrugated part **15***j* can be deformed in accordance with change of battery stack **10** in the stacking direction, and can maintain the joint state.
(71) At least one corrugated piece **15***i* is formed for each of battery cells **1**. As illustrated in the enlarged plan view of FIG. **5** and the like, corrugated piece **15***i* is preferably formed for each battery cell **1** of battery stack **10**. This enables deformation of the outer covering can of each battery cell **1** to be individually addressed. However, the corrugated piece is not necessarily formed for each battery cell, and corrugated piece **15***i* may be formed for every other battery cell, i.e., every two battery cells, for example, as in a plan view of power supply device **200** according to a second exemplary embodiment, in which an insulating sheet is not illustrated, illustrated in FIG. **12**. Corrugated pieces **15***i* are formed at a pitch that is appropriately designed according to the specification of the battery cell, battery capacity, expected use environment (temperature, humidity, and the like) of the power supply device, the expected amount of deformation of the outer covering can, and the like. As illustrated in FIG. **5**, corrugated piece **15***i* is bent in a chevron shape outside battery stack **10** in a direction in which battery stack **10** expands. Protruding corrugated piece **15***i* outward as described above enables avoidance of a situation in which corrugated piece **15***i* interferes with battery stack **10**.
(72) Each corrugated piece **15***i* may be formed in the shape of chevrons other than the shape of one chevron. Besides a curved state, a zigzag shape, a bellows shape, an accordion shape, and the like are available. Corrugated pieces **15***i* may not be identical in shape, and may be changed in shape according to position.
(73) Although bind bar **15** in FIGS. **8** to **11** includes intermediate part **15***a* that is corrugated part **15***j*, bind bar **15** may include intermediate part **15***a* in a planar shape. Bind bar **15** including intermediate part **15***a* that is corrugated part **15***j* can smoothly absorb expansion of battery cells **1**. Bind bar **15** including intermediate part **15***a* in a planar shape can prevent positional displacement of battery cells in the stacking direction by suppressing the expansion of battery cells **1**.
(74) (Pressing Piece **15***l*)
(75) Bind bars **15** disposed on both sides of battery stack **10** are provided with pressing pieces **15***l* that press upper surfaces of respective battery cells **1** constituting battery stack **10**. Bind bar **15** in FIGS. **9** to **11** is provided with pressing pieces **15***l* that independently and separately press respective battery cells **1**. Pressing pieces **15***l* for pressing respective battery cells **1** independently have a feature in that all battery cells **1** can be pressed in an ideal state and disposed at respective predetermined positions. Pressing pieces **15***l* can press the upper surfaces of respective battery cells **1** independently when pressing pieces **15***l* each have a narrower lateral width than the upper surface

