US 20250266543A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2025/0266543 A1**

(43) **Pub. Date: Aug. 21, 2025**

TANAKA

(54) **BATTERY CELL, BATTERY MODULE, AND BATTERY CELL MANUFACTURING METHOD**

(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI KAISHA**, Aichi-ken (JP)

(72) Inventor: **Takumi TANAKA**, Toyota-shi (JP)

(21) Appl. No.: **19/021,167**

(22) Filed: **Jan. 15, 2025**

(30) **Foreign Application Priority Data**

Feb. 20, 2024 (JP) 2024-023400

Publication Classification

(51) **Int. Cl.**

H01M 50/186	(2021.01)
H01M 50/103	(2021.01)
H01M 50/198	(2021.01)
H01M 50/533	(2021.01)

(52) **U.S. Cl.**

CPC ***H01M 50/186*** (2021.01); ***H01M 50/103*** (2021.01); ***H01M 50/198*** (2021.01); ***H01M 50/533*** (2021.01)

(57) **ABSTRACT**

A battery cell includes: an electrode assembly in which positive electrodes and negative electrodes are alternately stacked in a first direction; a first current collector unit connected to at least one of the positive electrodes; a second current collector unit connected to at least one of the negative electrodes; and an exterior case accommodating the electrode assembly, the first current collector unit, and the second current collector unit. The exterior case includes a first casing body and a second casing body. At least a portion of the first current collector unit is located between the first casing body and the electrode assembly in the first direction and is electrically connected to the first casing body. At least a portion of the second current collector unit is located between the second casing body and the electrode assembly in the first direction, and is electrically connected to the second casing body.

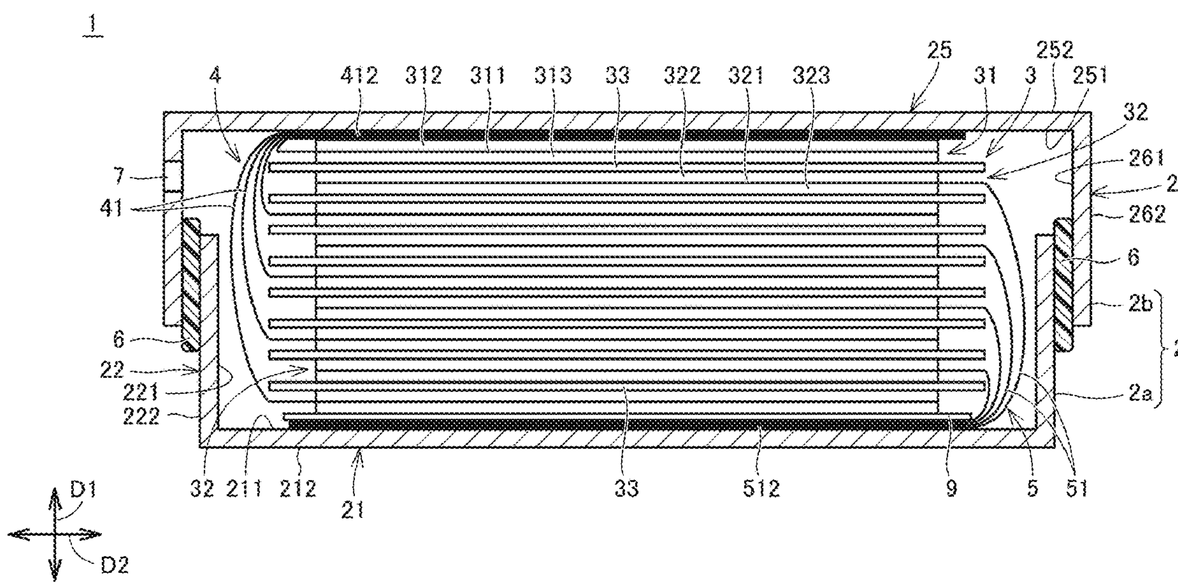


FIG.1

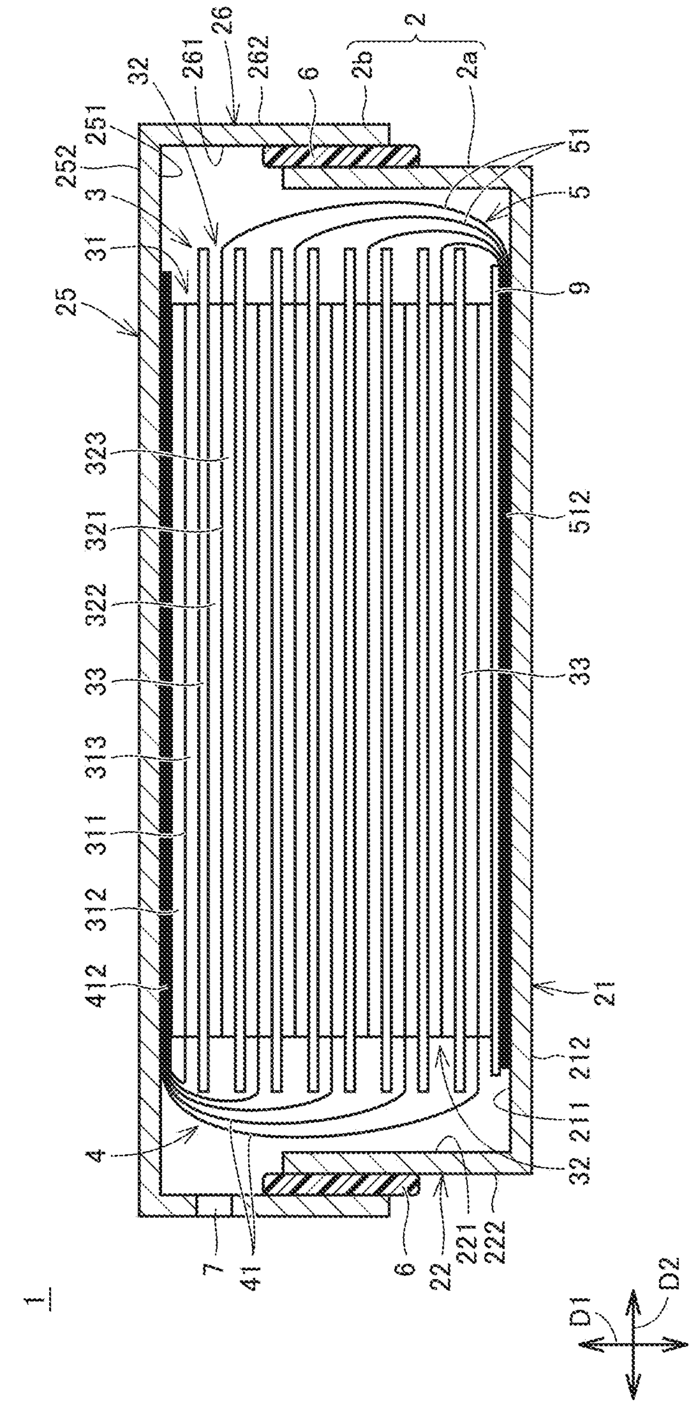

1
2
2a
2b
6
262
26
261
32
251
252
3
31
25
5
51
9
323
321
322
33
313
311
312
412
4
7
41
6
22
221
222
32
211
212
21
512
33
D1
D2

