(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 216 325 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
26.07.2023 Bulletin 2023/30

(21) Application number: **21869479.2**

(22) Date of filing: **21.09.2021**

(51) International Patent Classification (IPC):
H01M 10/04 *(2006.01)* ***H01M 50/152*** *(2021.01)*
H01M 50/533 *(2021.01)* ***H01M 50/536*** *(2021.01)*

(52) Cooperative Patent Classification (CPC):
H01M 10/04; H01M 50/152; H01M 50/533; H01M 50/536; Y02E 60/10; Y02P 70/50

(86) International application number:
PCT/JP2021/034620

(87) International publication number:
WO 2022/059797 (24.03.2022 Gazette 2022/12)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **21.09.2020 US 202063081068 P**

(71) Applicant: **Panasonic Intellectual Property Management Co., Ltd.**
Osaka-shi, Osaka 540-6207 (JP)

(72) Inventors:
- **GESHI, Shinya**
  Osaka-shi, Osaka 540-6207 (JP)
- **SAKAMOTO, Shinichi**
  Osaka-shi, Osaka 540-6207 (JP)
- **SHIMIZU, Kazumichi**
  Osaka-shi, Osaka 540-6207 (JP)
- **KOZUKI, Kiyomi**
  Osaka-shi, Osaka 540-6207 (JP)
- **KOHIRA, Kazutoshi**
  Osaka-shi, Osaka 540-6207 (JP)

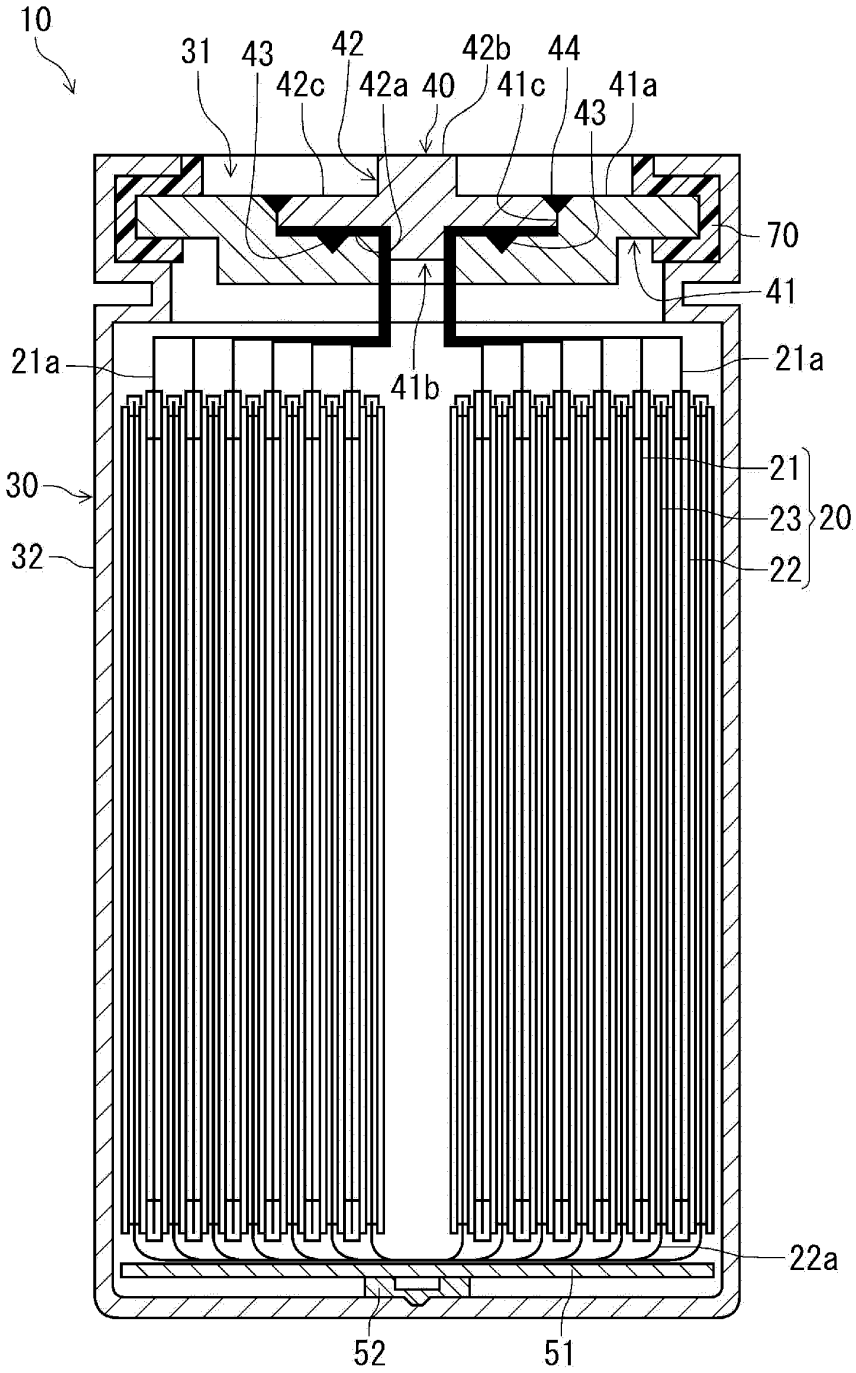
(74) Representative: **Novagraaf International SA**
Chemin de l'Echo 3
1213 Onex, Geneva (CH)

(54) **POWER STORAGE DEVICE**

(57) A power storage device 10 includes a first electrode 21 having a first current collector, a second electrode 22 having a second current collector, and a separator 23. The first electrode 21, the second electrode 22, and the separator 23 form a columnar wound body 20. The power storage device 10 further includes a cylinder 32, 61 covering an outer periphery of the columnar wound body 20 and having a first opening 31, a sealing body 40 that seals the first opening 31, and at least one first tab 21a, its one end connected to the first current collector and the other end connected to the sealing body 40. The sealing body 40 has a first member 41 including a first face 41a facing away from the columnar wound body 20, and a second member 42 including a second face 42a facing the columnar wound body 20. The other end of the first tab 21a is welded to the first face 41a of the first member 41 to form a first welding portion 43, and the first welding portion 43 is positioned between the first face 41a and the second face 42a. This allows the internal resistance of the power storage device 10 to decrease.