of each battery cell **1**. Alternatively, the pressing piece may be formed in a shape that allows pressing upper surfaces of battery cells. A pressing piece by itself for pressing upper surfaces of battery cells has a wide width to press the upper surfaces of the battery cells. Additionally, a pressing piece by itself can press upper surfaces of all battery cells constituting a battery stack to dispose all the battery cells at respective predetermined positions. In particular, power supply device **100** illustrated in FIG. **13** includes pressing piece **15***l* that presses the upper surface of each battery cell **1** with elastomer molding **18** interposed therebetween to dispose battery cell **1** at a predetermined position, so that one pressing piece **15***l* itself can press the upper surfaces of all battery cells **1** to dispose all battery cells **1** at respective predetermined positions. In contrast, power supply device **100** including pressing pieces **15***l* that independently press respective battery cells **1** enables battery cells **1** to be disposed at respective predetermined positions in an ideal state.
(76) Pressing piece **15***l* is provided integrally with bind bar **15** by bending a metal sheet. As illustrated in the vertical sectional view of FIG. **7** and the enlarged sectional view of the main part of FIG. **13**, pressing piece **15***l* presses the upper surface of battery cell **1** with elastomer molding **18** and insulating sheet **30** that are interposed between pressing piece **15***l* and the upper surface. This structure causes each battery cell **1** to be pressed by elastomer molding **18** and pressing piece **15***l*, and thus suppressing positional displacement in a height. In particular, battery cell **1** is held in a pressed state using elastomer molding **18**, so that each battery cell **1** can be held by being prevented from being displaced vertically even under vibration, impact, or the like.
(77) As illustrated in FIGS. **9** to **11**, bind bar **15** including intermediate part **15***a*, which is corrugated part **15***j*, is preferably configured such that pressing piece **15***l* is provided at a position different from a position of corrugated piece **15***i*. FIGS. **3**, **5**, and the like each illustrate an example in which pressing piece **15***l* is formed on flat piece **15***k* located between corrugated pieces **15***i*. This enables avoiding a situation in which pressing piece **15***l* bent from intermediate part **15***a* obstructs deformation of corrugated piece **15***i* and effectively exerting the springiness of corrugated piece **15***i*.
(78) Bind bar **15** can be made of a metal sheet made of iron or the like, preferably a steel sheet, or can be made of iron, an iron alloy, SUS, aluminum, an aluminum alloy, or the like. Bind bar **15** may be made of a single member with joint **15***c* and intermediate part **15***a* that are different in thicknesses from each other. Alternatively, joint **15***c* may be made of a first metal, and intermediate part **15***a* may be made of a second metal different from the first metal. In this case, the first metal has higher rigidity than the second metal, and the second metal has higher stretchability than the first metal. Selection of dissimilar metal enables providing rigidity to joint **15***c* and stretchability to intermediate part **15***a*.
(79) (Locking Block **15***b*)
(80) As illustrated in FIGS. **9** to **11**, bind bar **15** includes intermediate part **15***a*, joints **15***c*, and locking blocks **15***b* each in the shape of a block. Intermediate part **15***a* is a plate-shaped member, and has opposite ends in its longitudinal direction to which respective joints **15***c* are joined. Locking block **15***b* is fixed to an inner surface of joint **15***c* near its end edge. Locking block **15***b* is in a plate shape having a predetermined thickness, and is fixed in an attitude protruding inward of joint **15***c*. Bind bar **15** connected to end plates **20** is locked to steps **20***b* provided on respective end plates **20** to dispose bind bar **15** at a predetermined position on each side of battery stack **10**. Locking block **15***b* is fixed to joint **15***c* by welding such as spot welding or laser welding.
(81) Locking block **15***b* illustrated in the drawing has joint-side through-hole **15***bc* that is opened to align with end plate screw hole **20***c* when end plate **20** is joined to locking block **15***b*. Joint **15***c* has joint main surface-side through-hole **15***ac* opened at a position corresponding to joint-side through-hole **15***bc*. Joint-side through-hole **15***bc* and joint main surface-side through-hole **15***ac* are designed to align with each other when locking block **15***b* is fixed to joint **15***c*.
(82) Multiple joint-side through-holes **15***bc* opened in locking block **15***b* are opened in an extending direction of locking block **15***b*. Similarly, joint main surface-side through-holes **15***ac* are

