United States Patent Application Publication	20250260113
Kind Code	A1
Publication Date	August 14, 2025
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POWER STORAGE MODULE

Abstract

A power storage module includes at least one cylindrical power storage device, and a lower holder that holds a lower end part of the power storage device, wherein at least one concave part is formed on one of a surface of the power storage device facing a holding part and a surface of the holding part facing the power storage device, and at least one convex part fitted in the concave part is formed on the other.

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Family ID: **1000008571943**

Appl. No.: **19/195145**

Filed: **April 30, 2025**

Foreign Application Priority Data

JP	2019-158693	Aug. 30, 2019

Related U.S. Application Data

parent US continuation 17635688 20220215 PENDING WO continuation PCT/JP2020/031347 20200819 child US 19195145

Publication Classification

Int. Cl.: **H01M50/244** (20210101); **H01M50/186** (20210101); **H01M50/213** (20210101); **H01M50/218** (20210101); **H01M50/24** (20210101); **H01M50/242** (20210101)

U.S. Cl.:

CPC **H01M50/244** (20210101); **H01M50/186** (20210101); **H01M50/213** (20210101); **H01M50/218** (20210101); **H01M50/24** (20210101); **H01M50/242** (20210101);

Background/Summary

CROSS-REFERENCE OF RELATED APPLICATIONS [0001] This application is a Continuation of U.S. patent application Ser. No. 17/635,688, filed on Feb. 15, 2022, which is the U.S. National Phase under 35 U.S.C. § 371 of International Patent Application No. PCT/JP2023/031347, filed on Aug. 19, 2020, which claims the benefit of Japanese Patent Application No. 2019-158693, filed on Aug. 30, 2019, the entire disclosures of which applications are incorporated by reference herein.

TECHNICAL FIELD
[0002] The present disclosure relates to a power storage module including at least one power storage device.
BACKGROUND ART
[0003] Conventionally, a power storage module including at least one power storage device is widely known. For example, PTL 1 discloses a power storage module molded by filling resin between a plurality of power storage devices.
CITATION LIST
Patent Literature
[0004] PTL 1: Japanese Patent No. 5512446
SUMMARY OF THE INVENTION
[0005] A power storage module including a plurality of power storage devices may be used as a power source for power. A power storage module used as a power source for power is used in an environment where vibration is generated for a long time, and it is a problem to secure reliability of fixing of the power storage devices.
[0006] An object of the present disclosure is to provide a power storage module capable of firmly fixing a power storage device in a holder.
[0007] A power storage module according to one aspect of the present disclosure includes at least one cylindrical power storage device, and a first holder that holds one end of the power storage device, wherein at least one concave part is formed on one of a surface of the power storage device facing the first holder and a surface of the first holder facing the power storage device, and at least one convex part fitted in the concave part is formed on the other.
[0008] According to one aspect of the present disclosure, it is possible to provide the power storage module capable of firmly fixing the power storage device in the holder.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0009] FIG. **1** is a schematic view illustrating a power storage module of a first exemplary embodiment.
[0010] FIG. **2** is a perspective view illustrating an example of a convex part formed on a bottom part of a power storage device of the first exemplary embodiment.
[0011] FIG. **3** is a schematic view illustrating an exhaust action of a high-temperature gas of the power storage device of the first exemplary embodiment.
[0012] FIG. **4** is a perspective view illustrating another example of the convex part formed on the bottom part of the power storage device of the first exemplary embodiment.
[0013] FIG. **5** is a schematic view illustrating a power storage module of a second exemplary