EP 4 216 325 A1

FIG. 1


10
31
43
42
42c
42a
40
42b
41c
44
43
41a
70
41
21a
41b
21a
30
21
23
20
32
22
22a
52
51

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a power storage device.

BACKGROUND ART

[0002] Conventionally, a power storage device that stores electricity is known (e.g., Patent Literature 1). The power storage device of Patent Literature 1 is a battery including a wound electrode group in which a positive electrode plate and a negative electrode plate are wound with a separator interposed therebetween; a battery case accommodating the wound electrode group; and a battery sealing lid that seals the battery case and also serves as an external output terminal. In the power storage device of Patent Literature 1, a plurality of current collecting tabs drawn out from the wound electrode group are welded to a current collecting ring disposed at an upper portion of the wound electrode group. The current collecting ring and battery sealing lid are connected to each other with a lead plate.

Citation List

Patent Document

[0003] Patent Literature 1: Japanese Patent No. 4356209

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004] However, in the power storage device of Patent Literature 1, the plurality of current collecting tabs are connected to the battery sealing lid through the current collecting ring and lead plate. Therefore, with the presence of particularly the lead plate, the internal resistance of the power storage device is increased. Under such circumstances, the present disclosure aims to, as one of the purposes, decrease the internal resistance of the power storage device.

MEANS FOR SOLVING THE PROBLEM

[0005] An aspect of the present disclosure relates to a power storage device. The power storage device includes a first electrode having a strip first current collector, and a first active material layer carried on the first current collector; a second electrode having a strip second current collector, and a second active material layer carried on the second current collector; and a separator interposed between the first electrode and the second electrode, wherein the first electrode, the second electrode, and the separator form a columnar wound body, the power storage device further includes a cylinder covering an outer periphery of the columnar wound body, electrically connected to the second current collector, and having a first opening, a sealing body that seals the first opening, and at least one first tab that electrically connects the first current collector and the sealing body, one end of the first tab is connected to the first current collector, the other end of the first tab is connected to the sealing body, the sealing body has a first member including a first face facing away from the columnar wound body, and a second member including a second face facing the columnar wound body, the other end of the first tab is welded to the first face of the first member to form a first welding portion, and the first welding portion is positioned between the first face and the second face.

Effects of the Invention

[0006] The present disclosure allows for decrease in the internal resistance of the power storage device.

[0007] While the novel features of the invention are set forth particularly in the appended claims, the invention, both as to organization and content, will be better understood and appreciated, along with other objects and features thereof, from the following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

[FIG. 1] FIG. 1 is a cross sectional view schematically illustrating a power storage device of Embodiment 1.
[FIG. 2] FIG. 2 is a cross sectional view schematically illustrating a power storage device of Embodiment 2.
[FIG. 3] FIG. 3 is a developed view of a columnar wound body of Embodiment 3.
[FIG. 4] FIG. 4 is a cross sectional view schematically illustrating a power storage device of Embodiment 3.

DESCRIPTION OF THE EMBODIMENTS

[0009] Embodiments of the power storage device of the present disclosure are described below with examples. However, the present disclosure is not limited to the examples below. In the description below, specific numeral values and materials are given as examples, but other numeral values and materials can be used as long as effects of the present disclosure can be achieved.

[0010] A power storage device of the present disclosure includes a strip first electrode, a strip second electrode, and a separator interposed between the first electrode and second electrode. The first electrode, second electrode, and separator form a columnar wound body. That is, the first electrode and second electrode are wound with the separator interposed therebetween.

[0011] The first electrode has a strip first current collector, and a first active material layer carried on the first

current collector. The second electrode has a strip second current collector, and a second active material layer carried on the second current collector.

[0012] The power storage device further includes a cylinder having a first opening, a sealing body that seals the first opening, and at least one first tab. The contour of the first opening matches the contour of the sealing body, and generally is circular. The first tab has, for example, a ribbon shape or a strip shape. An insulating material such as a gasket may be interposed between the cylinder and sealing body.

[0013] The cylinder covers the outer periphery of the columnar wound body and is electrically connected to the second current collector. The cylinder may be formed of a conductive material.

[0014] The sealing body has a first member including a first face facing away from the columnar wound body, and a second member including a second face facing the columnar wound body. That is, the sealing body is formed of a plurality of members, and may further include another member. The first member and second member are disposed so as to partially overlap each other in the axis direction of the cylinder. The first member and second member may be electrically connected. A thick conductive path can be formed in this manner.

[0015] The first tab electrically connects the first current collector to the sealing body. One end of the first tab is connected to the first current collector. The other end of the first tab is connected to the sealing body. The first tab may be integrated with the first current collector or separated from the first current collector. When the first tab is integrated with the first current collector, one end of the first tab is a proximal end of the first tab, and the other end of the first tab is a distal end of the first tab. When the first tab is separated from the first current collector, one end of the first tab is electrically connected to the first current collector by welding and the like.