opened along the end edge of joint **15***c* or in the extending direction of locking block **15***b*. Multiple end plate screw holes **20***c* are also formed along a side surface of end plate **20** accordingly.
(83) Locking block **15***b* is fixed to an outer peripheral surface of end plate **20** with bolts **15***f*. The fixing of bind bar **15**, locking block **15***b*, and end plate **20** is not necessarily limited to the screwing using the bolts, and may use a pin, a rivet, or the like.
(84) As described above, intermediate part **15***a*, joint **15***c*, and locking block **15***b*, which constitute bind bar **15**, each can be made of iron, an iron alloy, SUS, aluminum, an aluminum alloy, or the like. Locking block **15***b* can have a width of 10 mm or more in the stacking direction of the battery. End plate **20** can be made of metal. Locking block **15***b* and joint **15***c* are preferably made of the same metal. This facilitates welding between locking block **15***b* and joint **15***c*.
(85) As described above, bind bar **15** is not bent at its left and right ends in the longitudinal direction, i.e., at its opposite ends in the stacked layer direction of battery stack **10** and is not screwed to end plate **20** from its main surface side. Alternatively, as illustrated in FIGS. **1** to **3**, bind bar **15** is formed in a flat plate shape in the stacking direction of battery stack **10** without providing a bent part, and fastens battery stack **10** by screwing using a locking structure formed by step **20***b* of end plate **20** and locking block **15***b*, thereby increasing rigidity to enable reducing a risk of breakage or the like due to expansion of battery cells **1**.
(86) A power supply device including many battery cells **1** stacked is configured such that battery stack **10** composed of battery cells **1** is provided at opposite ends with respective end plates **20**, and bind bars **15** are coupled to end plates **20** to bind battery cells **1**. Binding battery cells **1** with end plate **20** and bind bar **15**, which have high rigidity, enables suppressing expansion, deformation, relative movement, damage due to vibration, and the like of battery cells **1** due to charging and discharging, and degradation.
(87) As described above, power supply device **100** according to the present exemplary embodiment has stress generated by expansion of battery cells **1**. The stress acts for expansion in the stacking direction of battery and is applied not only to joint **15***c* itself but also to members related to: locking between step **20***b* and locking block **15***b*; welding between joint **15***c* and locking block **15***b*; and screwing with bolt **15***f*. Thus, increasing rigidity of each of the members to appropriately disperse the stress enables increasing rigidity of power supply device **100** as a whole and fabricating power supply device **100** capable of addressing expansion and contraction of battery cells **1**. Additionally, corrugated part **15***j* including corrugated piece **15***i* is deformed in accordance with expansion of battery cells **1**, and thus enables addressing displacement of battery stack **10**.
(88) (Elastomer Molding **18**)
(89) Elastomer molding **18** is disposed between pressing piece **15***l* and the upper surface of battery cell **1**, and elastically presses the upper surface of battery cell **1** to dispose battery cell **1** at a predetermined position. Elastomer molding **18** is formed by molding a polymer elastomer having elasticity. As the elastomer, a thermoplastic elastomer or a thermosetting elastomer can be used. As the thermoplastic elastomer, one selected from a polyamide-based elastomer, a polyurethane-based elastomer, a polyolefin-based elastomer, a polyester-based elastomer, a styrene-based elastomer, a vinyl chloride-based elastomer, and a fluorine-based elastomer can be used alone, or a combination of two or more thereof can be used. The thermosetting elastomer is synthetic rubber such as urethane rubber, silicone rubber, and fluorocarbon rubber, or natural rubber. Elastomer molding **18** can control pressing force for pressing the upper surface of battery cell **1** by being adjusted for hardness. Elastomer molding **18** has hardness, for example, from 30 degrees to 80 degrees inclusive, preferably from 40 degrees to 80 degrees inclusive, and the hardness is set optimally in consideration of an area where elastomer molding **18** presses the upper surface of battery cell **1**, strength of the upper surface of battery cell **1**, and the like.
(90) Elastomer molding **18** illustrated in the sectional view of FIG. **13** is formed by being molded into the shape of a groove holding upper and lower surfaces of pressing piece **15***l*. Elastomer molding **18** in the drawing is molded into the shape of the groove in which both pressing piece **15***l*

and insulating sheet **30** are disposed inside. Insulating sheet **30** is disposed on an inner surface of the groove, and pressing piece **15***l* is disposed inside insulating sheet **30**. As illustrated in FIG. **4**, elastomer molding **18** is molded into a shape coupled to pressing pieces **15***l* adjacent to each other, or is molded into a shape separately and independently coupled to each pressing piece **15***l*. Elastomer molding **18** molded into the shape of the groove and having pressing piece **15***l* disposed inside has a feature in that elastomer molding **18** can be coupled to pressing piece **15***l* without positional displacement.

(91) Elastomer molding **18** illustrated in FIG. **13** is provided with rubbery pressing part **18***a* protruding from a pressing surface covering the lower surface of pressing piece **15***l* toward the upper surface of battery cell **1**. Rubbery pressing part **18***a* is in a columnar shape or a plate shape that locally presses the upper surface of battery cell **1**. Rubbery pressing part **18***a* has a leading end that is in a planar shape in surface contact with the upper surface of battery cell **1**, and presses the upper surface of battery cell **1** with a predetermined area. Elastomer molding **18** of FIG. **13** is provided with rubbery pressing parts **18***a* different in protrusion height. Elastomer molding **18** provided with rubbery pressing parts **18***a* different in height can reliably dispose each battery cell **1** at a predetermined position by pressing the upper surface of battery cell **1**. This is because rubbery pressing part **18***a* protruding high presses the upper surface of battery cell **1** with a wide gap between the upper surface of battery cell **1** and pressing piece **15***l*, and many rubbery pressing parts **18***a* press the upper surface of battery cell **1** with a narrow gap between pressing piece **15***l* and the upper surface of battery cell **1**, thereby disposing battery cells **1** at respective predetermined positions.