FIG.2

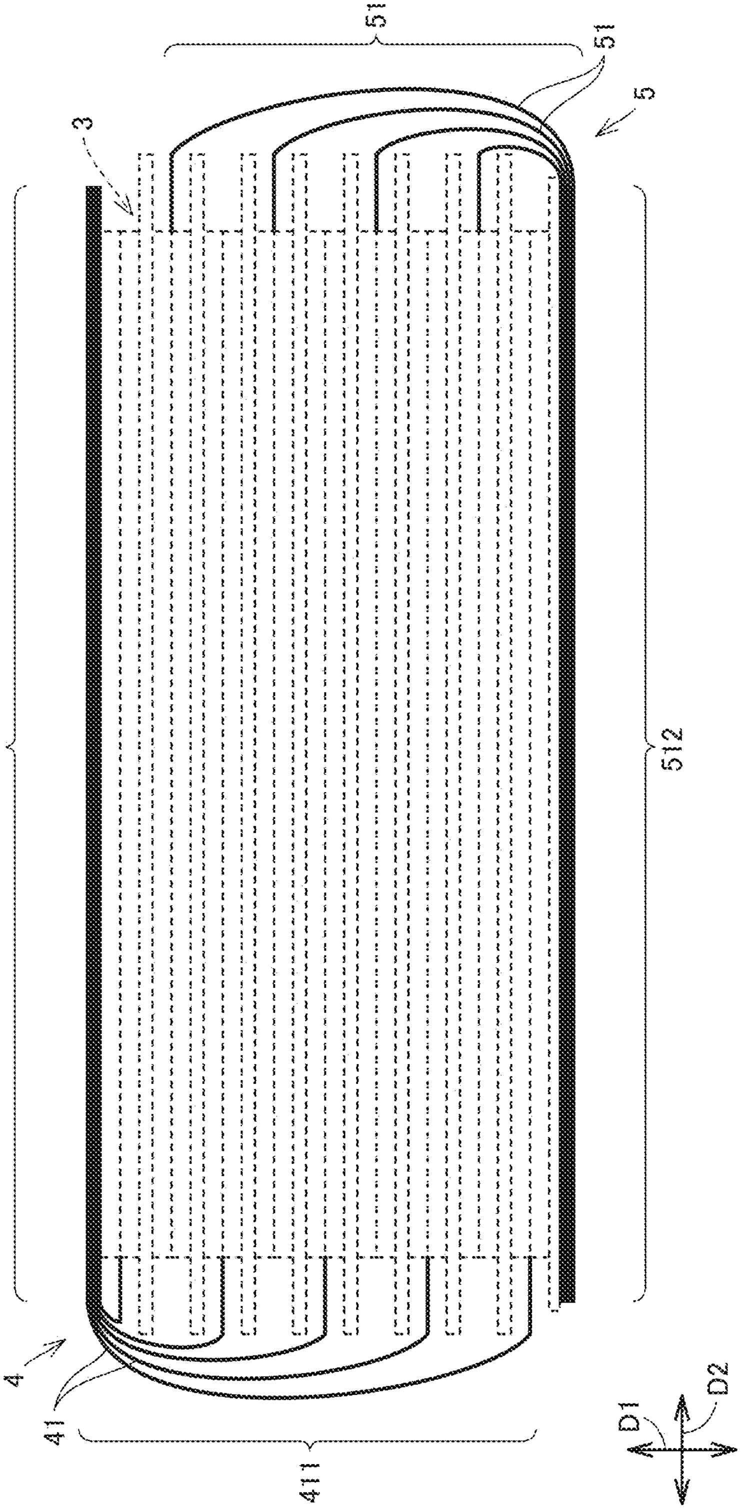


FIG.3

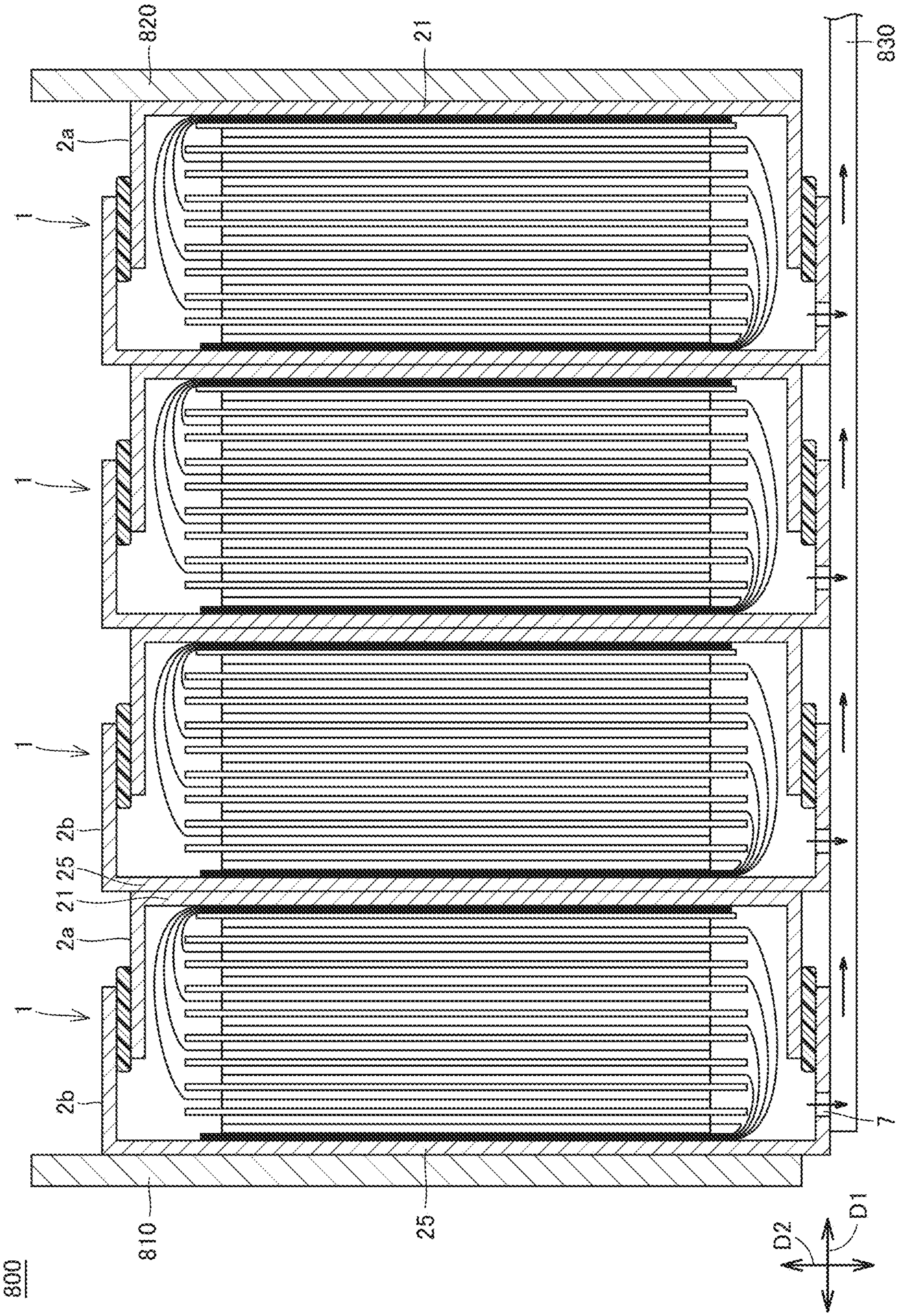


FIG.4

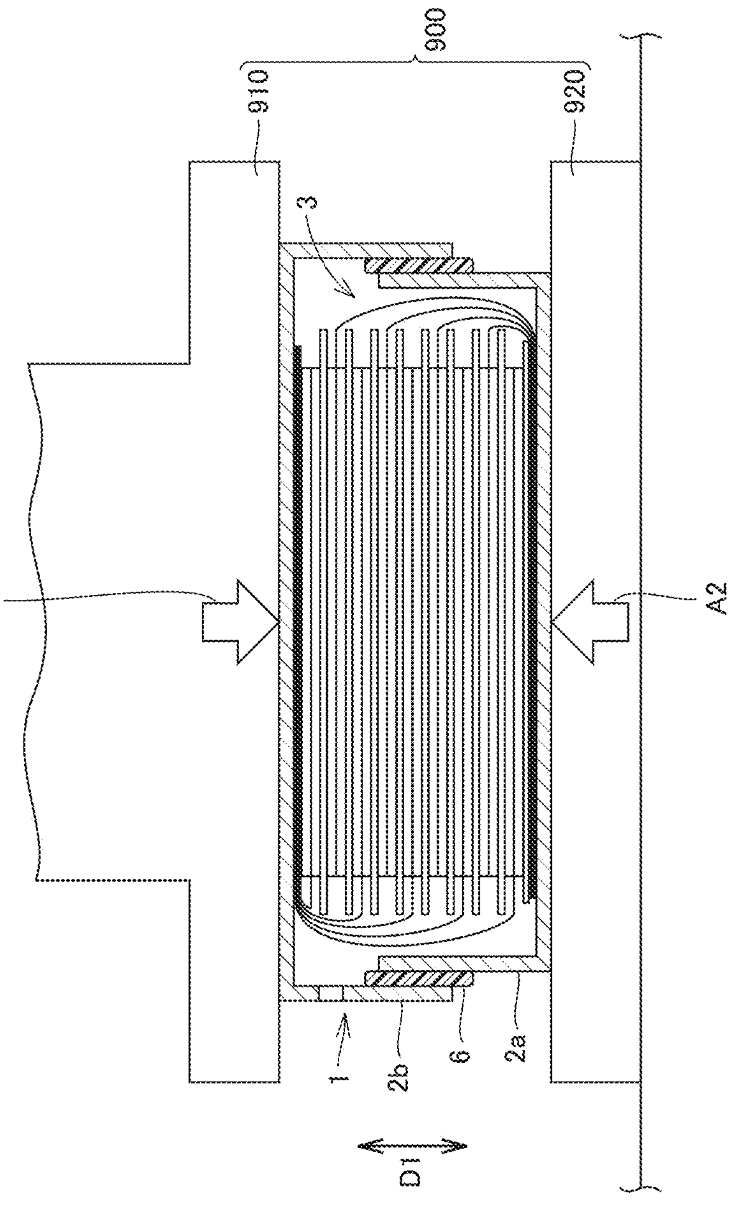


FIG.5

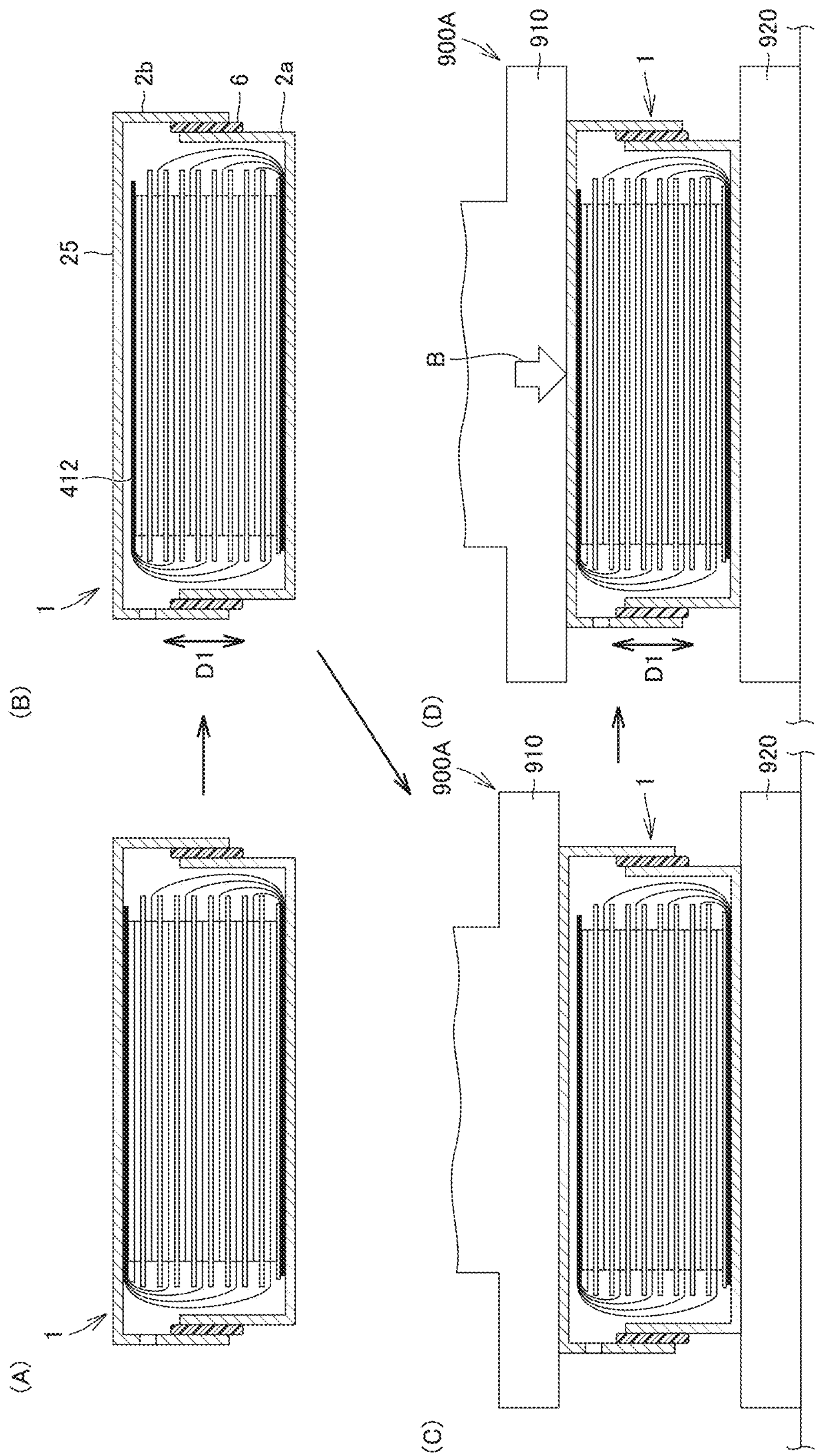


FIG.6

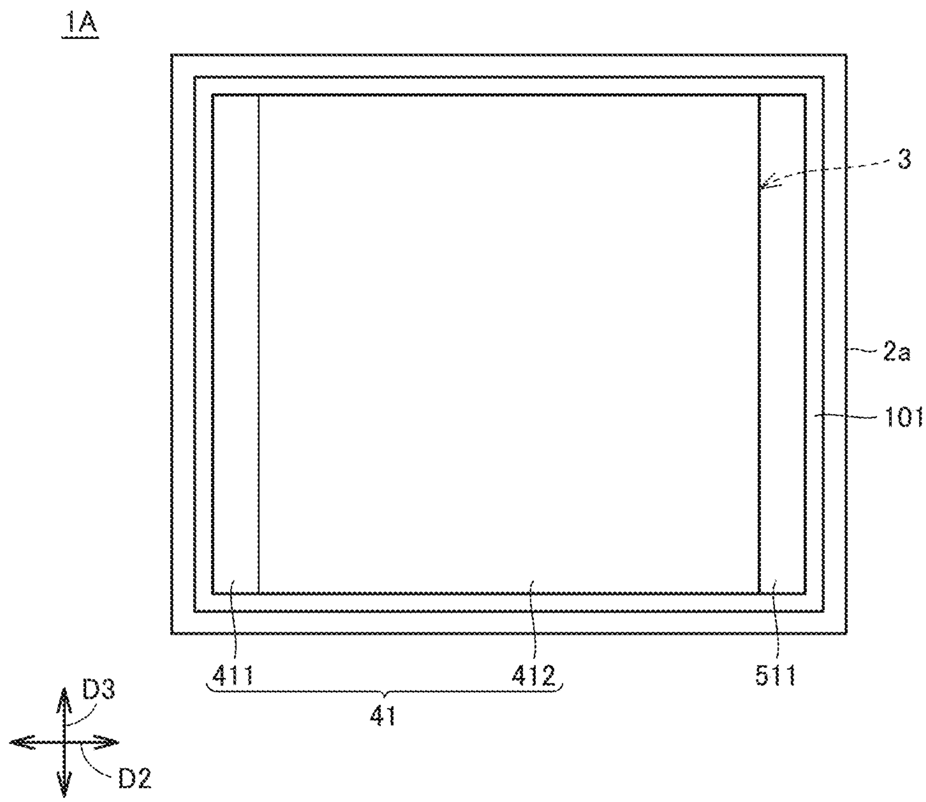
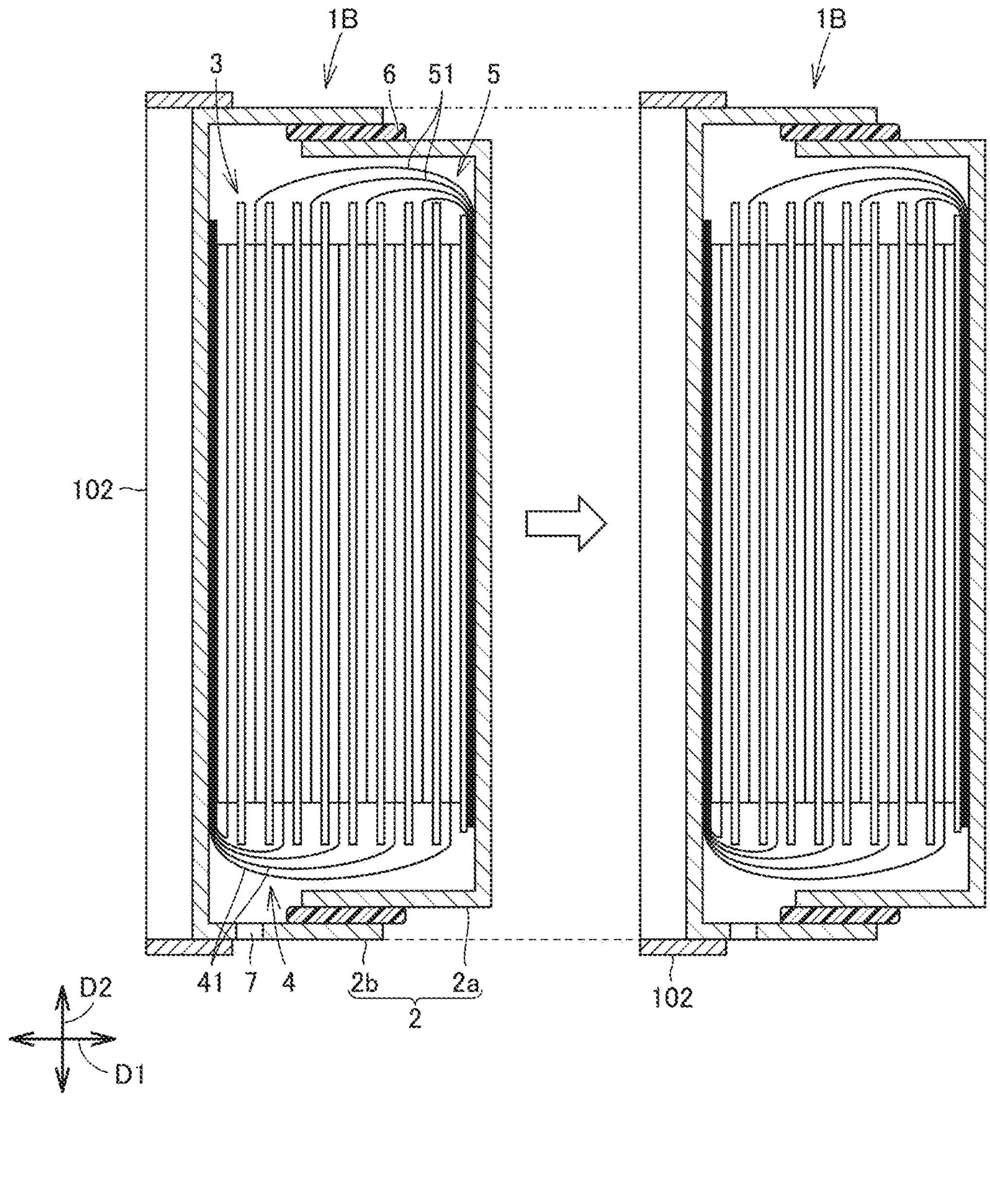