[0016] The other end of the first tab is welded to the first face of the first member to form a first welding portion. The first welding portion may be formed by, for example, laser welding or ultrasonic welding. The first welding portion is positioned between the first face and the second face.

[0017] As described above, with the present disclosure, the first tab is directly connected to the sealing body. That is, no intermediate member such as a current collecting ring is present between the first tab and the sealing body. Thus, the internal resistance of the power storage device can be decreased. Furthermore, with the present disclosure, the first welding portion is positioned between the first face and the second face, and therefore the connection strength of the first welding portion can be made strong. Furthermore, when the first tab is welded to the first face of the first member facing away from the columnar wound body, the welding step is stabilized. This is because a robust first member (thickness is, for example, 500 μm or more) is interposed between the first welding portion and the columnar wound body, and therefore the sputter at the time of welding does not splash easily to the columnar wound body. Stabilizing the welding step allows for an increase in the strength of the first welding portion easily, which decreases the connection resistance of the first welding portion easily.

[0018] The first welding portion can be sandwiched between the first face and the second face. This configuration allows for decrease in contact resistance between the second member and first welding portion. Furthermore, the second face may also be joined with the first tab. Specifically, by welding the second member and the first tab from the rear side of the second face of the second member, they may be joined. This configuration allows for further decrease in the resistance between the first tab and the second member.

[0019] The first face, first tab, and second face may be joined with a common welding portion. This configuration allows for decrease in resistance, and also stronger fixing of the first tab to the sealing plate. When the second member is accommodated in a recessed portion of the first member, the second member also having a recessed portion at its outer face (upper face) similarly with the first member allows for the portion where the second member faces the first tab to be thin, which makes welding easier when joining the second member with the first tab.

[0020] The first member may be an annular member having a through hole at a center for the first tab to pass through. The second member may plug the through hole. The second member may have a disc shape. The disc second member may have a center portion and a flange portion (outer periphery portion) at its peripheral edge.

[0021] The first member and second member may be welded at a second welding portion radially outside of the first welding portion. An even thicker conductive path can be formed in this manner.

[0022] The first member may have a recessed portion formed into an annular shape and having the first face as a bottom face. The second member may have a center portion that plugs the through hole, and an outer periphery portion provided surrounding the center portion. The outer periphery portion may be a flange portion of the disc shaped second member. The outer periphery portion may be joined to the first member by the second welding portion throughout its entire periphery. In this case, the second welding portion forms a thick conductive path, and a gap that may be formed between the first member and second member can be sealed.

[0023] The first tab may be joined with the second face and first face. This configuration allows for formation of a thick conductive path and decrease in the internal resistance of the power storage device.

[0024] The power storage device may include a plurality of first tabs. At least two of the other ends of the first tab may be overlapped with each other and welded to the first face of the first member. With this configuration, welding portions can be decreased compared with the case where a plurality of first tabs are welded to the first face one by one. A recessed portion for accommo-

dating an end portion of the first tab may be formed in a region in the first face where the first tab is disposed, or a region in the second face facing the first tab.

[0025] The cylinder may be formed of a portion of a metal case. For example, the cylinder may be formed of a side wall portion of a bottomed cylindrical metal case.

[0026] The cylinder may be formed of a wound body of a metal sheet. The metal sheet may be integrated with a second current collector, or separated from the second current collector. The metal sheet thickness TC may be the same as the thickness T2 of the second current collector, and may satisfy, for example, $0.5 \leq TC/T2 \leq 1.5$. When the cylinder is formed of a metal sheet, the metal sheet is preferably wound, for example, twice or more around the outer periphery of the columnar wound body to increase the strength of the cylinder. This configuration allows for continuous steps: a step of forming the wound body to a step of accommodating the wound body to the metal case. Furthermore, without joining the bottom of the metal case with the second current collecting plate, the metal case and second electrode can be electrically connected, and therefore works involved with connection can be simplified. Also, by electrically connecting the terminal end of the second electrode in the winding direction with the metal case, the current collecting paths between the metal case and the second electrode increase, which allows for a decrease in resistance even more. The cylinder can be formed by joining the terminal end in the winding direction of the metal sheet with another portion of the outer surface of the metal sheet.

[0027] In the following, an example of the power storage device of the present disclosure is described in detail with reference to the drawings. For the elements in an example of the power storage device described below, the above-described elements can be used. The elements of the example of the power storage device described below can be changed based on the description above. The matters described below can also be applied to the above-described embodiment. Of the elements in the example of the power storage device described below, elements that are not essential to the power storage device of the present disclosure can be omitted. The figures shown below are schematic, and do not accurately represent shapes and numbers of actual members.

« Embodiment 1 »

[0028] Embodiment 1 of the present disclosure is described. A power storage device 10 of this embodiment is a lithium ion secondary battery, without limitation. As shown in FIG. 1, the power storage device 10 includes a columnar wound body 20, a case 30, and a sealing body 40.

[0029] The columnar wound body 20 is formed by winding a strip positive electrode 21, a strip negative electrode 22, and a separator 23 interposed between the positive electrode 21 and negative electrode 22. The positive electrode 21 is an example of the first electrode. The negative electrode 22 is an example of the second electrode.

[0030] The positive electrode 21 has a strip positive electrode current collector, and a positive electrode active material layer carried thereon. A plurality of positive electrode current collecting tabs 21a are connected to the positive electrode current collector. The positive electrode current collector is an example of the first current collector. The positive electrode active material layer is an example of the first active material layer. The positive electrode current collecting tab 21a is an example of the first tab.