embodiment.
[0014] FIG. **6** is a schematic view illustrating a power storage module of a third exemplary embodiment.
[0015] FIG. **7** is a schematic view illustrating a power storage module of a fourth exemplary embodiment.
DESCRIPTION OF EMBODIMENT
[0016] Hereinafter, exemplary embodiments of the present disclosure will be described with reference to the drawings. The shape, material, and number described below are examples for description, and can be appropriately changed according to the specification of the power storage module. In the following description, the same elements are denoted by the same reference marks in all the drawings.
[0017] Power storage module **10** of a first exemplary embodiment will be described with reference to FIG. **1**. FIG. **1** is a schematic view illustrating power storage module **10**.
[0018] Power storage module **10** is mainly used as a power source for power. Power storage module **10** is used as a power source of an electrically powered device driven by a motor such as an electrically powered tool, an electrically powered automobile, an electrically powered assist bicycle, an electrically powered motorcycle, an electrically powered wheelchair, an electrically powered tricycle, or an electrically powered cart, for example. However, the application of power storage module **10** is not specified, and the power storage module may be used as a power source for various electric devices used indoors and outdoors, such as electric devices other than electrically powered devices, for example, cleaners, wireless devices, lighting devices, digital cameras, and video cameras.
[0019] Power storage module **10** of the first exemplary embodiment includes a plurality of cylindrical power storage devices **50**, lower holder **11** as a first holder that holds lower end parts of the plurality of power storage devices **50**, and upper holder **12** as a second holder that holds upper end parts of the plurality of power storage devices **50**. Holding part **13** is provided between power storage device **50** and lower holder **11**. Note that the first holder may include holding part **13**.
[0020] As power storage device **50**, a cylindrical lithium ion secondary battery is used. Power storage device **50** may be a nickel-metal hydride storage or a capacitor. The plurality of power storage devices **50** are densely filled in power storage module **10**, and adjacent power storage devices **50** are arranged substantially close to each other. Power storage device **50** includes electrode assembly **55** including a positive electrode and a negative electrode, exterior can **51** as a case having a cylindrical cylinder part, bottom part **51**B formed at a lower end of the cylinder part, and an opening part formed at an upper end, and sealing body **52** that seals the opening part of exterior can **51** in a state of being insulated from exterior can **51**. In power storage device **50**, the positive electrode of the electrode assembly and sealing body **52** are electrically connected to each other, and the negative electrode and exterior can **51** are electrically connected to each other. In power storage device **50**, a top plate of sealing body **52** is configured as a positive-electrode terminal. In power storage device **50**, exterior can **51** is configured as a negative-electrode terminal.
[0021] Upper holder **12** holds upper end parts of the plurality of power storage devices **50**, respectively. On a lower surface part of upper holder **12**, containers in which the upper end parts of power storage devices **50** are housed are formed. Upper holder **12** is made of a thermoplastic resin, a thermosetting resin, or the like, which is an insulating material. An opening part may be formed in each of the containers of upper holder **12**, and the positive-electrode terminal and the negative-electrode terminal may be exposed.
[0022] Positive electrode current collecting member **61** connected to the positive-electrode terminal is disposed above upper holder **12**. Negative electrode current collecting member **62** connected to the negative-electrode terminal is disposed above upper holder **12**. As positive electrode current collecting member **61** and negative electrode current collecting member **62**, a material having good electric conduction and thermal conduction is used, and an iron plate whose surface is plated with

nickel or the like, a metal plate such as a nickel plate, a copper plate, or an aluminum plate is preferably used. Note that positive electrode current collecting member **61** and negative electrode current collecting member **62** are disposed so as to overlap each other as illustrated in FIG. **1**, but are not limited to this configuration. For example, a plurality of current collecting members may be disposed on upper holder **12** at predetermined intervals, and the current collecting members may be connected in parallel or in series to the plurality of power storage devices **50**.

[0023] Lower holder **11** holds lower end parts of the plurality of power storage devices **50**, respectively. On an upper surface part of lower holder **11**, containers in which the lower end parts of power storage devices **50** are housed are formed. Lower holder **11** is made of a thermoplastic resin, a thermosetting resin, or the like, which is an insulating material. Holding part **13** is provided between each of the containers of lower holder **11** and the lower end part of power storage device **50**.