FIG.7



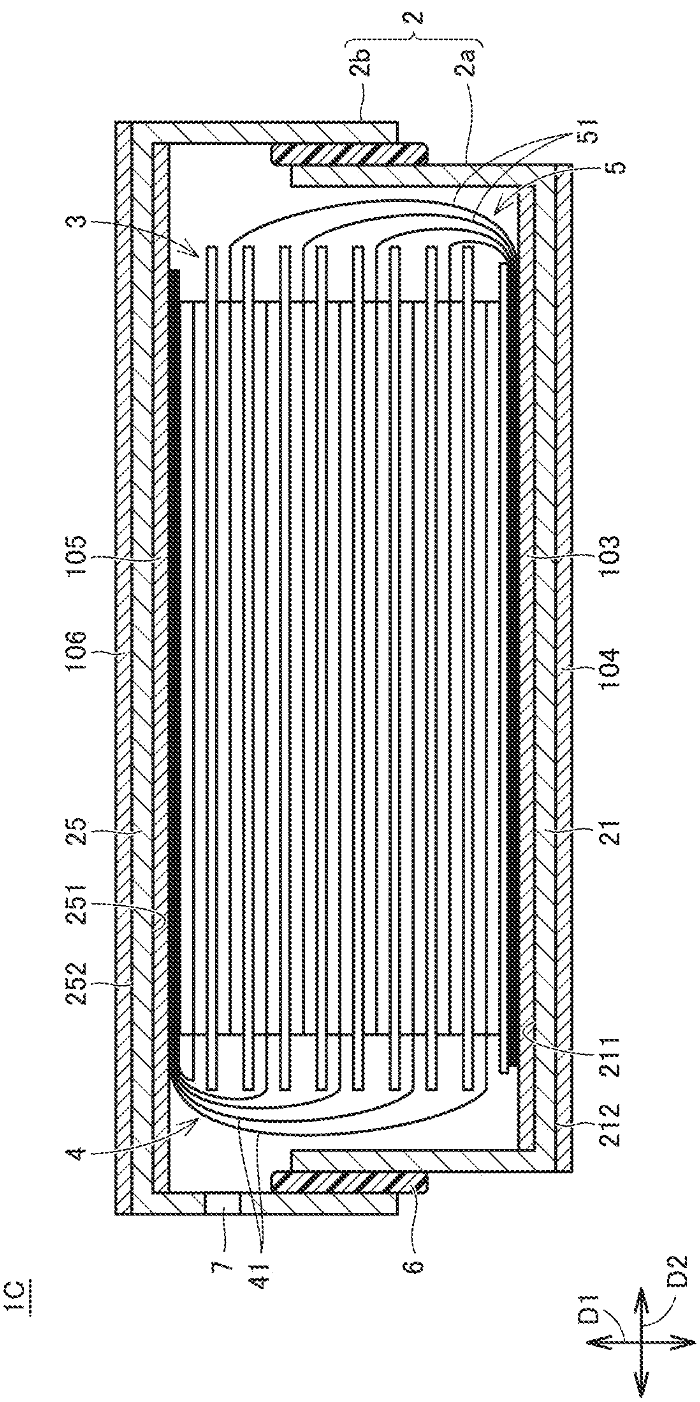
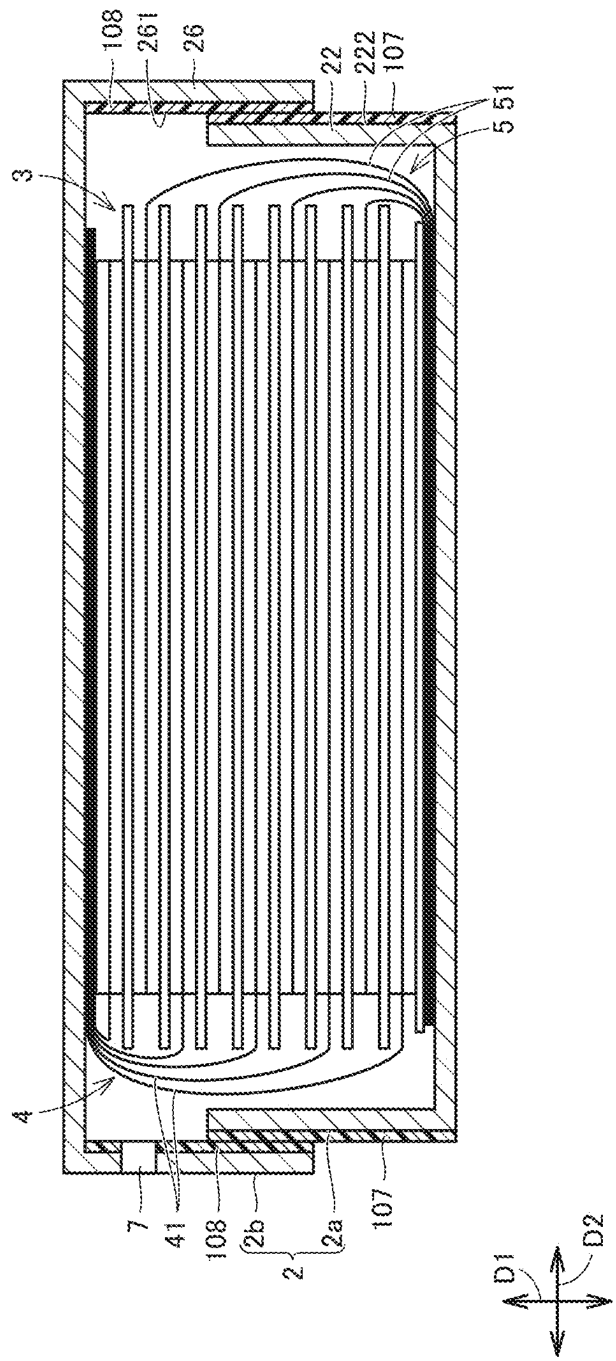


FIG.8

FIG.9

1D



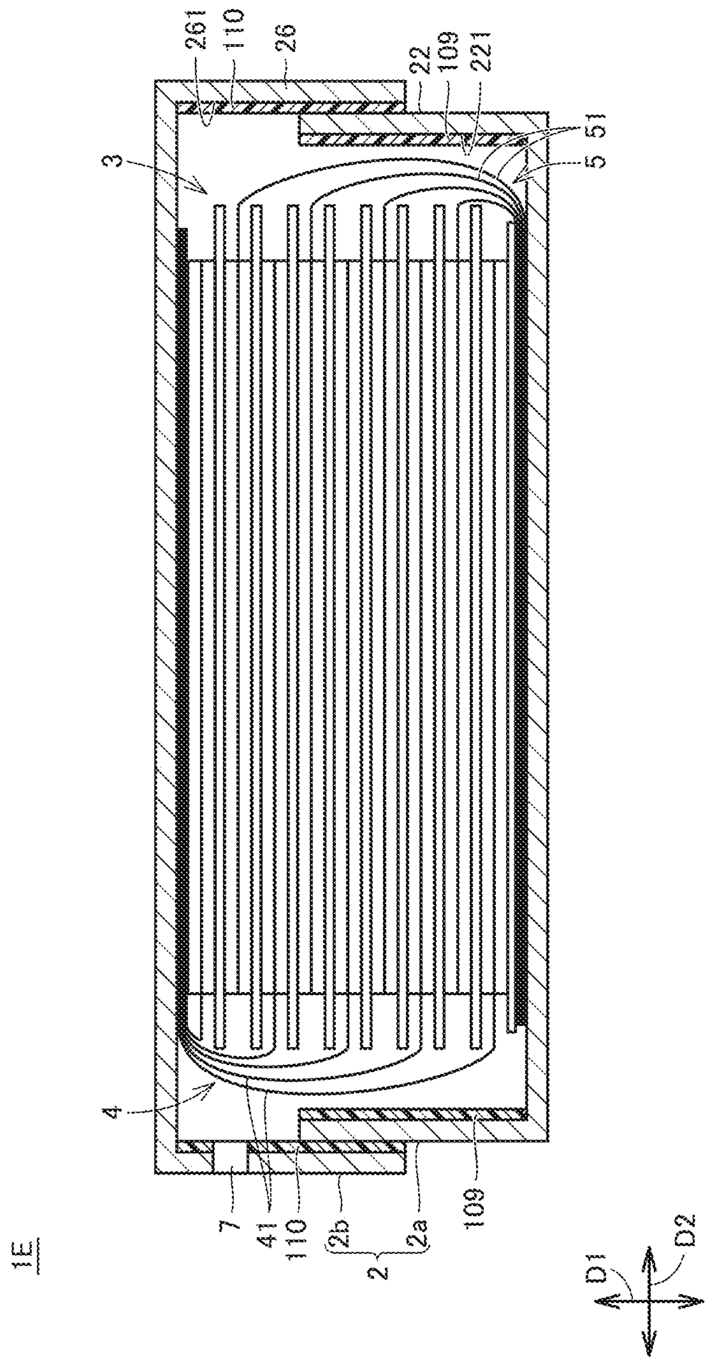


FIG.10

FIG.11

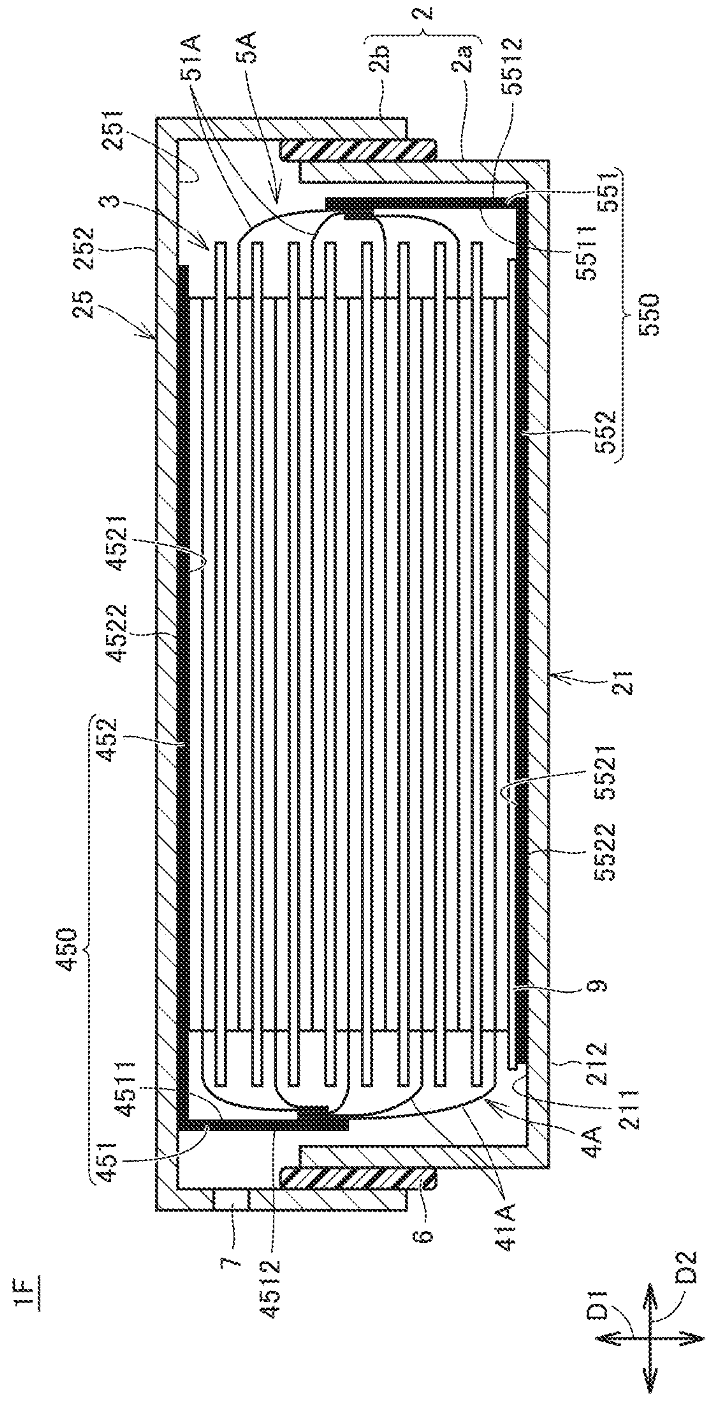

1F
2
2a
2b
5512
51A
5A
251
3
252
25
551
5511
550
552
4521
4522
21
452
5521
5522
450
9
212
211
4511
4A
451
41A
6
7
4512
D1
D2