[0031] For the positive electrode current collector, a strip metal material is used. The strip metal material may be metal foil, metal porous body, etc. Examples of the metal material include aluminum, aluminum alloy, nickel, and titanium. The positive electrode current collector has a thickness of, for example, 10 μm or more and 100 μm or less.

[0032] The positive electrode active material layer includes, for example, a positive electrode active material, conductive agent, and binder. The positive electrode active material layer is produced by, for example, applying a positive electrode mixture slurry containing a positive electrode active material, conductive agent, and binder onto both sides of the positive electrode current collector, drying the applied coating, and then rolling. The positive electrode active material is a material that stores and releases lithium ions. Examples of the positive electrode active material include a lithium-containing transition metal oxide, fluorinated transition metal, polyanion, fluorinated polyanion, and sulfide of transition metals.

[0033] A plurality of positive electrode current collecting tabs 21a are formed to be integrated with the positive electrode current collector. The positive electrode current collecting tabs 21a extend from one end portion (upper end portion in FIG. 1) along the longitudinal direction of the positive electrode current collector. When the positive electrode 21 is wound, a portion of the plurality of positive electrode current collecting tabs 21a coincide with each other in the circumferential direction. The remaining plurality of positive electrode current collecting tabs 21a coincide with each other when the positive electrode 21 is wound in the circumferential direction.

[0034] The negative electrode 22 has a strip negative electrode current collector, a negative electrode active material layer carried thereon, and a negative electrode current collector exposed portion 22a formed at one end in the width direction of the negative electrode current collector. The negative electrode current collector is an example of the second current collector. The negative electrode active material layer is an example of the second active material layer.

[0035] For the negative electrode current collector, a strip metal material is used. The strip metal material may be metal foil, metal porous body, etc. Examples of the metal material include copper, copper alloy, nickel, and stainless steel. The negative electrode current collector

has a thickness of, for example, 10 μm or more and 100 μm or less.

[0036] The negative electrode active material layer includes, for example, a negative electrode active material, a conductive agent, and a binder. The negative electrode active material layer is produced by, for example, applying a negative electrode mixture slurry containing a negative electrode active material, conductive agent, and binder onto both sides of the negative electrode current collector excluding the negative electrode current collector exposed portion 22a, drying the applied coating, and then rolling. The negative electrode active material is a material that stores and releases lithium ions. Examples of the negative electrode active material include a carbon material, metal compound, alloy, and ceramic material.

[0037] The negative electrode current collector exposed portion 22a is formed to be integrated with the negative electrode current collector. The negative electrode current collector exposed portion 22a is projected from one end in the winding axis direction of the wound body to form the end face of the wound body. The negative electrode current collector exposed portion 22a is welded and connected to the negative electrode current collecting plate 51 provided between the columnar wound body 20 and the bottom face of the case 30. The negative electrode current collecting plate 51 is welded to the inner bottom face of the case 30 with a welding member 52. In the negative electrode 22 as well, similarly with the positive electrode 21, connection can be made with the negative electrode current collecting plate 51 or case 30 using tabs.

[0038] The case 30 is formed to have a bottomed cylindrical shape with a first opening 31, and accommodates the columnar wound body 20 and a non-aqueous electrolyte (not shown). The case 30 is a metal-made case, and functions as an external negative electrode terminal. The case 30 has a side wall portion 32 covering the outer periphery of the columnar wound body 20 and electrically connected to the negative electrode current collector. The side wall portion 32 of the case 30 is an example of the cylinder.

[0039] The sealing body 40 seals the first opening 31 of the case 30. The sealing body 40 is electrically connected to the positive electrode current collector through a plurality of positive electrode current collecting tabs 21a. The proximal end of the positive electrode current collecting tab 21a is connected to the first current collector, and the distal end of the positive electrode current collecting tab 21a is connected to the sealing body 40. The sealing body 40 is a metal-made body, and functions as an external positive electrode terminal. The sealing body 40 and the case 30 are insulated from each other with a gasket 70. The sealing body 40 may have an explosion protection mechanism, which is not shown.

[0040] The sealing body 40 has a first member 41 including a first face 41a facing away from the columnar wound body 20 (upper side in FIG. 1), and a second member 42 including a second face 42a facing a columnar wound body 20 side. The first member 41 is an annular member having a through hole 41b at a center for the positive electrode current collecting tab 21a to pass through. The second member 42 is a plate member for plugging the through hole 41b.

[0041] The distal end of the positive electrode current collecting tab 21a is welded to the first face 41a of the first member 41 and forms a first welding portion 43. The first welding portion 43 is sandwiched between the first face 41a and the second face 42a, and a pressure is applied from both of the first face 41a and second face 42a. In the first welding portion 43, the distal end of the plurality of positive electrode current collecting tabs 21a are overlapped and welded to the first face 41a of the first member 41. In the region of the first face 41a where the first welding portion 43 is formed, a recess deeper than the total thickness of the distal end of the plurality of positive electrode current collecting tabs 21a may be formed.

[0042] The first member 41 has a recessed portion 41c formed to be annular and having the first face 41a as the bottom face. The second member 42 has a center portion 42b plugging the through hole 41b of the first member 41 and an outer periphery portion 42c accommodated in the recessed portion 41c. The peripheral edge portion of the outer periphery portion 42c is welded and joined to the first member 41 throughout its entire periphery by a second welding portion 44 radially outside of the first welding portion 43. In this manner, even if a gap is formed between the first face 41a of the first member 41 and the second face 42a of the second member 42, sufficient sealing properties can be ensured in the case 30.