(92) Elastomer molding **18** having rubbery pressing parts **18***a* different in protrusion height is configured such that rubbery pressing part **18***a* protruding high is formed in a shape that deforms itself in a bent manner, i.e., deforms resulting in buckling, in a state where rubbery pressing part **18***a* protruding high is strongly crushed and compressed on the upper surface of battery cell **1**, thereby disposing battery cell **1** at a predetermined position without pressing the upper surface of battery cell **1** under too strong pressure. This is because rubbery pressing part **18***a* is buckled to suppress an increase in pressing force. Elastomer molding **18** illustrated in the sectional view of FIG. **13** includes rubbery pressing parts **18***a* different in protrusion height that are disposed side by side in the longitudinal direction of the upper surface of battery cell **1**, and rubbery pressing parts **18***a* each having a high protrusion height that are disposed on the upper surface of battery cell **1** on respective opposite end. Battery cell **1** is manufactured by laser welding sealing plate **1***b* to an elongated upper end opening of outer covering can **1***a* formed by deep drawing a metal sheet. Battery cell **1** having this structure is configured such that sealing plate **1***b* has opposite end parts in each of which both side edges and an end edge are laser-welded, and an intermediate part in which only both sides are laser-welded, thereby coupling sealing plate **1***b* to outer covering can **1***a* and increasing bending strength at the opposite end parts of sealing plate **1***b*. Elastomer molding **18** including rubbery pressing parts **18***a* each having a high protrusion height, which are disposed in the respective opposite end parts of sealing plate **1***b*, strongly press the respective opposite end parts of sealing plate **1***b*, and can suppress damage to battery cell **1** due to a pressing force while disposing battery cell **1** at a predetermined position.

Second Exemplary Embodiment

(93) Power supply device **300** according to a second exemplary embodiment of the present invention is illustrated in FIGS. **14** and **15**. In these drawings, FIG. **14** is a perspective view of power supply device **300**, and FIG. **15** is an exploded perspective view of power supply device **300** of FIG. **14**. Power supply device **300** illustrated in these drawings includes bind bar **15** configured to press upper surfaces of all battery cells **1** constituting battery stack **10** with one pressing piece **15***n*, and elastomer moldings **18** disposed between the upper surfaces of respective battery cells **1** and pressing piece **15***n* to independently press respective battery cells **1**. Thus, power supply device **300** is different from power supply device **100** of the first exemplary embodiment described above

in structure of bind bar **15**, insulating sheet **30**, and elastomer molding **18**. Other configuration elements are identical in structure to the exemplary embodiment described above, so that the configuration elements are denoted by the same reference numerals as those of the exemplary embodiment described above, and the detailed description thereof will be eliminated.

(94) (Bind Bar **15**)

(95) Bind bar **15** illustrated in FIGS. **14** and **15** includes intermediate part **15***m* that is in a planar shape instead of a corrugated shape. Bind bar **15** including intermediate part **15***m* in a planar shape can prevent positional displacement of battery cells **1** in the stacking direction by suppressing the expansion of battery cells **1**. Bind bar **15** in the drawing also includes pressing pieces **15***n* formed by bending upper and lower end edge parts of intermediate part **15***m* in a planar shape toward battery stack **10** into an L shape. Bind bar **15** illustrated in the drawing is configured such that pressing piece **15***n* has a total length substantially equal to a length of battery stack **10** in the stacking direction to press the upper surfaces of all battery cells **1** constituting battery stack **10** with one pressing piece **15***n*. The structure described above in which the upper surfaces of all battery cells **1** constituting battery stack **10** are pressed by one pressing piece **15***n* has a feature in that bind bar **15** can be manufactured with a simple structure at low cost. Here, when the upper surfaces of all battery cells **1** are pressed by one pressing piece **15***n*, there is a concern that all battery cells **1** cannot be reliably disposed at respective predetermined positions by pressing piece **15***n* due to a dimensional error or the like of battery cell **1**. However, the power supply device of the present invention allows pressing piece **15***n* to press the upper surfaces of respective battery cells **1** with respective elastomer moldings **18** interposed therebetween, so that the dimensional error of battery cell **1** can be absorbed by elastomer molding **18** and all battery cells **1** can be disposed at the respective predetermined positions.