[0024] Holding part **13** is filled between power storage device **50** and lower holder **11**. As holding part **13**, an epoxy-based adhesive, a silicone-based elastic adhesive, or the like is preferably used. The epoxy-based adhesive is an adhesive using a resin having an epoxy group (oxirane ring). The epoxy-based adhesive is generally a two-component adhesive, and a main component thereof is a substance containing an epoxy group. The epoxy-based adhesive is also in the form of an amine, an ether, or an ester containing an epoxy group as a hardener, and becomes an epoxy-based adhesive by a chemical reaction started by mixing two components. On the other hand, the elastic adhesive is an adhesive in which a cured product after curing is a rubber-like elastic body.

[0025] Furthermore, a potting material can also be used as holding part **13**. As the potting material, a transparent polyurethane resin obtained by chemically reacting two liquids of a polyol as a main agent and an isocyanate as a hardener is preferably used. Protective material B is not limited to a polyurethane resin, and a urethane resin, an epoxy resin, an acrylic resin, a UV curable resin, or the like may be used. In particular, when a material having rigidity is used as the holding part after the power storage module such as a potting material is produced, only the holding part may be used as the lower holder.

[0026] In exterior can **51** constituting power storage device **50**, a concave shape or a convex shape is formed on a surface facing holding part **13**. In exterior can **51** exemplified in FIG. **1**, convex part **51**C is formed on bottom part **51**B of exterior can **51**.

[0027] In holding part **13**, a concave shape or a convex shape is formed in a part facing bottom part **51**B of exterior can **51**. When a convex shape is formed in exterior can **51**, a concave shape is formed in holding part **13**. When a concave shape is formed in exterior can **51**, a convex shape is formed in holding part **13**. The convex shape or the concave shape formed in exterior can **51** and the convex shape or the concave shape formed in holding part **13** are formed so as to be fitted to each other. Similarly to exterior can **51**, a convex shape or a concave shape may also be provided on a surface of lower holder **11** facing holding part **13** to increase fixing strength of holding part **13** to lower holder **11**. At this time, the convex part or the concave part of exterior can **51** and the convex shape or the concave shape of lower holder **11** may not face each other. A convex shape may be formed in exterior can **51**, and a convex shape may also be formed in lower holder **11**.

[0028] An example of convex part **51**C will be described with reference to FIG. **2**. FIG. **2** is a perspective view illustrating bottom part **51**B of exterior can **51** in which convex part **51**C is formed.

[0029] As described above, in power storage device **50**, convex part **51**C is formed on bottom part **51**B of exterior can **51**. A side peripheral surface of convex part **51**C exemplified in FIG. **2** is formed in a non-annular shape. Specifically, convex part **51**C has a shape in which a substantially circular shape and a long circular shape protruding at an interval of 120° from an outer side of the substantially circular shape are integrated in a plan view. Note that, as described above, in holding part **13**, concave part **13**C that fits with convex part **51**C illustrated in FIG. **2** is formed on a surface facing bottom part **51**B of exterior can **51**. Note that the lower end surface of the convex part **51**C