FIG.12

1G

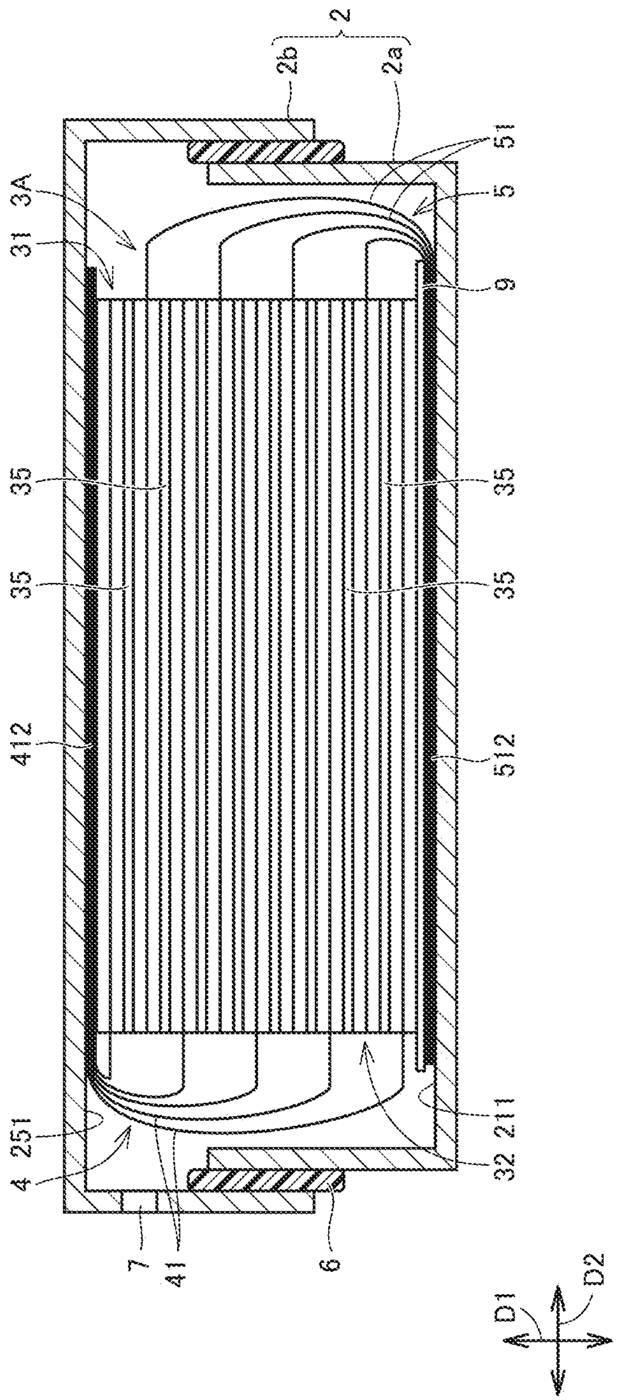


FIG.13

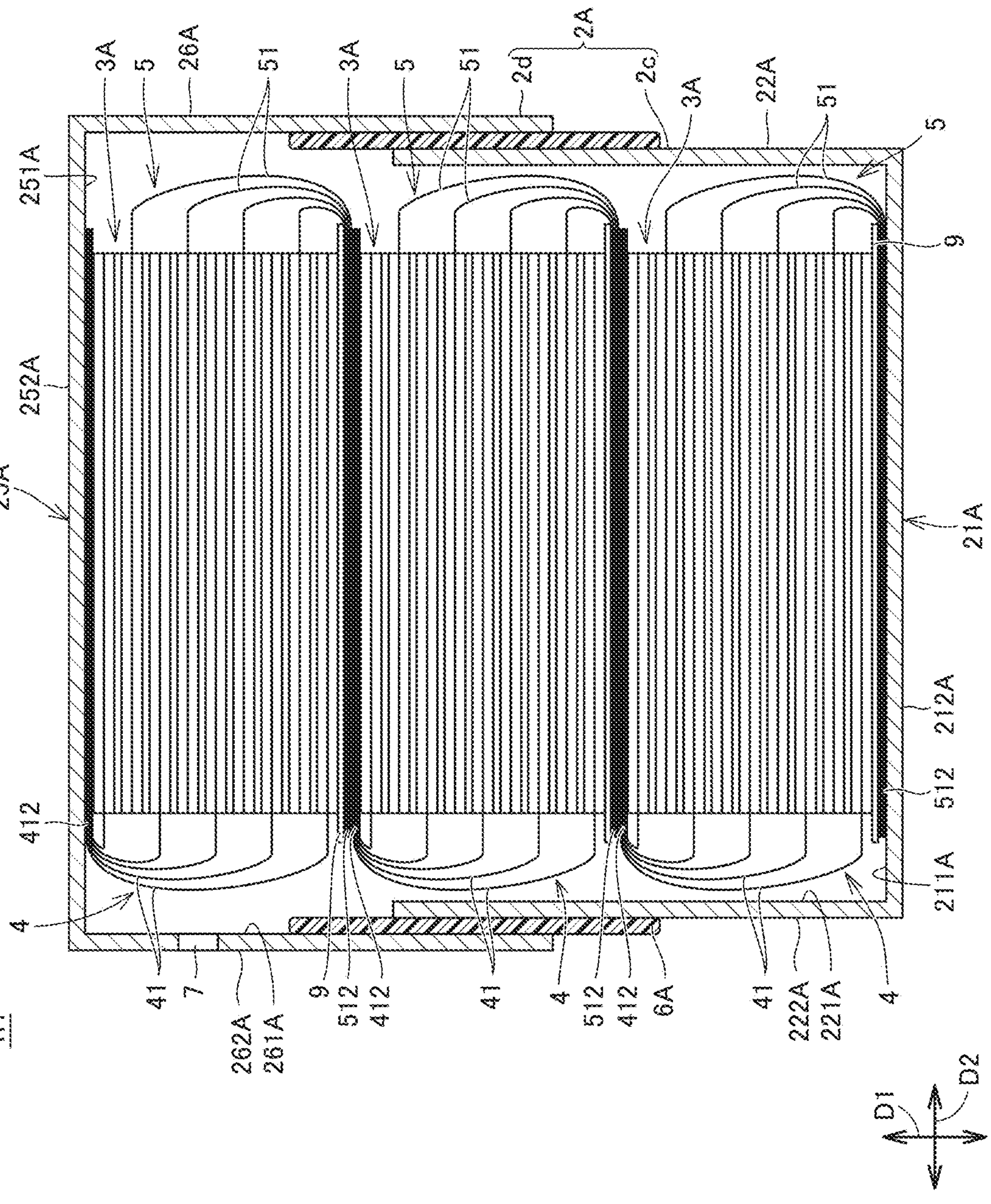

1H
2A
2d
2c
3A
5
26A
51
22A
251A
252A
25A
21A
212A
512
211A
9
412
4
41
7
262A
261A
222A
221A
6A
D1
D2

FIG.14

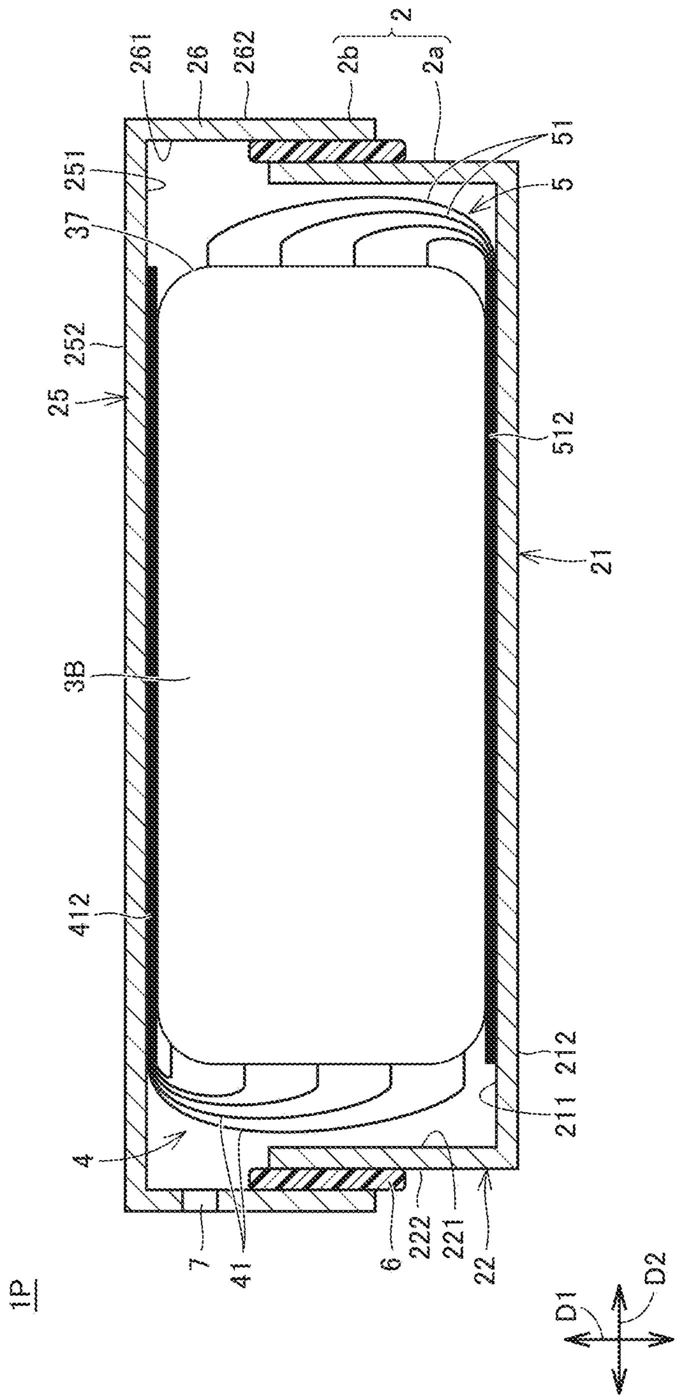

1P
2
2b
2a
261
26
262
51
5
251
37
252
25
512
21
3B
412
212
211
4
7
41
6
222
221
22
D1
D2

FIG.15

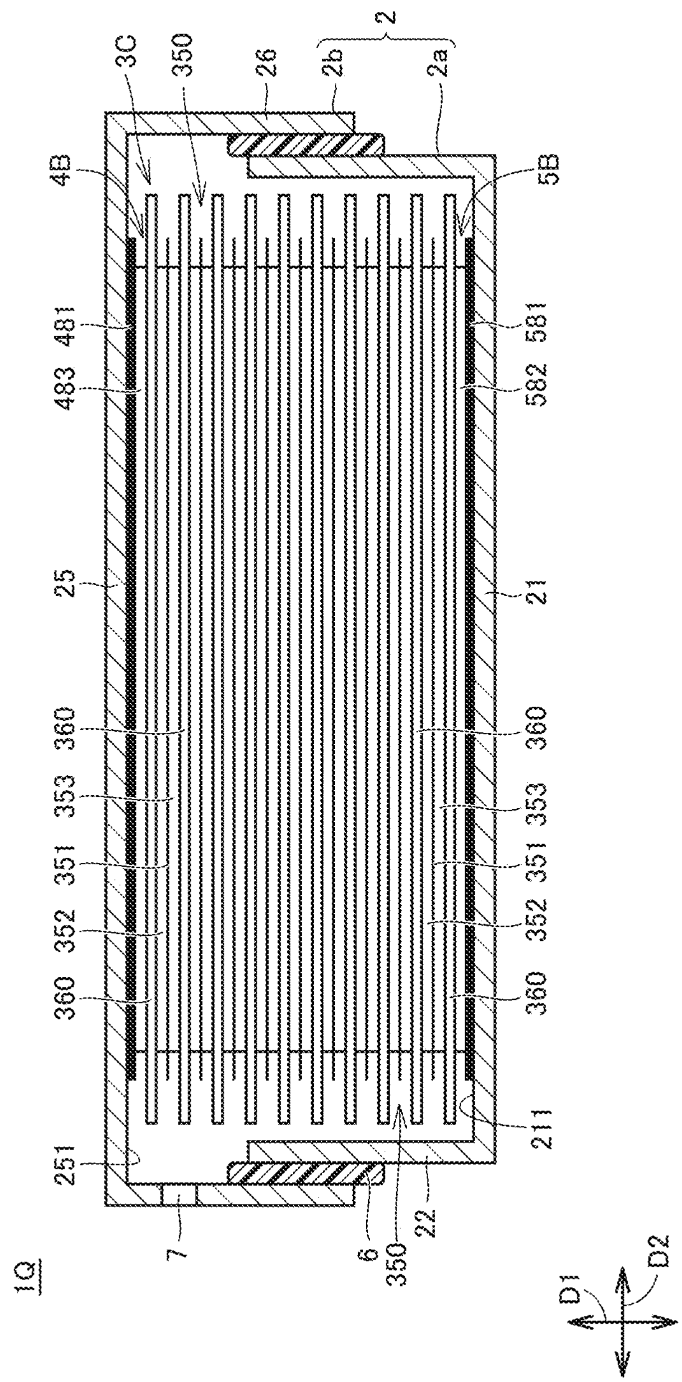

1Q
2
2a
2b
26
350
3C
4B
5B
481
483
581
582
25
21
360
353
351
352
360
353
351
352
360
360
251
211
7
6
350
22
D1
D2