(96) (Insulating Sheet **30**)

(97) Insulating sheet **30** interposed between bind bar **15** and battery stack **10** includes flat plate **31** for covering the side surface of battery stack **10**, and pressing piece covering parts **33** provided up and down flat plate **31**. Pressing piece covering part **33** is bent from flat plate **31** into an L-shape covering an inner surface of pressing piece **15***n* of bind bar **15**. As a result, the entire inner surface of bind bar **15** is covered with insulating sheet **30**.

(98) (Elastomer Molding **18**)

(99) Power supply device **300** illustrated in FIG. **15** includes elastomer moldings **18** that are disposed between pressing piece **15***n* and the upper surfaces of respective battery cells **1**, and that independently press respective battery cells **1**. As illustrated in FIG. **16**, elastomer moldings **18** are disposed facing the respective upper surfaces of all battery cells **1** constituting battery stack **10**. Then as illustrated in FIGS. **16** and **17**, pressing pieces **15***n* disposed above the upper surface of the battery stack on respective opposite sides press respective opposite end parts of the upper surfaces of respective battery cells **1** with respective elastomer moldings **18** interposed therebetween to dispose respective battery cells **1** at predetermined positions.

(100) As illustrated in FIGS. **16** to **18**, elastomer moldings **18** are connected to each other at predetermined intervals using coupling part **19** while being disposed at predetermined positions on the upper surfaces of the respective battery cells **1** constituting battery stack **10**. In the example illustrated in FIG. **18**, elastomer moldings **18** and coupling part **19** are integrally molded with a polymer elastomer having elasticity to form elastomer unit **40**. Elastomer unit **40** of FIGS. **17** and **18** is molded in a groove shape holding upper and lower surfaces of pressing piece **15***n* between elastomer moldings **18** disposed facing the upper surfaces of respective battery cells **1** and coupling part **19** having an inverted L-shape in a cross section coupled to one ends of respective elastomer moldings **18**. Elastomer unit **40** of FIG. **17** is molded into the shape of a groove in which both pressing piece **15***n* and insulating sheet **30** are disposed inside, the groove being formed by elastomer molding **18** and coupling part **19**. Insulating sheet **30** is disposed on an inner surface of the groove, and pressing piece **15***n* is disposed inside insulating sheet **30**. As described above, the

structure in which elastomer moldings **18** are coupled to each other by coupling part **19** has a feature in that elastomer moldings **18** can be disposed at respective predetermined positions on the upper surfaces of respective battery cells **1** while being efficiently connected to pressing piece **15***n*. However, elastomer moldings each can be molded into the shape of a groove holding upper and lower surfaces of the pressing piece instead of being integrally coupled, and can be disposed at a predetermined position with respect to the pressing piece.

(101) Elastomer unit **40** of FIGS. **16** and **18** includes elastomer moldings **18** that each have lateral width (w) set to a predetermined width and that are disposed at equal intervals and at predetermined pitch (t) such that elastomer moldings **18** can be disposed facing the upper surfaces of respective battery cells **1** adjacent to each other. When lateral width (w) of each elastomer molding **18** is too wide, a position of elastomer molding **18** facing the upper surface of battery cell **1** that contracts in the stacking direction is shifted at the time of discharging battery cell **1**, and thus the upper surface of battery cell **1** cannot be accurately pressed. In contrast, when lateral width (w) is too narrow, the upper surface of battery cell **1** cannot be pressed with a sufficient pressing force. Thus, lateral width (w) of each elastomer molding **18** is set to 0.3 times to 0.8 times, preferably 0.4 times to 0.7 times, thickness (d) of battery cell **1** in consideration of the above so that the upper surface of battery cell **1** can be reliably pressed. Pitch (t) of elastomer moldings **18** is made equal to a pitch of battery cells **1** constituting battery stack **10**, and is preferably made equal to pitch (T) of battery cells **1** in battery stack **10** in a state where end plates **20** disposed on respective opposite end surfaces of battery stack **10** are joined by bind bars **15**.