may be polygonal.
[0030] Effects of convex part **51**C and concave part **13**C will be described. According to convex part **51**C and concave part **13**C, convex part **51**C and concave part **13**C act as an anchor effect on holding part **13**. The anchor effect is an effect of increasing a fixing force by holding part **13** entering the irregularities of a material surface like a tree root and curing in the fixing. This is because a fixing force is increased by friction or the like due to an increase in a contact area between exterior can **51** and holding part **13**, and convex part **51**C and concave part **13**C serve as wedges when power storage device **50** is about to rotate in holding part **13** (eventually, lower holder **11**). With such a configuration, position regulation between bottom part **51**B of exterior can **51** and holding part **13** (furthermore, lower holder **11**) becomes easy. That is, power storage device **50** and holding part **13** can be further strengthened. In particular, when holding part **13** (lower holder **11** directly abutting on exterior can **51** when holding part **13** is not provided) is molded by impregnating power storage device **50** with a viscous material and then curing the viscous material, it is difficult to arrange a member for fixing power storage device **50** such as an adhesive between molded holding part **13** and exterior can **51**. Therefore, the fixing force of power storage device **50** in lower holder **11** (including holding part **13**) can be increased by a simple operation.
[0031] Convex part **51**C formed on bottom part **51**B of exterior can **51**, and concave part **13**C formed on holding part **13** and locked to convex part **51**C particularly act as an anchor effect against vibration in a rotation direction of power storage device **50** in lower holder **11**. In the convex part (or the concave part) formed on exterior can **51** of the present disclosure, reliability of alignment in a height with respect to holding part **13** (eventually, lower holder **11**) may be enhanced by further forming a convex part or a concave part on an outer peripheral surface (an inner peripheral surface in the case of a concave part) of the convex part.
[0032] For example, a convex shape may be formed in a part facing holding part **13** on a side circumferential surface of exterior can **51**. In this case, in holding part **13**, a concave shape is formed in a part facing the side peripheral surface of exterior can **51**. Also in this case, the convex shape of exterior can **51** and the concave shape of holding part **13** are fitted to each other. With such a configuration, the convex part formed on the side circumferential surface of exterior can **51** and the concave part formed on holding part **13** and fitted to the convex part act as an anchor effect on vibration of power storage device **50** in a vertical direction particularly in lower holder **11**.
[0033] With reference to FIG. **3**, an exhaust action of a high-temperature gas of power storage device **50** will be described. FIG. **3** is a schematic view illustrating a cross section of power storage device **50** using exterior can **51** of FIG. **2** taken along cutting line BB.
[0034] Electrode assembly **55** and electrolyte solution are accommodated in power storage device **50**. Electrode assembly **55** includes positive electrode **56**, negative electrode **57**, and separator **58** interposed between positive electrode **56** and negative electrode **57**, and has a wound structure in which positive electrode **56** and negative electrode **57** are wound with separator **58** interposed therebetween. Insulating plate **59** is disposed below electrode assembly **55**.
[0035] In power storage device **50**, in an abnormal state, for example, when positive electrode **56** and negative electrode **57** are short-circuited, a very large current flows in a short-circuited part and large heat is generated, and then positive electrode **56** or negative electrode **57** and the electrolytic solution react with each other to generate a high-temperature gas.
[0036] As described above, in power storage device **50**, convex part **51**C is formed on bottom part **51**B of exterior can **51**. An inner surface of bottom part **51**B exemplified in FIG. **3** is formed by recessing a part corresponding to convex part **51**C. Convex part **51**C of bottom part **51**B exemplified in FIG. **3** extends in a radial direction of bottom part **51**B.
[0037] In power storage device **50** exemplified in FIG. **3**, as compared with power storage device **50** in which a solid convex part is formed in exterior can **51**, the high-temperature gas generated in exterior can **51** passes through space R**1** formed close to an inner surface side of convex part **51**C, and is discharged from a space formed in a shaft part of electrode assembly **55** to an upper part of

exterior can **51**. The high-temperature gas is released to an outside by breaking a part of sealing body **52**. Accordingly, when the high-temperature gas is generated inside power storage device **50** at the time of abnormality, the high-temperature gas is smoothly discharged from power storage device **50**. At this time, when convex part **51**C forming space R**1** has a region overlapping with the center of bottom part **51**B of exterior can **51** as illustrated in FIGS. **2** and **3**, the exhaust efficiency is further enhanced. It is considered that a similar effect can be obtained even when a concave part having an anchor effect on holding part **13** is formed in the bottom part of exterior can **51** and the concave part is formed to extend in the radial direction of the bottom part.

[0038] Another example of convex part **51**C will be described with reference to FIG. **4**. FIG. **4** is a perspective view illustrating bottom part **51**B of exterior can **51** in which convex part **51**C is formed.

[0039] A plurality of (in the drawings, for example, four) convex parts **51**C are formed. Convex part **51**C has a substantially cylindrical shape. Furthermore, convex parts **51**C are disposed at positions not overlapping with central axis P of exterior can **51** in bottom part **51**B. Note that, as described above, in holding part **13**, only a plurality of concave parts **13**C to be fitted to convex parts **51**C are formed on a surface facing bottom part **51**B of exterior can **51** (not illustrated).