« Embodiment 2 »

[0043] Embodiment 2 of the present disclosure is described. The power storage device 10 of this embodiment is different from the above-described Embodiment 1 in terms of the configuration of the first member 41 and the second member 42. In the following, the points differing from the above-described Embodiment 1 are mainly described.

[0044] As shown in FIG. 2, the first member 41 does not have the recessed portion accommodating the second member 42. The outer peripheral edge portion of the first member 41 and the outer peripheral edge portion of the second member 42 are overlapped with each other and held by the gasket 70. The first member 41 and second member 42 are welded and joined to each other by the second welding portion 44 at the outer peripheral edge portion. In this case, no pressure is applied to the first welding portion 43 from the second face 42a, and a sufficiently large gap is present between the first face 41a and the second face 42a, more than the thickness of the distal end of the positive electrode current collecting tab 21a. Therefore, the effect of decreasing the contact resistance in the first welding portion 43 is milder than Embodiment 1. However, the disposition of the sec-

ond member 42 has no effect from the distal end thickness of the positive electrode current collecting tab 21a, and therefore production process can be stabilized.

<< Embodiment 3 >>

[0045] Embodiment 3 of the present disclosure is described. The power storage device 10 of this embodiment is different from the above-described Embodiment 1 in terms of not including the metal-made case 30. In the following, the points differing from the above-described Embodiment 1 are mainly described.

[0046] As shown in FIG. 3 and FIG. 4, in this embodiment, functions of the case 30 of Embodiment 1 are served by a cylinder 61 formed of a metal sheet wound body. The metal sheet is formed to be integrated with the negative electrode current collector, without limitation. The columnar wound body 20 is wound from left to right in FIG. 3. The cylinder 61 covers the outer periphery of the columnar wound body 20 and electrically connected to the negative electrode current collector.

[0047] The first opening 31 of the cylinder 61 is sealed with a sealing body 40. The cylinder 61 and sealing body 40 are insulated from each other with an insulative adhesive 80. The cylinder 61 has a second opening 61a at an opposite side of the first opening 31. The second opening 61a is sealed with a metal plate 62 (e.g., copper plate). The cylinder 61 and the metal plate 62 are welded and joined with each other throughout its entire periphery. Similarly with Embodiment 1, the negative electrode may be provided with a negative electrode current collector exposed portion, and the negative electrode current collector exposed portion and the metal plate 62 may be welded and joined.

[0048] Although the present invention has been described in terms of the presently preferred embodiments, it is to be understood that such disclosure is not to be interpreted as limiting. Various alterations and modifications will no doubt become apparent to those skilled in the art to which the present invention pertains, after having read the above disclosure. Accordingly, it is intended that the appended claims be interpreted as covering all alterations and modifications as fall within the true spirit and scope of the invention.

Industrial Applicability

[0049] The present disclosure can be applied to a power storage device.

Description of Reference Numerals

[0050]

10: power storage device
20: columnar wound body
21: positive electrode (first electrode)
21a: positive electrode current collecting tab (first tab)
22: negative electrode (second electrode)
22a: negative electrode current collector exposed portion
23: separator
30: case

31: first opening
32: side wall portion (cylinder)

40: sealing body

41: first member

41a: first face
41b: through hole
41c: recessed portion

42: second member

42a: second face
42b: center portion
42c: outer periphery portion

43: first welding portion
44: second welding portion

51: negative electrode current collecting plate
52: welding member
61: cylinder
61a: second opening
62: metal plate
70: gasket
80: adhesive

Claims

1. A power storage device comprising a first electrode having a strip first current collector and a first active material layer carried on the first current collector,

a second electrode having a strip second current collector and a second active material layer carried on the second current collector; and
a separator interposed between the first electrode and the second electrode, wherein
the first electrode, the second electrode, and the separator form a columnar wound body,
the power storage device further comprises
a cylinder covering an outer periphery of the columnar wound body, the cylinder being electrically connected to the second current collector, and having a first opening,
a sealing body that seals the first opening, and
at least one first tab that electrically connects the first current collector to the sealing body,
one end of the first tab is connected to the first

current collector,
the other end of the first tab is connected to the sealing body,
the sealing body has a first member including a first face facing away from the columnar wound body, and a second member including a second face facing the columnar wound body,
the other end of the first tab is welded to the first face of the first member to form a first welding portion, and
the first welding portion is positioned between the first face and the second face.

2. The power storage device of claim 1, wherein the first member is a annular member having a through hole at a center thereof for the first tab to pass through, and
the second member plugs the through hole.

3. The power storage device of claim 2, wherein the first member and the second member are welded by a second welding portion radially outside of the first welding portion.

4. The power storage device of claim 3, wherein the first member has a recessed portion formed into an annular shape and having the first face as a bottom face,

the second member has a center portion plugging the through hole and an outer peripheral portion surrounding the center portion, and
an entire periphery of the outer peripheral portion is joined to the first member by the second welding portion.

5. The power storage device of any one of claims 1 to 4, wherein the first tab is joined to the second face and the first face.

6. The power storage device of any one of claims 1 to 5, comprising a plurality of the first tabs, and
at least two of the other ends of the first tabs are overlapped with each other and welded to the first face of the first member.