(102) As illustrated in FIGS. **17** and **18**, each elastomer molding **18** is provided with rubbery pressing part **18***a* protruding from a pressing surface covering the lower surface of pressing piece **15***n* toward the upper surface of battery cell **1**. Rubbery pressing part **18***a* is in a columnar shape or a plate shape that locally presses the upper surface of battery cell **1**. Rubbery pressing part **18***a* has a leading end that is in a planar shape in surface contact with the upper surface of battery cell **1**, and presses the upper surface of battery cell **1** with a predetermined area. Elastomer molding **18** in the drawing is provided with rubbery pressing parts **18***a* different in protrusion height so that each battery cell **1** can be reliably disposed at a predetermined position. Elastomer molding **18** illustrated in FIG. **17** includes rubbery pressing parts **18***a* different in protrusion height that are disposed side by side in the longitudinal direction of the upper surface of battery cell **1**, rubbery pressing parts **18***a* each having a high protrusion height that are disposed on the upper surface of battery cell **1** on respective opposite end sides.

(103) Although not illustrated, the power supply device can include a bind bar provided with pressing pieces that independently press respective battery cells, and elastomer moldings disposed between respective pressing pieces and upper surfaces of the respective battery cells to independently press the respective battery cells. This power supply device has a feature in that the pressing piece and the elastomer molding are disposed facing each battery cell to enable each battery cell constituting the battery stack to be disposed at a predetermined position in the most ideal state.

(104) The power supply device described above can be used as a power supply for a vehicle where electric power is supplied to a motor used for traveling an electric vehicle. As an electric vehicle on which the power supply device is mounted, an electric vehicle such as a hybrid automobile or a plug-in hybrid automobile that travels by both an engine and a motor, or an electric automobile that travels only by a motor can be used, and the power supply device is used as a power supply for these vehicles. To obtain electric power that drives a vehicle, a large-capacity, high-output power supply device may be assembled by connecting many power supply devices described above in series or in parallel, a required controlling circuit is added to such large-capacity, high-output power supply device, and such a power supply device may be mounted on a vehicle.

(105) (Power Supply Device for Hybrid Automobile)

(106) FIG. **19** illustrates an example in which a power supply device is mounted on a hybrid

automobile that travels using both an engine and a motor. Vehicle HV illustrated in the drawing on which the power supply device is mounted includes: vehicle body **91**; engine **96** and running motor **93** for travelling vehicle body **91**; wheels **97** that are driven by engine **96** and running motor **93**; power supply device **100** that supplies electric power to running motor **93**; and power generator **94** that charges a battery of power supply device **100**. Power supply device **100** is connected to running motor **93** and power generator **94** via DC/AC inverter **95**. Vehicle HV travels using both running motor **93** and engine **96** while charging or discharging the battery of power supply device **100**. Running motor **93** is driven in a region where an engine efficiency is low, e.g., during acceleration or low-speed traveling, and causes the vehicle to travel. Running motor **93** is driven by electric power supplied from power supply device **100**. Power generator **94** is driven by engine **96** or driven by regenerative braking acquired when braking is applied to a vehicle, and charges the battery of power supply device **100**. As illustrated in the drawing, vehicle HV may include charging plug **98** to charge power supply device **100**. Connecting charging plug **98** to an external power source enables charging of power supply device **100**.

(107) (Power Supply Device for Electric Automobile)

(108) FIG. **20** illustrates an example in which a power supply device is mounted on an electric automobile that travels using only a motor. Vehicle EV illustrated in FIG. **20** on which the power supply device is mounted includes: vehicle body **91**; running motor **93** for travelling vehicle body **91**; wheels **97** driven by running motor **93** for vehicle traveling; power supply device **100** that supplies electric power to running motor **93**; and power generator **94** that charges a battery of power supply device **100**. Power supply device **100** is connected to running motor **93** and power generator **94** via DC/AC inverter **95**. Running motor **93** is driven by electric power supplied from power supply device **100**. Power generator **94** is driven by the energy at the time of applying regenerative braking to vehicle EV, and charges the battery of power supply device **100**. Vehicle EV further includes charging plug **98**, and power supply device **100** can be charged by connecting charging plug **98** to an external power source.

(109) (Power Supply Device for Electrical Storage Device)

(110) The application of the power supply device of the present invention is not limited to a power source for a motor that causes a vehicle to travel. The power supply device according to the exemplary embodiments can be used as a power source for an electrical storage device that performs power storage by charging a battery with electric power generated by photovoltaic power generation, wind power generation, or other methods. FIG. **21** illustrates an electrical storage device that performs power storage by charging the battery of power supply device **100** by solar battery **82**.