FIG.16

1R

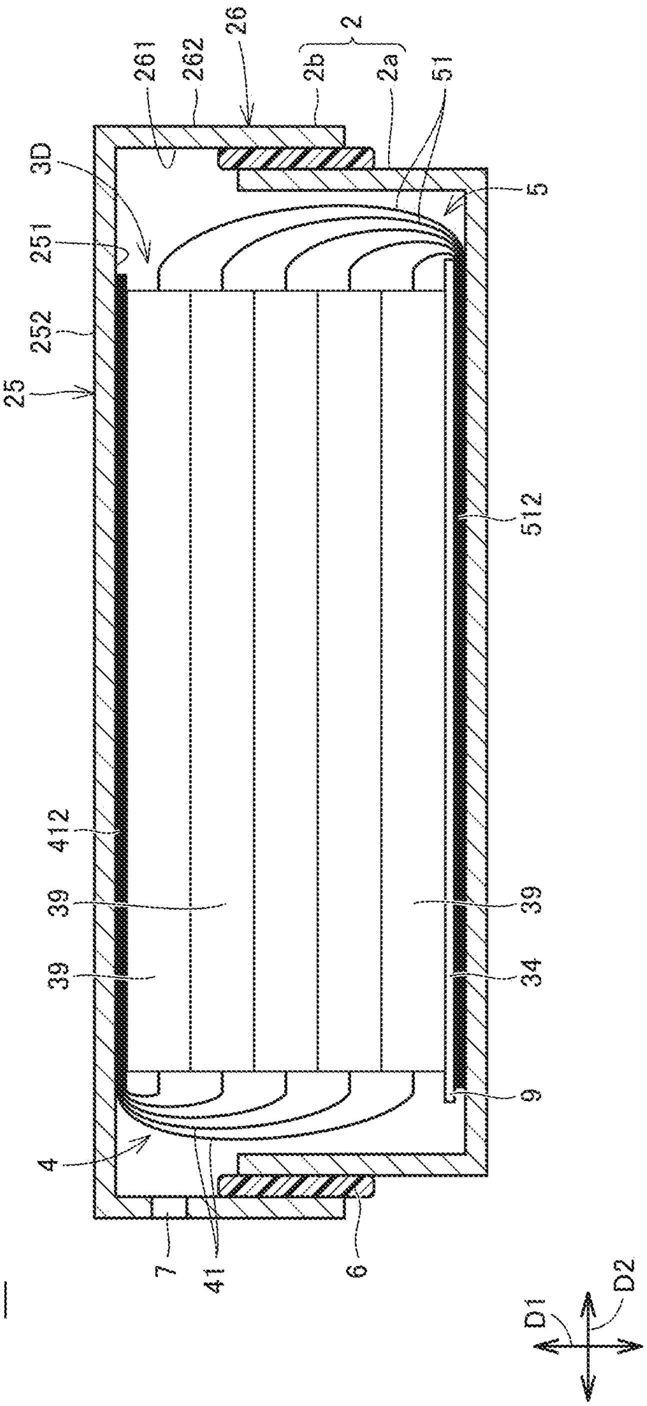
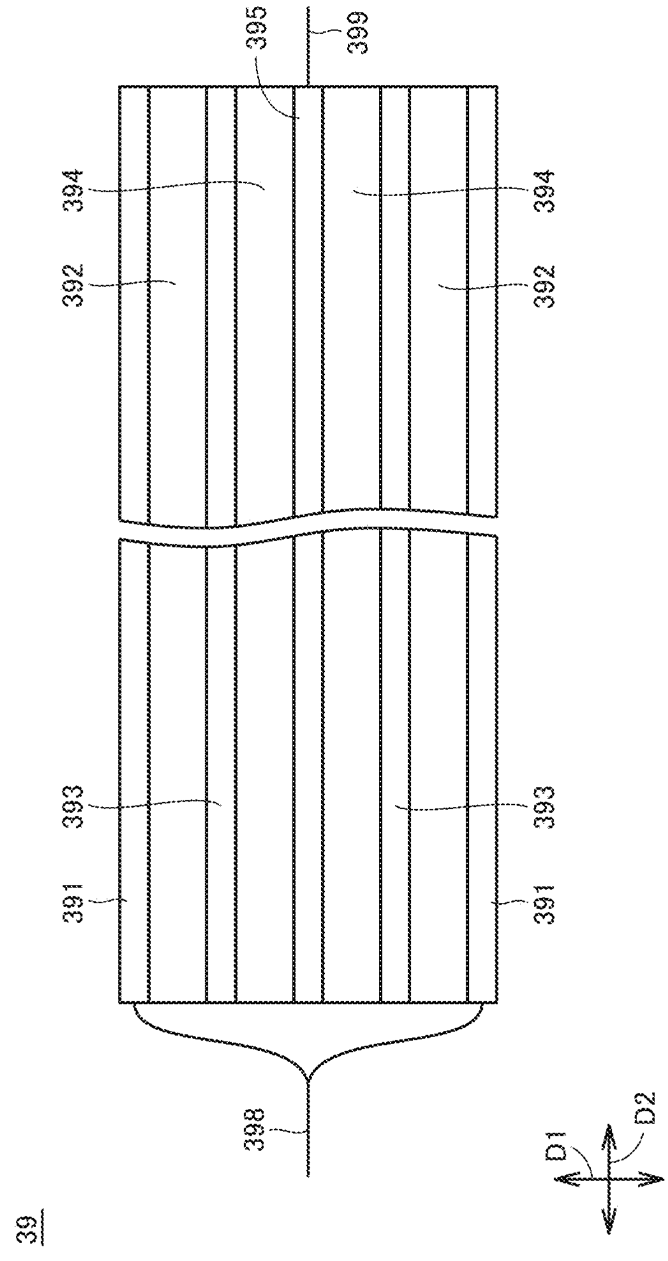

2
26
262
261
2b
2a
51
3D
5
251
252
25
512
412
39
39
39
34
9
4
7
41
6
D1
D2

FIG.17



BATTERY CELL, BATTERY MODULE, AND BATTERY CELL MANUFACTURING METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This nonprovisional application is based on Japanese Patent Application No. 2024-023400 filed on Feb. 20, 2024 with the Japan Patent Office, the entire content of which is hereby incorporated by reference.

BACKGROUND

Field

[0002] The present disclosure relates to a battery cell, a battery module, and a battery cell manufacturing method.

Description of the Background Art

[0003] Conventionally, various battery cells are known. As such a battery cell, for example, Japanese Patent Laying-Open No. 2005-310618 discloses a nonaqueous electrolyte secondary battery. The nonaqueous electrolyte secondary battery includes a group of electrode plates obtained by winding into a spiral shape, via a separator, a positive plate having an active material deposited on a band current collector and a negative plate having an active material deposited on a band current collector. The group of electrode plates and a nonaqueous electrolyte are inserted in a metal exterior case. The outermost periphery of the group of electrode plates is formed of a positive current collector that has no active material deposited thereon. The positive current collector is in contact with the inner wall of the exterior case.

SUMMARY

[0004] In the battery cell disclosed in Japanese Patent Laying-Open No. 2005-310618, the negative-current collector unit (the negative current collector) is not in contact with the exterior case. Therefore, there is still room to further improve the volume efficiency.

[0005] The present disclosure is to provide a battery cell having an increased volume efficiency, a battery module including the battery cell, and a method of manufacturing the battery cell.

[0006] According to a certain aspect of the present disclosure, a battery cell includes: an electrode assembly in which positive electrodes and negative electrodes are alternately stacked in a first direction; a first current collector unit connected to at least one of the positive electrodes; a second current collector unit connected to at least one of the negative electrodes; and an exterior case accommodating the electrode assembly, the first current collector unit, and the second current collector unit. The exterior case includes a first casing body and a second casing body. At least a portion of the first current collector unit is located between the first casing body and the electrode assembly in the first direction and is electrically connected to the first casing body. At least a portion of the second current collector unit is located between the second casing body and the electrode assembly in the first direction, and is electrically connected to the second casing body.

[0007] With such a configuration, the first current collector unit can cause the first casing body of the exterior case to function as a terminal for the positive electrodes. The second current collector unit can cause the second casing body of the exterior case to function as a terminal for the negative electrodes.

[0008] Furthermore, a portion of the first current collector unit located between the first casing body and the stacked electrode assembly in the first direction is connected to the first casing body. A portion of the second current collector unit located between the cover and the stacked electrode assembly in the first direction is connected to the second casing body. Accordingly, the first current collector unit and the second current collector unit be brought into contact with the exterior case, while being separated from each other in the first direction.

[0009] Therefore, according to the battery cell, the volumetric efficiency can be increased, as compared to a battery cell configuration in which only one of the current collector unit for the positive electrodes and the current collector unit for the negative electrodes is in contact with the exterior case.

[0010] Preferably, the first casing body has a first base connected to the at least a portion of the first current collector unit, and a first side wall extending from an outer periphery of the first base in a first orientation of the first direction, the first orientation pointing toward the electrode assembly. The second casing body has a second base opposite the first base and connected to the at least a portion of the second current collector unit, and a second side wall extending from an outer periphery of the second base in a second orientation opposite the first orientation. The first side wall and the second side wall partially overlap, as viewed in a second direction perpendicular to the first direction.

[0011] With such a configuration, stacked electrode assembly, the first current collector unit, the second current collector unit, and the insulating material can certainly be sealed in the exterior case.

[0012] Preferably, an insulating material is loaded between the first side wall portion and the second side wall portion.

[0013] With such a configuration, a short circuit can be prevented from occurring between the first casing body and the second casing body of the exterior case.

[0014] Preferably, the first current collector unit includes a plurality of first current-collector foils which are each connected to a different positive electrode among the positive electrodes. The first current-collector foils each have a first part extending from the positive electrode in a direction toward the first base, and a second part which continues to the first part and extends in parallel to the first base between the first base and the electrode assembly. The second part is electrically connected to the first casing body and opposite the negative electrode in the first direction. The second part and the negative electrode opposite the second part in the first direction are insulated from each other.

[0015] With such a configuration, a short circuit can be prevented from occurring between the first current collector unit and the negative electrode opposite a portion of the first current collector unit in the first direction.

[0016] Preferably, the second current collector unit includes a plurality of second current-collector foils which are each connected to a different negative electrode among the negative electrodes. The second current-collector foils each have a first part extending from the negative electrode in a direction toward the second base, and a second part which continues to the first part and extends in parallel to the second base between the second base and the electrode assembly. The second part is electrically connected to the second casing body and opposite the positive electrode in the first direction. The second part and the positive electrode opposite the second part in the first direction are insulated from each other.

[0017] With such a configuration, a short circuit can be prevented from occurring between the second current collector unit and the positive electrode opposite a portion of the second current collector unit in the first direction.

[0018] Preferably, the electrode assembly further includes a separator layer between the positive electrode and the negative electrode, the separator layer including a solid electrolyte.

[0019] With such a configuration, no injection of the electrolyte solution in the exterior case is required. Thus, the electrode assembly can be subjected to discharge and charge tests prior to be accommodated into exterior case.

[0020] Preferably, one of the first casing body and the second casing body is a main unit of the exterior case and the other one of the first casing body and the second casing body is a cover of the exterior case.

[0021] With such a configuration, one of the first casing body and the second casing body functioning as the main unit is put on the other one of the first casing body and the second casing body, thereby the electrode assembly being accommodated in the exterior case.

[0022] According to another aspect of the present disclosure, the battery module includes a plurality of battery cells, including the above-described battery cell, and the plurality of battery cells are stacked in the first direction.

[0023] With such a configuration, the volumetric efficiency of the battery cell can be improved, thereby improved the volumetric efficiency of the battery module.

[0024] According to still another aspect of the present disclosure, a battery cell manufacturing method includes: mounting a battery cell having: an electrode assembly in which positive electrodes and negative electrodes are alternately stacked in a first direction; a first current collector unit connected to at least one of the positive electrodes; and a second current collector unit connected to at least one of the negative electrodes so that the first current collector unit is in contact with a first casing body of an exterior case of the battery cell in the first direction; moving the first casing body and a second casing body of the exterior case relative to each other so that the second current collector unit is in contact with the second casing body in the first direction; and securing one of the first casing body and the second casing body to the other one of the first casing body and the second casing body.

[0025] With such a configuration, a battery cell having a high volumetric efficiency can be manufactured.

[0026] Preferably, the first casing body has a first base connected to the at least a portion of the first current collector unit, and a first side wall extending from an outer periphery of the first base in a first orientation of the first direction, the first orientation pointing toward the electrode assembly. The second casing body has a second base opposite the first base and connected to the at least a portion of the second current collector unit, and a second side wall extending from an outer periphery of the second base in a second orientation opposite the first orientation. The first side wall and the second side wall partially overlap, as viewed in a second direction perpendicular to the first direction. The battery cell manufacturing method further include loading an insulating material between the first side wall and the second side wall.

[0027] With such a configuration, the second casing body and the first casing body of the exterior case can be insulated from each other. Therefore, a short circuit can be prevented from occurring between the second casing body and the first casing body.

[0028] The foregoing and other objects, features, aspects and advantages of the present disclosure will become more apparent from the following detailed description of the present disclosure when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] FIG. **1** is a diagram showing a battery cell.

[0030] FIG. **2** is a diagram showing a positive-current collector unit and a negative-current collector unit.

[0031] FIG. **3** is a diagram showing a battery module.

[0032] FIG. **4** is a diagram for illustrating a method for manufacturing the battery cell.

[0033] FIG. **5** is a diagram for illustrating a repair method for the battery cell.

[0034] FIG. **6** is a diagram illustrating a variation of the battery cell.

[0035] FIG. **7** is a diagram illustrating another variation of the battery cell.

[0036] FIG. **8** is a diagram illustrating still another variation of the battery cell.

[0037] FIG. **9** is a diagram illustrating still another variation of the battery cell.

[0038] FIG. **10** is a diagram illustrating still another variation of the battery cell.

[0039] FIG. **11** is a diagram illustrating still another variation of the battery cell.

[0040] FIG. **12** is a diagram showing a battery cell according to another embodiment.

[0041] FIG. **13** is a diagram showing a battery cell according to still another embodiment.

[0042] FIG. **14** is a diagram showing a battery cell according to still another embodiment.

[0043] FIG. **15** is a diagram showing a battery cell according to still another embodiment.

[0044] FIG. **16** is a diagram showing a battery cell according to still another embodiment.

[0045] FIG. **17** is a diagram showing an electrode unit.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0046] Hereinafter, embodiments according to the present disclosure will be described, with reference to the accompanying drawings. In the following description, the same reference signs refer to the same members. Their names and functionalities are also the same. Therefore, detailed description thereof will not be repeated.

[0047] Various battery cells and battery modules including the battery cells (described below) are mounted on hybrid electric vehicles capable of traveling using a mechanical power of at least one of the motor or the engine, or electric-powered vehicles such as electric vehicles that travel using a driving force obtained from electrical energy.

[0048] In the following, the terms upward, downward, top, and bottom are based on positions of a battery cell during manufacture. The position of the battery cell when mounted on an electric-powered vehicle is not necessarily be the same as that during manufacture.

Embodiment 1

(1. Battery Cell)

[0049] FIG. **1** is a diagram showing a battery cell according to the present embodiment. As shown in FIG. **1**, a battery cell **1** includes an exterior case **2**, a stacked electrode assembly **3**, a positive-current collector unit **4**, a negative-current collector unit **5**, an insulating material **6**, and an insulating sheet **9**. Note that, for convenience of illustration, FIG. **1** shows cross sections of exterior case **2** and insulating material **6**.

[0050] Exterior case **2** accommodates stacked electrode assembly **3**, positive-current collector unit **4**, and negative-current collector unit **5**. Exterior case **2** includes a main unit **2***a* and a cover **2***b*. Main unit **2***a* has a bottom **21** and a side wall portion **22** projecting upward from the outer periphery of bottom **21**. Cover **2***b* has a top **25** opposite the bottom **21**, and a side wall portion **26** projecting downward from the outer periphery of top **25**.

[0051] Note that one of main unit **2***a* and cover **2***b* corresponds to a "first casing body" according to the present disclosure, and the other corresponds to a "second casing body" according to the present disclosure. One of bottom **21** and top **25** corresponds to a "first base" according to the present disclosure and the other corresponds to a "second base" according to the present disclosure.