7. The power storage device of any one of claims 1 to 6, wherein the cylinder is formed of a portion of a metal case.

8. The power storage device of any one of claims 1 to 6, wherein the cylinder is formed of a metal sheet wound body.

FIG. 1

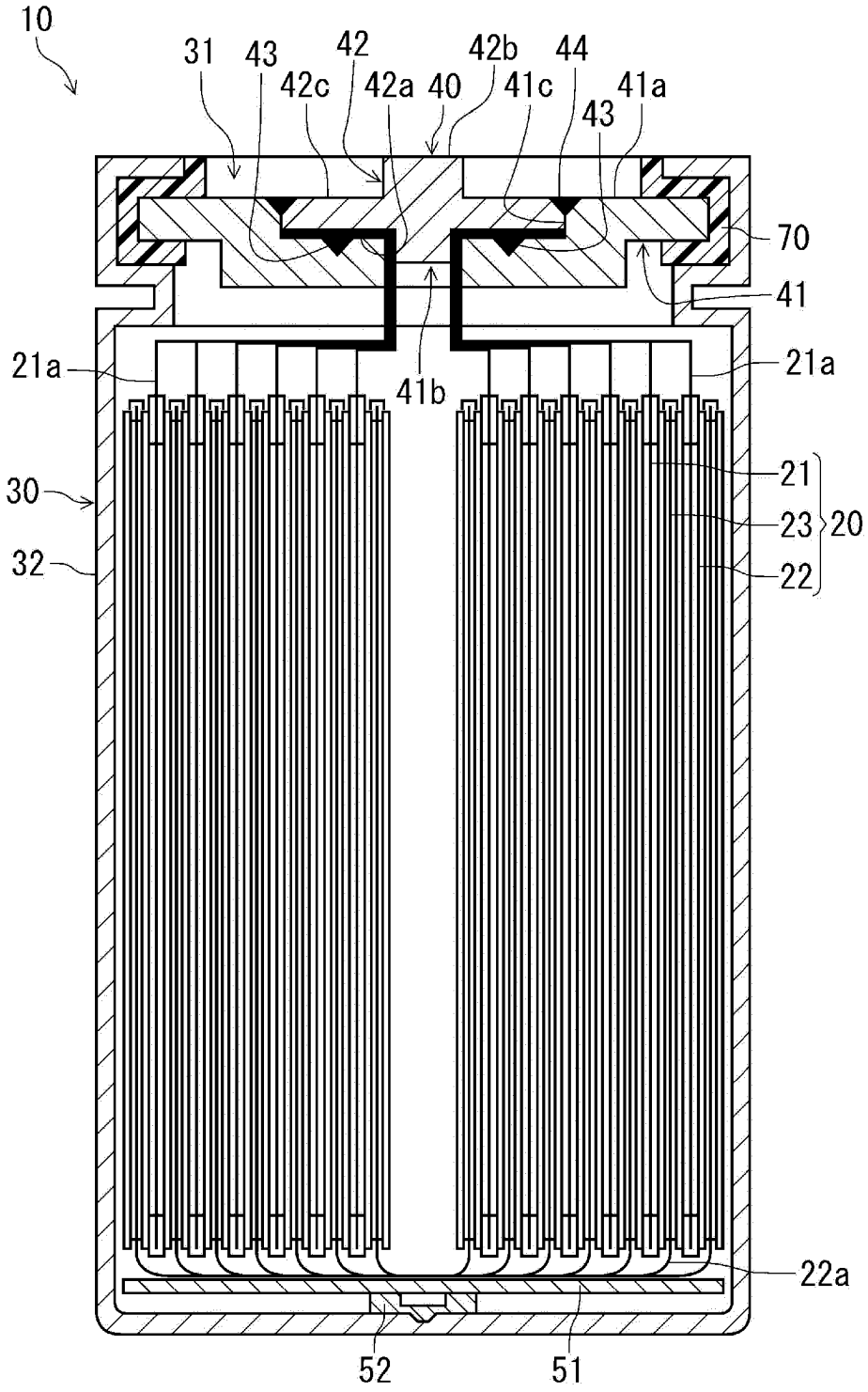

10
31
43
42
42c
42a
40
42b
41c
44
43
41a
70
41
21a
41b
21a
30
21
23
20
32
22
22a
52
51