(111) The electrical storage device illustrated in FIG. **21** charges the battery of power supply device **100** with electric power generated by solar battery **82** disposed on a roof or a rooftop of building **81** such as a house and a factory. This electrical storage device charges the battery of power supply device **100** via charging circuit **83** with solar battery **82** serving as a charging power source, and then supplies electric power to load **86** via DC/AC inverter **85**. Thus, this electrical storage device includes a charge mode and a discharge mode. In the electrical storage device illustrated in the drawing, DC/AC inverter **85** and charging circuit **83** are connected to power supply device **100** via discharging switch **87** and charging switch **84**, respectively. Discharging switch **87** and charging switch **84** are turned on and off by power supply controller **88** of the electrical storage device. In the charge mode, power supply controller **88** turns on charging switch **84** and turns off discharging switch **87** to allow charging from charging circuit **83** to power supply device **100**. When charging is completed and the battery is fully charged or when the battery is in a state where a capacity of a predetermined value or greater is charged, power supply controller **88** turns off charging switch **84** and turns on discharging switch **87** to switch the mode to the discharge mode and allow discharging from power supply device **100** to load **86**. As necessary, power supply controller **88** can supply electric power to load **86** and charge power supply device **100** simultaneously by turning on

charging switch **84** and turning on discharging switch **87**.

(112) Although not illustrated, the power supply device can also be used as a power source of an electrical storage device that performs power storage by charging a battery using midnight electric power at night. The power supply device charged with midnight electric power is charged with the midnight electric power, which is surplus electric power generated by a power station, and outputs the electric power during the daytime when an electric power load increases. Thus, peak electric power during the daytime can be limited to a small value. The power supply device can also be used as a power source charged with both output of a solar battery and the midnight electric power. This power supply device can efficiently perform power storage effectively using both electric power generated by the solar battery and the midnight electric power in consideration of weather and electric power consumption.

(113) The electrical storage device described above can be suitably used for the following applications: a backup power supply device mountable in a rack of a computer server; a backup power supply device used for radio base stations of cellular phones; a power supply for power storage used at home or in a factory; an electrical storage device combined with a solar battery, such as a power supply for street lights; and a backup power supply for traffic lights or traffic displays for roads.

INDUSTRIAL APPLICABILITY

(114) The power supply device according to the present invention, and an electric vehicle and an electrical storage device that use the power supply device, can be suitably used as a large current power supply used as a power supply for a motor for driving an electric vehicle such as a hybrid automobile, a fuel cell vehicle, an electric vehicle, or an electric motorcycle. Examples of the power supply device include a power supply device for a plug-in hybrid electric automobile and a hybrid electric automobile capable of switching a traveling mode between an EV traveling mode and an HEV traveling mode, and a power supply device for an electric automobile. The power supply device can be appropriately used for the following applications: a backup power supply device mountable in a rack of a computer sever; a backup power supply device used for radio base stations of cellular phones; a power source for storage used at home or in a factory; an electrical storage device combined with a solar battery, such as a power source for street lights; and a backup power source for traffic lights.

REFERENCE MARKS IN THE DRAWINGS

(115) **100**, **200**, **300**: power supply device **1**: battery cell **1**X: terminal surface **1***a*: outer covering can **1***b*: sealing plate **2**: electrode terminal **10**: battery stack **15**: bind bar **15***a*: intermediate part **15***b*: locking block **15***c*: joint **15***ac*: joint main surface-side through-hole **15***bc*: joint-side through-hole **15***f*: bolt **15***i*: corrugated piece **15***j*: corrugated part **15***k*: flat piece **15***l*: pressing piece **15***m*: intermediate part **15***n*: pressing piece **16**: insulating spacer **17**: end face spacer **18**: elastomer molding **18***a*: rubbery pressing part **19**: coupling part **20**: end plate **20***b*: step **20***c*: end plate screw hole **30**: insulating sheet **31**: flat plate **32**: pressing piece support **33**: pressing piece covering part **40**: elastomer unit **81**: building **82**: solar battery **83**: charging circuit **84**: charging switch **85**: DC/AC inverter **86**: load **87**: discharging switch **88**: power supply controller **91**: vehicle body **93**: motor **94**: power generator **95**: DC/AC inverter **96**: engine **97**: wheel **98**: charging plug **900**: power supply device **901**: battery cell **902**: spacer **903**: end plate **904**: bind bar **910**: battery stack HV, EV: vehicle