[0052] Cover **2***b* is put on main unit **2***a* to cover a portion of side wall portion **22** of main unit **2***a*. Side wall portion **22** and side wall portion **26** partially overlap as viewed from D2 direction perpendicular to D1 direction which is the direction in which stacked electrode assembly **3** is stacked.

[0053] Exterior case **2**, typically, has a generally parallelepiped shape. However, the shape of exterior case **2** is not limited thereto. In this example, exterior case **2** is filled with an electrolyte solution. The interior of exterior case **2** is in vacuum.

[0054] Bottom **21** of main unit **2***a* has an inner wall surface **211** and an outer wall surface **212**. Side wall portion **22** of main unit **2***a* has an inner wall surface **221** and an outer wall surface **222**. Inner wall surface **211** and inner wall surface **221** are wall surfaces on the stacked electrode assembly **3** side.

[0055] Top **25** of cover **2***b* has an inner wall surface **251** and an outer wall surface **252**. Side wall portion **26** of cover **2***b* has an inner wall surface **261** and an outer wall surface **262**. Inner wall surface **251** and inner wall surface **261** are wall surfaces on the stacked electrode assembly **3** side. Inner wall surface **251** is opposite the inner wall surface **211** of bottom **21**.

[0056] There is a gap between side wall portion **22** of main unit **2***a* and side wall portion **26** of cover **2***b*. Specifically, there is a gap between outer wall surface **222** of side wall portion **22** and inner wall surface **261** of side wall portion **26**. More specifically, outer wall surface **222** of main unit **2***a* and inner wall surface **261** of cover **2***b* partially oppose to each other.

[0057] Insulating material **6** is loaded between side wall portion **22** and side wall portion **26**. Insulating material **6** is loaded between outer wall surface **222** and inner wall surface **261**. Insulating material **6** is loaded in a region (gap) where outer wall surface **222** and inner wall surface **261** oppose to each other. Insulating material **6** insulates main unit **2***a* and cover **2***b* from each other. Insulating material **6** allows cover **2***b* to be secured to main unit **2***a*. Insulating material **6** restricts the movement of cover **2***b* toward main unit **2***a* in D**1** direction. Insulating material **6** further restricts the movement of cover **2***b* toward main unit **2***a* in D2 direction and a direction (see D3 direction of FIG. **6**) perpendicular to D1 direction and D2 direction.

[0058] Insulating material **6**, in this example, is a thermoplastic resin. However, insulating material **6** is not limited thereto, and may be an adhesive, a thermosetting resin, or a highly viscous fluid. Insulating material **6** may contain insulative particles. Containing the insulative particles can more certainly prevent the contact between main unit **2***a* and cover **2***b*.

[0059] Cover **2***b* is provided with a gas-draining valve **7**. Specifically, side wall portion **26** is provided with valve **7**. Valve **7** allows a gas, generated by stacked electrode assembly **3**, to be drained out of exterior case **2**.

[0060] Stacked electrode assembly **3** includes multiple positive electrodes **31**, multiple negative electrodes **32**, and multiple separators **33**. In stacked electrode assembly **3**, two types of electrodes having different polarities (positive electrode **31** and negative electrode **32**) are alternately stacked in D1 direction via separator **33**. Cover **2***b* and main unit **2***a* apply a constraint force (a pressure) to stacked electrode assembly **3** in D1 direction. Specifically, top **25** and bottom **21** apply the constraint force to stacked electrode assembly **3** in D1 direction.

[0061] In this example, an end of stacked electrode assembly **3** on the top **25** side is a positive electrode **31**. An end of stacked electrode assembly **3** on the bottom **21** side is also a positive electrode **31**. Insulating sheet **9** is stacked on the end (positive electrode **31**) on the bottom **21** side. In the following, positive electrode **31** that is the end on the top **25** side will also be referred to as a "top-side positive electrode **31**." Positive electrode **31** that is the end on the bottom **21** side will also be referred to as a "bottom-side positive electrode **31**."

[0062] Each positive electrode **31** includes a current-collector foil **311** and active materials **312** and **313** coating the opposing surfaces of current-collector foil **311**. Active material **312** is closer to the top **25** side than active material **313** is.

[0063] Each negative electrode **32** includes a current-collector foil **321** and active materials **322** and **323** coating the opposing surfaces of current-collector foil **321**. Active material **322** is closer to the top **25** side than active material **323** is.

[0064] Each separator **33** is sandwiched between positive electrode **31** and negative electrode **32**. Each separator **33** is in contact with active material **313** (or active material **312**) and active material **322** (or active material **323**). The electrolyte solution penetrates each separator **33**.

[0065] Each positive electrode **31**, each negative electrode **32**, each separator **33**, and insulating sheet **9** expand in D2 direction and D3 direction (see FIG. **6**).

(2. Positive-Current Collector Unit and Negative-Current Collector Unit)

[0066] FIG. **2** is a diagram showing positive-current collector unit **4** and negative-current collector unit **5**. In the following, positive-current collector unit **4** and negative-current collector unit **5** will be described with reference to FIGS. **1** and **2**.

[0067] Positive-current collector unit **4** includes multiple current-collector foils **41** that are connected to different positive electrodes **31**. In this example, positive-current collector units **4** include five current-collector foils **41**. Each current-collector foil **41** has a part **411** extending from positive electrode **31** toward top **25**, and a part **412** that continues to part **411** and extends in parallel to top **25** between top **25** and stacked electrode assembly **3**. Therefore, positive-current collector unit **4** has five parts **411** and five parts **412**.

[0068] Parts **412** of current-collector foils **41** are collected and stacked in D**1** direction. In this example, parts **412** of five current-collector foils **41** are stacked in D**1** direction in intimate physical contact with each other. Parts **412** may be or may not be welded together. Parts **411** differ for each current-collector foil **41**. Parts **412** of current-collector foils **41**, in contrast, are the same in this example.

[0069] Parts **412** are located between cover **2***b* and stacked electrode assembly **3** in D**1** direction. Parts **412** are electrically connected to cover **2***b*. Parts **412** of current-collector foils **41** are connected to top **25** of cover **2***b*. Specifically, one part **412** is in contact with inner wall surface **251** of top **25** with a pressure being applied to the part **412** in D**1** direction. Parts **412** are opposite the top-side positive electrode **31** in D**1** direction. Parts **412** are placed on top-side positive electrode **31**, without being insulated from top-side positive electrode **31** of stacked electrode assembly **3**. In this manner, parts **412** are electrically connected to cover **2***b* and opposite the top-side positive electrode **31** of stacked electrode assembly **3** in D**1** direction.

[0070] In this example, current-collector foil **41** and current-collector foil **311** (FIG. **1**) of positive electrode **31** are one piece of foil. In other words, current-collector foil **41** and current-collector foil **311** are formed from one foil. In this example, an area uncoated with active materials **312** and **313** corresponds to current-collector foil **41**, and an area coated with active materials **312** and **313** corresponds to current-collector foil **311**. Current-collector foil **41** functions as a tab for positive electrode **31**. The present disclosure is not limited thereto. Current-collector foil **41** and current-collector foil **311** may be separate components. If current-collector foil **41** and current-collector foil **311** are separate components, a tab portion (an uncoated area) may be provided on current-collector foil **311** for welding current-collector foil **41** to current-collector foil **311**.

[0071] Negative-current collector unit **5** includes multiple current-collector foils **51** that are connected to different negative electrodes **32**. In this example, negative-current collector units **5** include four current-collector foils **51**. Each current-collector foil **51** has a part **511** extending from negative electrode **32** toward bottom **21**, and a part **512** that continues to part **511** and extends in parallel to bottom **21** between bottom **21** and stacked electrode assembly **3**. Therefore, negative-current collector unit **5** has four parts **511** and four parts **512**.

[0072] Parts **512** of current-collector foils **51** are collected and stacked in D**1** direction. In this example, parts **512** of four current-collector foils **51** are stacked in D**1** direction in intimate physical contact with each other. Parts **512** may be or may not be welded together. Parts **511** differ for each current-collector foil **51**. Parts **512** of current-collector foils **51**, in contrast, are the same in this example.

[0073] Parts **512** are located between main unit **2***a* and stacked electrode assembly **3** in D**1** direction. Parts **512** are electrically connected to main unit **2***a*. Parts **512** of current-collector foils **51** are connected to bottom **21** of main unit **2***a*. Specifically, one part **512** is in contact with inner wall surface **211** of bottom **21** with a pressure being applied to the part **512** in D**1** direction. Part **512** are opposite the bottom-side positive electrode **31** in D**1** direction. Parts **512** are placed on bottom-side positive electrode **31**, while being insulated from bottom-side positive electrode **31** of stacked electrode assembly **3**.

[0074] In this manner, parts **512** are electrically connected to main unit **2***a* and opposite the bottom-side positive electrode **31** of stacked electrode assembly **3** in D**1** direction. Part **512** and bottom-side positive electrode **31** opposite the part **512** in D**1** direction are insulated from each other. Parts **512** and bottom-side positive electrode **31** are insulated from each other by insulating sheet **9**.

[0075] In this example, current-collector foil **51** and current-collector foil **321** (FIG. **1**) of negative electrode **32** are one piece of foil. In other words, current-collector foil **51** and current-collector foil **321** are formed from one foil. In this example, an area uncoated with active materials **322** and **323** corresponds to current-collector foil **51**, and an area coated with active materials **322** and **323** corresponds to current-collector foil **321**. Current-collector foil **51** functions as a tab for negative electrode **32**. The present disclosure is not limited thereto. Current-collector foil **51** and current-collector foil **321** may be separate components. If current-collector foil **51** and current-collector foil **321** are separate components, a tab portion (an uncoated area) may be provided on current-collector foil **321** for welding current-collector foil **51** to current-collector foil **321**.

[0076] As shown in FIG. **1**, cover **2***b* of exterior case **2** is connected to positive-current collector unit **4**. Main unit **2***a* of exterior case **2** is connected to negative-current collector unit **5**. Cover **2***b* and main unit **2***a* are insulated from each other by insulating material **6**. Accordingly, battery cell **1** can cause cover **2***b* to function as a positive terminal and main unit **2***a* to function as a negative terminal.

(3. Summary of Battery Cell)

[0077] (1) Battery cell **1** includes: (i) stacked electrode assembly **3** in which negative electrodes **32** and positive electrodes **31** are alternately stacked in D**1** direction; (ii) negative-current collector unit **5** connected to the negative electrodes **32**; (iii) positive-current collector unit **4** connected to the positive electrodes **31**; and (iv) exterior case **2** accommodating stacked electrode assembly **3**, negative-current collector units **5**, and positive-current collector units **4**. Exterior case **2** includes main unit **2***a* and cover **2***b*. Parts **512** of negative-current collector unit **5** are located between main unit **2***a* and stacked electrode assembly **3** in D**1** direction, and are electrically connected to main unit **2***a*. Parts **412** of positive-current collector unit **4** are located between cover **2***b* and stacked electrode assembly **3** in D**1** direction, and are electrically connected to cover **2***b*.

[0078] With such a configuration, negative-current collector unit **5** can cause main unit **2***a* of exterior case **2** to function as a negative terminal. Positive-current collector unit **4** can cause cover **2***b* of exterior case **2** to function as a positive terminal.

[0079] Furthermore, negative-current collector unit **5** is connected to main unit **2***a* by parts **512** located between main unit **2***a* and stacked electrode assembly **3** in D**1** direction. Positive-current collector unit **4** is connected to cover **2***b* by parts **412** located between cover **2***b* and stacked electrode assembly **3** in D**1** direction. Accordingly, positive-current collector unit **4** and negative-current collector unit **5** can be brought into contact with exterior case **2**, while being separated from each other in D**1** direction.

[0080] Therefore, according to battery cell **1**, the volumetric efficiency can be increased, as compared to a battery cell configuration in which only one of the negative-current collector unit and the positive-current collector unit is in contact with the exterior case.

[0081] (2) Main unit **2***a* has bottom **21** connected to parts **512** of negative-current collector unit **5** and side wall portion **22** projecting upward from the outer periphery of bottom **21**. Cover **2***b* has top **25** opposite the bottom **21** and connected to parts **412** of positive-current collector unit **4**, and side wall portion **26** projecting downward from the outer periphery of top **25**. Side wall portion **22** and side wall portion **26** partially overlap as viewed from D**2** direction perpendicular to D**1** direction. With such a configuration, stacked electrode assembly **3**, positive-current collector unit **4**, negative-current collector unit **5**, and insulating material **6** can certainly be sealed in exterior case **2**.

[0082] (3) Insulating material **6** is loaded between side wall **22** and side wall **26**. With such a configuration, a short circuit can be prevented from occurring between main unit **2***a* and cover **2***b* of exterior case **2**.

[0083] (4) Negative-current collector unit **5** includes multiple current-collector foils **51** that are connected to different negative electrodes **32**. Each current-collector foil **51** has part **511** extending from negative electrode **32** toward bottom **21**, and part **512** that continues to part **511** and extends in parallel to bottom **21** between bottom **21** and stacked electrode assembly **3**. Parts **512** are electrically connected to main unit **2***a* and opposite the positive electrode **31** in D**1** direction. Parts **512** and positive electrode **31** (i.e., bottom-side positive electrode **31**) opposite the parts **512** in D**1** direction are insulated from each other. With such a configuration, a short circuit can be prevented from occurring between negative-current collector unit **5** and positive electrode **31** opposite the parts **512** of negative-current collector unit **5** in D**1** direction.

[0084] (5) Positive-current collector unit **4** includes multiple current-collector foils **41** that are connected to different positive electrodes **31**. Each current-collector foil **41** has part **411** extending from positive electrode **31** toward top **25** and part **412** that continues to part **411** and extends in parallel to top **25** between top **25** and stacked electrode assembly **3**. Parts **412** are electrically connected to cover **2***b*.

(4. Battery Module)

[0085] FIG. **3** is a diagram showing a battery module. As shown in FIG. **3**, a battery module **800** includes multiple battery cells **1**, a positive external terminal **810**, a negative external terminal **820**, and an exhaust duct **830**. In battery module **800**, battery cells **1** are connected in series. In this example, four battery cells **1** are stacked in D**1** direction.