FIG. 2

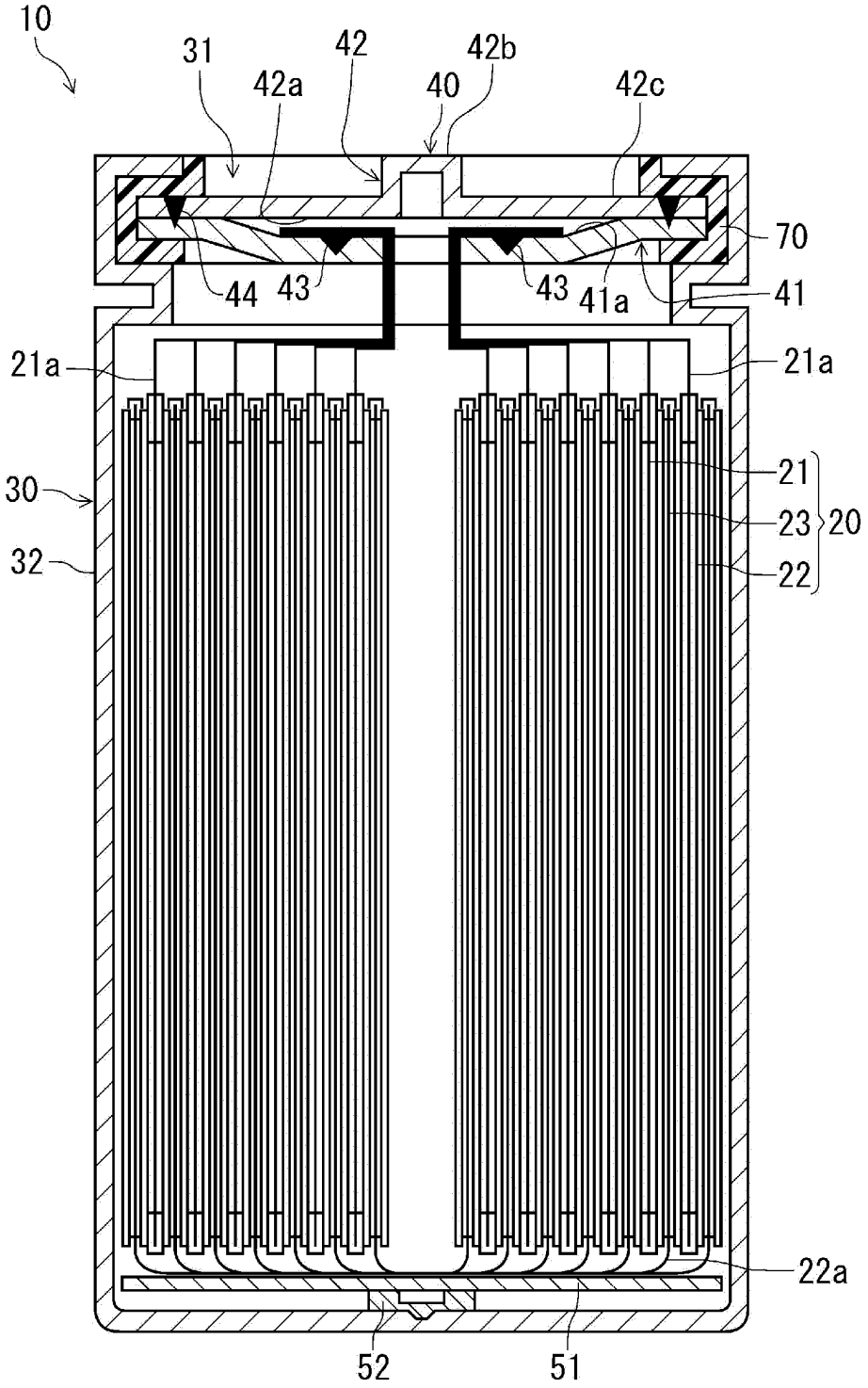

10
31
42
42b
42a
40
42c
70
44
43
43
41a
41
21a
21a
30
21
23
20
32
22
22a
52
51

FIG. 3

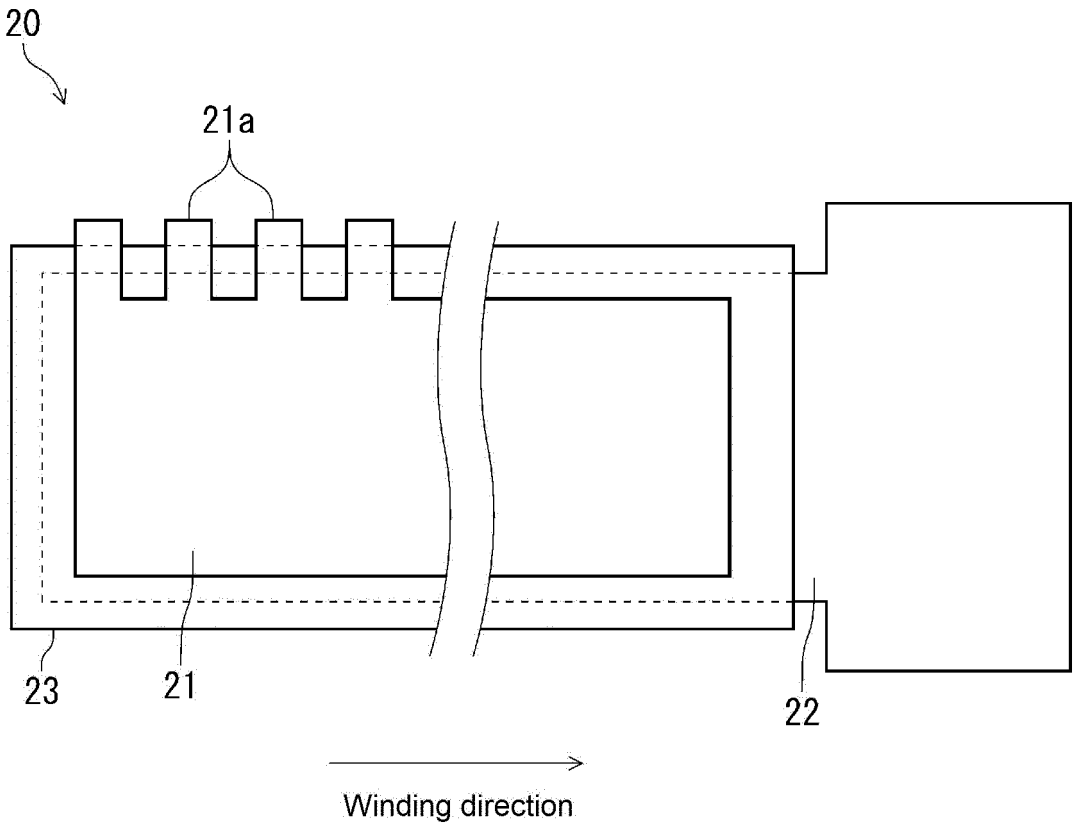
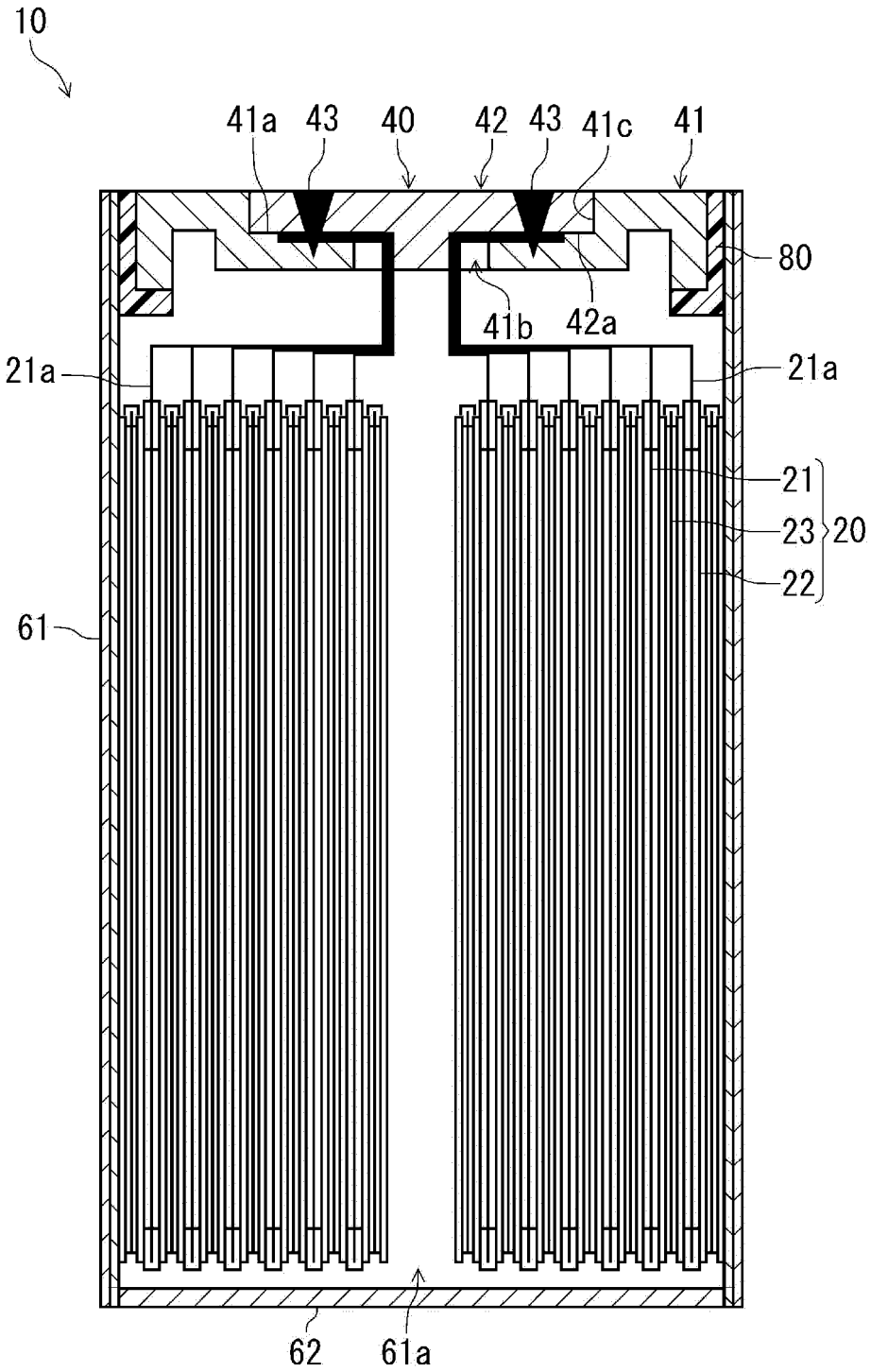


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/034620

A. CLASSIFICATION OF SUBJECT MATTER

H01M 10/04(2006.01)i; ***H01M 50/152***(2021.01)i; ***H01M 50/533***(2021.01)i; ***H01M 50/536***(2021.01)i
FI: H01M50/536; H01M50/533; H01M50/152; H01M10/04 W

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01M10/04; H01M50/152; H01M50/533; H01M50/536

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2021
Registered utility model specifications of Japan 1996-2021
Published registered utility model applications of Japan 1994-2021

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2000-243373 A (SANYO ELECTRIC CO., LTD.) 08 September 2000 (2000-09-08) paragraphs [0016], [0017], [0024], [0025], fig. 1	1-8
A	JP 11-312509 A (TOYOTA CENTRAL RES. & DEV. LAB., INC.) 09 November 1999 (1999-11-09) paragraphs [0013]-[0020], fig. 1-6	1-8
A	JP 2012-510143 A (A123 SYSTEMS, INC.) 26 April 2012 (2012-04-26) paragraphs [0022], [0028], [0029], fig. 3B	1-8
A	JP 2001-256994 A (SANYO ELECTRIC CO., LTD.) 21 September 2001 (2001-09-21) paragraphs [0002], [0003], fig. 7	1-8

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
11 November 2021	**22 November 2021**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/034620

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2000-243373 A	08 September 2000	(Family: none)	
JP 11-312509 A	09 November 1999	(Family: none)	
JP 2012-510143 A	26 April 2012	US 2010/0266893 A1 paragraphs [0031], [0037], [0038], fig. 3B CN 101916876 A KR 10-2011-0099110 A WO 2010/065378 A1	
JP 2001-256994 A	21 September 2001	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 4356209 B **[0003]**