Claims

1. A power supply device comprising: a plurality of battery cells each including an outer covering can in a prismatic shape and including a constant cell thickness, the plurality of battery cells being configured to be charged; a pair of end plates for covering both side end surfaces of a battery stack in which the plurality of battery cells are stacked; and bind bars that are disposed on opposite side

surfaces of the battery stack and coupled to the pair of the end plates, wherein the bind bars each include a pressing piece for pressing an upper surface of each of adjacent battery cells adjacent to each other among the plurality of battery cells, and an elastomer molding disposed between the pressing piece and the upper surface of the each of the adjacent battery cells, and the pressing piece elastically presses the upper surface of the each of the adjacent battery cells with the elastomer molding, the power supply device further comprising: a plurality of the elastomer moldings each being the elastomer molding, wherein the plurality of the elastomer moldings are spaced apart from each other in a stacking direction in which the plurality of battery cells are stacked, wherein the elastomer molding includes a rubbery pressing part in a columnar shape or in a plate shape protruding toward the upper surface of the each of the adjacent battery cells, and wherein a plurality of rubbery pressing parts being the rubbery pressing part, the elastomer molding includes the plurality of rubbery pressing parts different in protrusion height.

2. The power supply device according to claim 1, wherein the plurality of the elastomer moldings independently press the each of the adjacent battery cells.

3. The power supply device according to claim 1, wherein each of the bind bars includes a plurality of the pressing pieces each being the pressing piece independently pressing the each of the adjacent battery cells.

4. The power supply device according to claim 3, further comprising an insulating sheet disposed between each of the bind bars and the battery stack, wherein the insulating sheet is disposed between the plurality of the pressing pieces and the plurality of the elastomer moldings.

5. The power supply device according to claim 3, wherein the each of the bind bars is a metal sheet, and the metal sheet is bent providing the plurality of the pressing pieces integrally with the each of the bind bars.

6. The power supply device according to claim 1, wherein the plurality of the rubbery pressing parts are disposed apart from each other in a longitudinal direction of the upper surface of the each of the adjacent battery cells.

7. The power supply device according to claim 1, wherein at least one of the plurality of the rubbery pressing parts includes a length at which the at least one rubbery pressing part buckles in a pressed state on the upper surface of the each of the adjacent battery cells.

8. The power supply device according to claim 1, wherein the elastomer molding includes an elastomer or rubber.

9. An electric vehicle including the power supply device according to claim 1, the electric vehicle comprising: the power supply device; a motor for running that receives electric power from the power supply device; a vehicle body that is equipped with the power supply device and the motor; and a wheel that is driven by the motor to let the vehicle body travel.

10. An electrical storage device including the power supply device according to claim 1, the electrical storage device comprising: the power supply device; and a power supply controller configured to control charging and discharging of the power supply device, the power supply controller enabling charging of the plurality of battery cells with electric power supplied from an outside and causing the plurality of battery cells to charge.

11. A power supply device comprising: a plurality of battery cells each including an outer covering can in a prismatic shape and including a constant cell thickness, the plurality of battery cells being configured to be charged; a pair of end plates for covering both side end surfaces of a battery stack in which the plurality of battery cells are stacked; and bind bars that are disposed on opposite side surfaces of the battery stack and coupled to the pair of the end plates, wherein the bind bars each include a pressing piece for pressing an upper surface of each of adjacent battery cells adjacent to each other among the plurality of battery cells, and an elastomer molding disposed between the pressing piece and the upper surface of the each of the adjacent battery cells, and the pressing piece elastically presses the upper surface of the each of the adjacent battery cells with the elastomer molding, wherein the elastomer molding includes a rubbery pressing part in a columnar shape or in

a plate shape protruding toward the upper surface of the each of the adjacent battery cells, and wherein a plurality of rubbery pressing parts being the rubbery pressing part, the elastomer molding includes the plurality of rubbery pressing parts different in protrusion height.

12. The power supply device according to claim 11, wherein the plurality of the rubbery pressing parts are disposed apart from each other in a longitudinal direction of the upper surface of the each of the adjacent battery cells.

13. The power supply device according to claim 11, wherein at least one of the plurality of the rubbery pressing parts includes a length at which the at least one rubbery pressing part buckles in a pressed state on the upper surface of the each of the adjacent battery cells.