[0086] Note that, in the following, for convenience of illustration, a battery cell **1** on positive external terminal **810** side will also be referred to as a "first battery cell **1**." A battery cell **1** on negative external terminal **820** side will also be referred to as a "fourth battery cell **1**." A battery cell **1** adjacent to first battery cell **1** will also be referred to as a "second battery cell **1**." A battery cell **1** adjacent to fourth battery cell **1** will also be referred to as a "third battery cell **1**."

[0087] First battery cell **1** is in contact with positive external terminal **810**. Specifically, cover **2***b* of first battery cell **1** is in contact with positive external terminal **810**. More specifically, top **25** of cover **2***b* is in contact with positive external terminal **810**. Main unit **2***a* of first battery cell **1** is in contact with cover **2***b* of second battery cell **1**. Specifically, bottom **21** of main unit **2***a* is in contact with top **25** of cover **2***b*.

[0088] Similarly, bottom **21** of main unit **2***a* of second battery cell **1** is in contact with top **25** of cover **2***b* of third battery cell **1**. Bottom **21** of main unit **2***a* of third battery cell **1** in contact with top **25** of cover **2***b* of fourth battery cell **1**.

[0089] Fourth battery cell **1** is in contact with negative external terminal **820**. Specifically, main unit **2***a* of fourth battery cell **1** is in contact with negative external terminal **820**. More specifically, bottom **21** of main unit **2***a* is in contact with negative external terminal **820**.

[0090] As such, battery cells **1** are stacked and connected in a manner that main unit **2***a* of one battery cell **1** and cover **2***b* of another battery cell **1** are in contact, and battery module **800** is thereby manufactured. Accordingly, battery module **800** having a high volumetric efficiency can be readily manufactured.

[0091] Exhaust duct **830** is connected to valves **7** in side walls **26** of covers **2***b* of exterior cases **2**. Exhaust duct **830** covers respective valves **7**. Exhaust duct **830** is partially in contact with side wall **26** of cover **2***b* of each exterior case **2**.

[0092] Respective valves **7** and exhaust duct **830** allow gases generated by the respective stacked electrode assemblies **3** to be drained out of exterior cases **2**. The drained gas is treated by a downstream device to prevent untreated gas from leaking externally.

(5. Battery Cell Manufacturing Method)

[0093] FIG. **4** is a diagram for illustrating a method for manufacturing battery cell **1**. As shown in FIG. **4**, a pressing machine **900** includes a slide **910** and a bolster **920** disposed immediately below slide **910**.

[0094] Battery cell **1** having insulating material **6** before being solidified is mounted on bolster **920**. Battery cell **1** is stacked on bolster **920** in a manner that the direction (D**1**) in which the stacked electrode assembly **3** is stacked is the vertical direction. Battery cell **1** is mounted on bolster **920** so that bottom **21** of main unit **2***a* of exterior case **2** is in contact with bolster **920**.

[0095] Pressing machine **900** applies a force to battery cell **1** to compress battery cell **1** in orientations indicated by arrows A**1** and A**2** in D**1** direction. Specifically, slide **910** is lowered to apply a force in D**1** direction to battery cell **1**. Due to this, the force in D**1** direction is being applied to stacked electrode assembly **3**. In this state, insulating material **6** is solidified. The solidification of insulating material **6** secures cover **2***b* to main unit **2***a*. Therefore, even when slide **910** is raised, cover **2***b* and main unit **2***a* are allowed to continue to apply the force in D1 direction (a constraint force) to stacked electrode assembly **3**. In other words, a surface pressure can be applied to stacked electrode assembly **3**.

[0096] Specifically, since bolster **920** and slide **910** apply the force in D1 direction to battery cell **1** prior to the solidification of insulating material **6**, the load in D1 direction can be prevented from being focused on side wall **26** of cover **2***b* and side wall **22** of main unit **2***a*.

[0097] The method for manufacturing battery cell **1** includes: a step of mounting, on main unit **2***a* by a transfer machine (not shown), battery cell **1** having stacked electrode assembly **3**, in which negative electrodes **32** and positive electrodes **31** are alternately stacked in D1 direction, negative-current collector unit **5** connected to the negative electrodes **32**, the positive electrodes **31** connected to the positive-current collector unit **4**, so that negative-current collector unit **5** is brought into contact with exterior case **2** of main unit **2***a* in D1 direction; and a step of moving cover **2***b* by the transfer machine so that positive-current collector unit **4** is brought into contact with cover **2***b* of exterior case **2** in D1 direction. In this example, the movement puts cover **2***b* on main unit **2***a*. The method further includes a step of securing cover **2***b* to main unit **2***a*. According to such a method, the manufacturing efficiency of battery cell **1** can be enhanced.

[0098] In this example, cover **2***b* is secured to main unit **2***a* with exterior case **2** being compressed in D1 direction by pressing machine **900** and cover **2***b* and main unit **2***a* being insulated from each other. However, depending on component materials of the battery, cover **2***b* may be secured to main unit **2***a* as the above, without cover **2***b* and main unit **2***a* being insulated from each other. Note that the process of securing cover **2***b* to main unit **2***a* is, typically, performed by a machine (not shown).

[0099] In the above, cover **2***b* is put on main unit **2***a* by moving cover **2***b*. The present disclosure is not limited thereto. Main unit **2***a* may be moved, in stead of moving cover **2***b*. Cover **2***b* and main unit **2***a* may be moved. Main unit **2***a* and cover **2***b* may be moved relative to each other.

[0100] The method further includes a step of loading insulating material **6** between side wall **22** and side wall **26**. According to such a method, cover **2***b* and main unit **2***a* can be insulated from each other. Thus, a short circuit can be prevented from occurring between cover **2***b* and main unit **2***a*.

(6. Battery Cell Repair Method)

[0101] FIG. **5** is a diagram for illustrating a repair method for battery cell **1**. The use of battery cell **1** may reduce the thickness of stacked electrode assembly **3**. Specifically, the use of battery cell **1** reduces the thickness of stacked electrode assembly **3** in D1 direction, as compared to the initial state illustrated in a state (A) of FIG. **5**. When this happens, the force in D1 direction (the constraint force, the surface pressure) applied to stacked electrode assembly **3** ceases to exist, as illustrated in a state (B). Note that, the state (B) illustrates a gap being formed between parts **412** of positive-current collector unit **4** and top **25** of exterior case **2**.

[0102] In this case, battery cell **1** undergoes the following treatment using a heat press **900**A. Battery cell **1** is mounted on bolster **920** of heat press **900**A. Next, the slide of heat press **900**A is lowered to the location of top **25** of cover **2***b*, as illustrated in a state (C). In this state, heat is applied to battery cell **1**. Specifically, heat is applied to exterior case **2** from at least one of slide **910** and bolster **920**. The heat transferred to exterior case **2** is transferred to insulating material **6** as well. As a result, the solidified (cured) insulating material **6** is softened.

[0103] With insulating material **6** being softened, slide **910** is lowered further down, as illustrated in a state (D). Specifically, slide **910** is moved in the direction of arrow B. This applies the force in D1 direction to stacked electrode assembly **3**. In this state, the application of the heat is ceased and insulating material **6** is solidified. Solidifying, again, insulating material **6** secures cover **2***b* to main unit **2***a*. Therefore, even when slide **910** is raised, cover **2***b* and main unit **2***a* are allowed to continue to apply the force in D1 direction to stacked electrode assembly **3**. In this manner, the surface pressure can be applied to stacked electrode assembly **3**, again, by reducing the thickness of exterior case **2** in D1 direction, using heat press **900**A. This can recover the performance of battery cell **1**.

<Variations>

[0104] In the following, multiple variations of battery cell **1** are described. Similarly to battery cell **1**, even these variations can increase the volumetric efficiency, as compared to the battery cell configuration in which only one of the negative-current collector unit and the positive-current collector unit is in contact with the exterior case.

(Variation 1)

[0105] In the above, as shown in FIGS. **1**, **2**, etc., positive-current collector unit **4** is connected to cover **2***b* of exterior case **2** and negative-current collector unit **5** is connected to main unit **2***a* of exterior case **2**. However, the present disclosure is not limited thereto. Positive-current collector unit **4** may be connected to main unit **2***a* of exterior case **2** and negative-current collector unit **5** may be connected to cover **2***b* of exterior case **2**. In this case, the main unit **2***a* side is the positive electrode of battery cell **1**, and the cover **2***b* side is the negative electrode of battery cell **1**.

(Variation 2)

[0106] In stacked electrode assembly **3**, the electrodes on the opposing ends of the stack are positive electrodes **31**. However, the present disclosure is not limited thereto. Stacked electrode assembly **3** may be configured so that negative electrodes **32** are the opposing ends of the stack.

[0107] Alternatively, stacked electrode assembly **3** may be configured so that positive electrode **31** is the end on the main unit **2***a* side and negative electrode **32** is the end on the cover **2***b* side. With such a configuration, parts **412** are electrically connected to cover **2***b* and opposite the negative electrode **32** in D1 direction. Therefore, part **412** and negative electrode **32** opposite the parts **412** in D1 direction are insulated from each other with an insulating sheet (not shown). With such a configuration, a short circuit can be prevented from occurring between positive-current collector unit **4** and negative electrode **32** opposite the parts **412** of positive-current collector unit **4** in D1 direction.

[0108] Not limited to the above, stacked electrode assembly **3** may be configured so that negative electrode **32** is the end on the main unit **2***a* side and positive electrode **31** is the end on the cover **2***b* side. Even with this configuration, a short circuit may be prevented by appropriately arranging the insulating sheet.

(Variation 3)

[0109] FIG. **6** is a diagram illustrating Variation 3 of battery cell **1**. In FIG. **6**, for convenience of illustration, cover **2***b* of exterior case **2** is not shown. As shown in FIG. **6**, a battery cell **1**A further includes a spacer **101**, in addition to exterior case **2**, stacked electrode assembly **3**, positive-current collector unit **4**, negative-current collector unit **5**, and insulating material **6**. Battery cell **1**A differs from battery cell **1** in that the battery cell **1**A includes spacer **101**.

[0110] Spacer **101** is an insulative member. Spacer **101** is disposed between stacked electrode assembly **3** and main unit **2***a* of exterior case **2**. Specifically, spacer **101** is disposed within main unit **2***a* along inner wall surface **221** (see FIG. **1**) of side wall **22** of main unit **2***a*. Stacked electrode assembly **3** is surrounded by spacer **101**. In this example, spacer **101** is in contact with current-collector foil **41** and current-collector foil **51**. Specifically, spacer **101** is in contact with part **411** of current-collector foil **41** and part **511** of current-collector foil **51**.

[0111] With such a configuration, spacer **101** can prevent misalignment of stacked electrode assembly **3** within exterior case **2**. Specifically, spacer **101** can prevent stacked electrode assembly **3** from moving in D**2** direction and D**3** direction within exterior case **2**.

(Variation 4)

[0112] FIG. **7** is a diagram illustrating Variation 4 of battery cell **1**. As shown in FIG. **7**, a battery cell **1**B further includes a positioning frame **102**, in addition to exterior case **2**, stacked electrode assembly **3**, positive-current collector unit **4**, negative-current collector unit **5**, and insulating material **6**. Battery cell **1**B differs from battery cell **1** in that the battery cell **1**B includes frame **102**. Note that FIG. **7** shows a cross section of a portion of frame **102**.

[0113] Frame **102** extends upward from side wall **26** of cover **2***b* in D**1** direction. Specifically, frame **102** extends upward outer wall surface **262** (see FIG. **1**) of side wall **26** in an orientation opposite the orientation toward main unit **2***a*. Frame **102** projects in D**1** direction from top **25**. As exterior case **2** is viewed from the cover **2***b* side in D**1** direction, frame **102** has a rectangular frame shape having an opening along the side wall **26**.

[0114] With such a configuration, misalignment between battery cells **1**B can be prevented when stacking battery cells **1**B.

(Variation 5)

[0115] FIG. **8** is a diagram illustrating Variation 5 of battery cell **1**. As shown in FIG. **8**, similarly to battery cell **1**, a battery cell **1**C includes exterior case **2**, stacked electrode assembly **3**, positive-current collector unit **4**, negative-current collector unit **5**, and insulating material **6**. In battery cell **1**C, main unit **2***a* and cover **2***b* of exterior case **2** are covered with a highly electrically conductive material.

[0116] Specifically, inner wall surface **211** of bottom **21** of main unit **2***a* is covered with a highly conductive metal layer **103**. Outer wall surface **212** of bottom **21** is covered with a highly conductive metal layer **104**. Similarly, inner wall surface **251** of top **25** is covered with a highly conductive metal layer **105**. Outer wall surface **252** of top **25** is covered with a highly conductive metal layer **106**. For example, metal layers **103** to **106** may be formed from the same metal.

[0117] With such a configuration, the battery module configured of stacked battery cells **1**C as shown in FIG. **3** can reduce the electric resistance between adjacent battery cells **1**C, as compared to the configuration in which exterior case **2** is not covered with a highly conductive metal layer.

(Variation 6)

[0118] FIG. **9** is a diagram illustrating Variation 6 of battery cell **1**. As shown in FIG. **9**, a battery cell **1**D includes exterior case **2**, stacked electrode assembly **3**, positive-current collector unit **4**, and negative-current collector unit **5**. Unlike battery cell **1**, battery cell **1**D does not include insulating material **6**. However, as with battery cell **1**, main unit **2***a* and cover **2***b* of exterior case **2** of battery cell **1**D needs to be insulated. Because of this, battery cell **1**D has the following configuration.

[0119] For battery cell **1**D, side wall **22** of main unit **2***a* and side wall **26** of cover **2***b* of exterior case **2** have been previously insulated. Specifically, outer wall surface **222** of side wall **22** is covered with an insulative member **107**. Inner wall surface **261** of side wall **26** is covered with an insulative member **108**.