[0040] According to convex part **51**C and concave part **13**C of such another example, convex part **51**C and concave part **13**C act as an anchor effect on holding part **13**. With such a configuration, it is possible to facilitate alignment between bottom part **51**B of exterior can **51** and lower holder **11**. That is, it is possible to firmly fix power storage device **50** and holding part **13** and hence lower holder **11**.

[0041] Power storage module **20** of a second exemplary embodiment will be described with reference to FIG. **5**. FIG. **5** is a schematic view illustrating power storage module **20**.

[0042] Power storage module **20** of the second exemplary embodiment includes the plurality of cylindrical power storage devices **50**, lower holder **21** as a first holder that holds lower end parts of the plurality of power storage devices **50**, respectively, and upper holder **22** as a second holder that holds upper end parts of the plurality of power storage devices **50**, respectively. Since power storage device **50** has the same configuration as power storage device **50** of the first exemplary embodiment described above, the description thereof is omitted.

[0043] Upper holder **22** is molded by curing a potting material, and holds the upper end parts of the plurality of power storage devices **50**, respectively. On a lower surface part of upper holder **22**, containers **22**A to which an upper end part of the power storage device **50** is fitted are formed. In container **22**A, a part facing sealing body **52** of power storage device **50** is defined as thin part **22**B. Thin part **22**B is formed to have a sufficiently smaller thickness than other parts of container **22**A. Thin part **22**B is preferably 2 mm or less, for example.

[0044] Note that, when thin part **22**B is formed in upper holder **22**, by filling a potting material in a state where a rod is disposed at a position facing sealing body **52** of power storage device **50** at a predetermined interval and curing the potting material and then removing the rod when upper holder **22** is manufactured, thin part **22**B having the thickness of a dimension of the above-described interval is formed. Note that, when positive electrode current collecting member **61** and negative electrode current collecting member **62** are disposed on the upper part of upper holder **22**, upper holder **22** is manufactured after these current collecting members and the plurality of power storage devices **50** are joined to each other.

[0045] When power storage device **50** is in a normal state, thin part **22**B can cover power storage device **50**, so that insulation from the outside of the module of power storage device **50** can be achieved. Furthermore, it is possible to suppress entry of a foreign matter into the container and hence into the power storage device. Further, when an exhaust valve is provided in sealing body **52** and power storage device **50** is in an abnormal state, thin part **22**B can be destroyed by a jetting force of the high-temperature gas discharged from the exhaust valve when the exhaust valve is activated, and can be exhausted to the outside of the power storage module.

[0046] Power storage module **30** of a third exemplary embodiment will be described with reference to FIG. **6**. FIG. **6** is a schematic view illustrating power storage module **30**.
[0047] Power storage module **30** of the third exemplary embodiment includes a plurality of cylindrical power storage devices **50**, lower holder **31** as a first holder that holds lower end parts of the plurality of power storage devices **50**, respectively, and upper holder **32** as a second holder that holds upper end parts of the plurality of power storage devices **50**, respectively. In power storage module **30**, a gap between adjacent power storage devices **50** is filled with protective material B as potting.
[0048] Power storage device **50** includes exterior can **51** as a case having a cylindrical part, bottom part **51**B formed at a lower end of the cylindrical part and an opening part formed at an upper end, and sealing body **52** for sealing the opening part. Exterior can **51** includes, for example, grooved part **51**A that supports sealing body **52** and is formed by rolling a side surface part from the outside. Grooved part **51**A is preferably formed in an annular shape in a circumferential direction of exterior can **51**, and sealing body **52** is supported by an upper surface of the grooved part. Protective material B filled in the gap between adjacent power storage devices **50** flows into grooved part **51**A.
[0049] As protective material B used for potting, a transparent polyurethane resin obtained by chemically reacting two liquids of a polyol as a main agent and an isocyanate as a hardener is preferably used. Protective material B is not limited to a polyurethane resin, and a urethane resin, an epoxy resin, an acrylic resin, or the like may be used.
[0050] Effects of power storage module **30** of the third exemplary embodiment will be described. According to power storage module **30**, power storage device **50** can be firmly fixed. That is, protective material B flows into space R**2** and grooved part **51**A as an adhesive, and acts as an anchor effect. Accordingly, power storage device **50** can be firmly fixed to upper holder **32**.
[0051] Power storage module **40** of a fourth exemplary embodiment will be described with reference to FIG. **7**. FIG. **7** is a plan cross-sectional view illustrating power storage module **40**.
[0052] Power storage module **40** of the fourth exemplary embodiment includes a plurality of (three in the exemplification of FIG. **7**) cylindrical power storage devices **50**, a lower holder (not illustrated) as a first holder that holds lower end parts of the plurality of power storage devices **50**, respectively, and upper holder **42** (not illustrated) as a second holder that holds upper end parts of the plurality of power storage devices **50**, respectively. Furthermore, in power storage module **40**, a gap between adjacent power storage devices **50** is filled with protective material B as potting. Since power storage device **50** and protective material B have the same configurations as those of power storage device **50** of the first exemplary embodiment described above, the description thereof is omitted.
[0053] In upper holder **42**, container **42**A to which the upper end part of power storage device **50** is fitted is formed. In container **42**A, opening part **42**C through which a part of sealing body **52** is exposed, and cutout part **42**D through which a side peripheral surface of power storage device **50** is exposed are formed. Cutout part **42**D is provided at a position not interposed between a pair of adjacent batteries in plan view.
[0054] In a gap between adjacent power storage devices **50**, gap BV not filled with protective material B is formed in a vertical direction along the side peripheral surface of power storage device **50** below cutout part **42**D. Gap BV is formed to communicate with cutout part **42**D. As a method of forming gap BV, for example, gap BV may be formed by inserting a rod-like jig into a part where gap BV is formed when protective material B is filled, and removing the jig after protective material B is cured.
[0055] In power storage device **50**, thermal runaway in which a high-temperature gas is released by breaking exterior can **51** may occur. According to power storage module **40**, even when thermal runaway occurs in one power storage device **50**, the high-temperature gas breaks the outer peripheral surface of exterior can **51** exposed from brittle cutout part **42**D having a low heat

capacity, and is directed to the outside, so that it is possible to suppress an adverse effect caused by the high-temperature gas on power storage device **50** adjacent to one power storage device **50** in which the thermal runaway has occurred.

[0056] Note that the present invention is not limited to the above-described exemplary embodiments and modifications thereof, and it is a matter of course that various changes and improvements can be made within the scope of the matters described in the claims of the present application.

REFERENCE MARKS IN THE DRAWINGS

[0057] **10** power storage module [0058] **11** lower holder [0059] **13**C concave part [0060] **12** upper holder [0061] **13** holding part [0062] **50** power storage device [0063] **51** exterior can [0064] **51**A grooved part [0065] **51**B bottom part [0066] **51**C convex part [0067] **52** sealing body [0068] **55** electrode assembly [0069] **56** positive electrode [0070] **57** negative electrode [0071] **58** separator [0072] **59** insulating plate [0073] **61** positive electrode current collecting member [0074] **62** negative electrode current collecting member

Claims

1. A power storage module comprising: a plurality of power storage devices arranged in a first direction, each of the plurality of power storage devices comprises a cylindrical shape; and a current collecting member for connecting electrically the plurality of power storage devices at one end surface of each of the plurality of power storage devices comprising a cylindrical shape in a second direction perpendicular to the first direction, an insulating member arranged at another end surface of each of the plurality of power storage devices comprising a cylindrical shape in the second direction, wherein: power storage device includes a concave part is formed on the another end each of the plurality of power storage devices in the second direction or a convex part, the convex part or the convex part include a surface crossing a line extending in a peripheral direction of each of the plurality of power storage devices comprising a cylindrical shape.

2. The power storage module according to claim 1, wherein the plurality of power storage devices comprising a cylindrical shape for connecting in parallel with each other via the current collecting member.

3. The power storage module according to claim 1, wherein the convex part or the convex part include a part extending in the radial direction of the plurality of power storage devices comprising a cylindrical shape.