[0120] With such a configuration, outer wall surface **222** of side wall **22** and inner wall surface **261** of side wall **26** do not come into contact. Therefore, a short circuit can be prevented from occurring between main unit **2***a* and cover **2***b*.

[0121] As viewed from D**2** direction, overlapping area of main unit **2***a* and cover **2***b* overlap with insulative members **107** and **108**. Owing to this, a short circuit can be better prevented from occurring between main unit **2***a* and cover **2***b*, as compared to a configuration without the insulative members.

(Variation 7)

[0122] FIG. **10** is a diagram illustrating Variation 7 of battery cell **1**. As shown in FIG. **10**, a battery cell **1**E includes exterior case **2**, stacked electrode assembly **3**, positive-current collector unit **4**, and negative-current collector unit **5**. As with battery cell **1**D, battery cell **1**E does not include insulating material **6**.

[0123] For battery cell **1**E, side wall **22** of main unit **2***a* and side wall **26** of cover **2***b* of exterior case **2** have been previously insulated. Specifically, inner wall surface **221** of side wall **22** is covered with an insulative member **109**. Inner wall surface **261** of side wall **26** is covered with an insulative member **110**.

[0124] With such a configuration, member **110** prevents contact between main unit **2***a* and cover **2***b* of exterior case **2**. Therefore, a short circuit can be prevented from occurring between main unit **2***a* and cover **2***b*. Furthermore, member **109** prevents contact between exterior case **2** and stacked electrode assembly **3**. Specifically, side wall **22** of exterior case **2** and stacked electrode assembly **3** do not come into contact. Therefore, a short circuit can be prevented from occurring between main unit **2***a* and stacked electrode assembly **3**.

[0125] Note that, as with battery cell **1**D described above, outer wall surface **222** of side wall **22** of main unit **2***a* may be previously insulated too. In other words, inner wall surface **221** and outer wall surface **222** of side wall **22** may be previously insulated. Furthermore, outer wall surface **262** of the side wall of cover **2***b* may be previously insulated. In other words, inner wall surface **261** and outer wall surface **262** of side wall **26** may be insulated.

[0126] Not limited to the above, at least one of outer wall surface **222** of side wall **22** and inner wall surface **261** of side wall **26** may be insulated. Preferably, like battery cell **1**D, outer wall surface **222** of side wall **22** and inner wall surface **261** of side wall **26** are both insulated.

[0127] Preferably, outer wall surfaces **222** and **262** are insulated. With such a configuration, a short circuit can be prevented from occurring between battery cell **1** and an object external to battery cell **1**.

(Variation 8)

[0128] FIG. **11** is a diagram illustrating Variation 8 of battery cell **1**. As shown in FIG. **11**, a battery cell **1**F includes exterior case **2**, stacked electrode assembly **3**, a positive-current collector unit **4**A, a negative-current collector unit **5**A, and insulating material **6**. Battery cell **1**F differs from battery cell **1** in that the battery cell **1**F includes positive-current collector unit **4**A and negative-current collector unit **5**A, while battery cell **1** includes positive-current collector unit **4** and negative-current collector unit **5**.

[0129] Positive-current collector unit **4**A includes multiple current-collector foils **41**A and an L-shaped positive plate **450**. Positive plate **450** has a part **451** extending in D**1** direction, and a part **452** that continues to part **451** and extends in parallel to top **25** between top **25** and stacked electrode assembly **3**.

[0130] Part **451** has an inner side surface **4511** on the stacked electrode assembly **3** side and an outer side surface **4512** opposite the inner side surface **4511**. Part **452** has an inner side surface **4521** on the stacked electrode assembly **3** side and an outer side surface **4522** opposite the inner side surface **4521**. Inner side surface **4521** is in contact with top-side positive electrode **31**. Outer side surface **4522** is in contact with top **25** of exterior case **2**. Specifically, outer side surface **4522** is in contact with inner wall surface **251** of top **25**.

[0131] In this example, current-collector foil **41**A and current-collector foil **311** of positive electrode **31** are one piece of foil. Current-collector foils **41**A are collected and welded to part **451** of positive plate **450**. Specifically, current-collector foils **41**A are welded to inner side surface **4511** of part **451**.

[0132] Negative-current collector unit **5**A includes multiple current-collector foils **51**A and an L-shaped negative plate **550**. Negative plate **550** has a part **551** extending in D**1** direction, and a part **552** that continues to part **551** and extends in parallel to bottom **21** between bottom **21** and stacked electrode assembly **3**.

[0133] Part **551** has an inner side surface **5511** on the stacked electrode assembly **3** side and an outer side surface **5512** opposite the inner side surface **5511**. Part **552** has an inner side surface **5521** on the stacked electrode assembly **3** side and an outer side surface **5512** opposite the inner side surface **5521**. Inner side surface **5521** is in contact with insulating sheet **9**. Outer side surface **5512** is in contact with bottom **21** of exterior case **2**. Specifically, outer side surface **5512** is in contact with inner wall surface **211** of bottom **21**.

[0134] In this example, current-collector foil **51**A and current-collector foil **321** of negative electrode **32** are one piece of foil. Current-collector foils **51**A are collected and welded to part **551** of negative plate **550**. Specifically, current-collector foils **51**A are welded to inner side surface **5511** of part **551**.

[0135] According to the above configuration, for example, size reduction of battery cell **1**F, as compared to battery cell **1**, can achieved by reducing a combined thickness of positive plate **450** and negative plate **550** to be less than the thickness of the overlaid current-collector foils **41**A.

[0136] Furthermore, according to the above configuration, for example, the resistances at positive-current collector unit **4**A and negative-current collector unit **5**A can be reduced to be less than the resistances at positive-current collector unit **4** and negative-current collector unit **5** of battery cell **1** by increasing a combined thickness of positive plate **450** and negative plate **550** to be greater than the thickness of the overlaid current-collector foils **41**A. Therefore, variations in current within the surface of negative-current collector unit **5**A in contact with bottom **21** and the surface of positive-current collector unit **4**A in contact with top **25** can be reduced. As a result, temperature distributions in part **452** and in part **552** can be made uniform.

[0137] Furthermore, according to the above configuration, for example, the resistances at positive-current collector unit **4**A and negative-current collector unit **5**A can be reduced to be less than the resistances at positive-current collector unit **4** and negative-current collector unit **5** of battery cell **1** by using metals whose electrical conductivities are higher than the electrical conductivities of current-collector foils **41**A and **51**A to form positive-current collector unit **4**A and negative-current collector unit **5**A. Therefore, variations in current can be reduced in the surface of negative-current collector unit **5**A in contact with bottom **21** and the surface of positive-current collector unit **4**A in contact with top **25**. As a result, temperature distributions in part **452** and part **552** can be made uniform.

[0138] Preferably, the surfaces of the current-collector foils **41**A are insulated. With such a configuration, a short circuit can be prevented from occurring between current-collector foils **41**A and main unit **2***a* of exterior case **2**. Similarly, preferably, the surfaces of current-collector foils **51**A are insulated. With such a configuration, a short circuit can be prevented from occurring between current-collector foils **51**A and cover **2***b* of exterior case **2**.

Embodiment 2

[0139] Embodiment 1 has been described in which the electrolyte solution is injected in exterior case **2** and stacked electrode assembly **3** includes separator **33**. In the present embodiment, the battery cell is an all-solid-state battery which requires no electrolyte solution.

[0140] FIG. **12** is a diagram showing a battery cell **1**G according to the present embodiment. As shown in FIG. **12**, battery cell **1**G includes an exterior case **2**, a stacked electrode assembly **3**A, a positive-current collector unit **4**, a negative-current collector unit **5**, an insulating material **6**, and an insulating sheet **9**. Battery cell **1**G differs from battery cell **1** in that the battery cell **1**G includes stacked electrode assembly **3**A, instead of stacked electrode assembly **3**. In the following, a configuration of battery cell **1**G will be described, focusing on differences from battery cell **1**.

[0141] Stacked electrode assembly **3**A includes multiple positive electrodes **31**, multiple negative electrodes **32**, and multiple separator layers **35**. Stacked electrode assembly **3**A differs from stacked electrode assembly **3** in that the stacked electrode assembly **3**A has separator layers **35**, instead of the separators **33**. Each separator layer **35** includes a solid electrolyte and a binder.

[0142] In stacked electrode assembly **3**A, positive electrodes **31** and negative electrodes **32** are alternately stacked in D**1** direction via separator layers **35**. In other words, stacked electrode assembly **3**A has separator layer **35** between positive electrode **31** and negative electrode **32**. Note that, similarly to stacked electrode assembly **3**, a constraint force (a pressure) in D**1** direction is applied by a cover **2***b* and a main unit **2***a* to stacked electrode assembly **3**A.

[0143] Since battery cell **1**G requires no injection of the electrolyte solution in exterior case **2**, battery cell **1**G is easy to manufacture, as compared to battery cell **1**. Furthermore, battery cell **1**G yields the same advantages effects as those of battery cell **1** according to Embodiment 1. Moreover, the variations of Embodiment 1 described above are applicable to battery cell **1**G, as appropriate.

Embodiment 31

[0144] Embodiment 2 has been described with reference to battery cell **1**G including one stacked electrode assembly **3**A. In the present embodiment, a battery cell includes multiple stacked electrode assemblies **3**A.

[0145] FIG. **13** is a diagram showing a battery cell **1**H according to the present embodiment. As shown in FIG. **13**, battery cell **1**H includes an exterior case **2**A, three stacked electrode assemblies **3**A, three positive-current collector units **4**, three negative-current collector units **5**, and an insulating material **6**A. The three stacked electrode assemblies **3**A are aligned in D**1** direction. The three positive-current collector units **4** and the three negative-current collector units **5** are also aligned in D**1** direction. Note that the number of stacked electrode assemblies **3**A, the number of positive-current collector units **4**, and the number of negative-current collector units **5** are not limited to three and may be at least two.

[0146] Exterior case **2**A includes a main unit **2***c* and a cover **2***d*. Main unit **2***c* has a bottom **21**A and a side wall **22**A extending upward from the outer periphery of bottom **21**A. Cover **2***d* has a top **25**A opposite the bottom **21**A and a side wall **26**A extending downward from the outer periphery of top **25**A.

[0147] Cover **2***d* is put on main unit **2***c* to cover a portion of side wall **22**A of main unit **2***c*. Side wall **22**A and side wall **26**A partially overlap as viewed from D**2** direction perpendicular to D**1** direction which is the direction in which the stacked electrode assemblies **3**A are stacked.

[0148] As with exterior case **2**, exterior case **2**A has, typically, a generally parallelepiped shape. However, the shape of exterior case **2**A is not limited thereto.

[0149] Bottom **21**A of main unit **2***c* has an inner wall surface **211**A and an outer wall surface **212**A. Side wall **22**A of main unit **2***c* has an inner wall surface **221**A and an outer wall surface **222**A. Inner wall surface **211**A and inner wall surface **221**A are wall surfaces on the stacked electrode assembly **3**A side.

[0150] Bottom **21**A has the same function as bottom **21** according to Embodiment 1. Bottom **21**A has the same shape as bottom **21**. Side wall **22**A has the same function as side wall **22** according to Embodiment 1. Since multiple stacked electrode assemblies **3**A are accommodated within exterior case **2**A, the length of side wall **22**A in D**1** direction is longer than the length of side wall **22** in D**1** direction.

[0151] Top **25**A of cover **2***d* has an inner wall surface **251**A and an outer wall surface **252**A. Side wall **26**A of cover **2***d* has an inner wall surface **261**A and an outer wall surface **262**A. Inner wall surface **251**A and inner wall surface **261**A are wall surfaces on the stacked electrode assembly **3**A side. Inner wall surface **251**A is opposite the inner wall surface **211**A of bottom **21**A.

[0152] Top **25**A has the same function as top **25** according to Embodiment 1. Top **25**A has the same shape as top **25**. Side wall **26**A has the same function as side wall **26** according to Embodiment 1. Since multiple stacked electrode assemblies **3**A are accommodated within exterior case **2**A, the length of side wall **26**A in D**1** direction is longer than the length of side wall **26** in D**1** direction.

[0153] There is a gap between side wall **22**A of main unit **2***c* and side wall **26**A of cover **2***d*. Specifically, there is a gap between outer wall surface **222**A of side wall **22**A and inner wall surface **261**A of side wall **26**A. More specifically, a portion of outer wall surface **222** of main unit **2***a* and a portion of inner wall surface **261** of cover **2***b* are opposite to each other.

[0154] Insulating material **6**A is loaded between side wall **22** and side wall **26**. Insulating material **6**A is loaded between outer wall surface **222**A and inner wall surface **261**A. Insulating material **6**A is loaded in a region (gap) where outer wall surface **222**A and inner wall surface **261**A oppose to each other. Insulating material **6**A insulates main unit **2***c* and cover **2***d* from each other. Cover **2***d* is secured to main unit **2***c* by insulating material **6**A. Insulating material **6**A restricts the movement of cover **2***d* relative to main unit **2***c* in D**1** direction, D**2** direction, and D**3** direction.

[0155] Insulating material **6**A has the same material as insulating material **6** according to Embodiment 1. Note that, in this example, the length of insulating material **6**A in D**1** direction is longer than the length of insulating material **6** in D**1** direction. Similarly to cover **2***b* according to Embodiment 1, cover **2***d* is provided with a gas-draining **7**.

[0156] In the following, for convenience of illustration, stacked electrode assembly **3**A on the top **25** side are also be referred to as a "top-side stacked electrode assembly **3**A." Stacked electrode assembly **3**A on the bottom **21** side will also be referred to as a "bottom-side stacked electrode assembly **3**A." Stacked electrode assembly **3**A between top-side stacked electrode assembly **3**A and bottom-side stacked electrode assembly **3**A will also be referred to as an "intermediate stacked electrode assembly **3**A."

[0157] Similarly, positive-current collector unit **4** and negative-current collector unit **5** that are connected to top-side stacked electrode assembly **3**A will also be referred to as a "top-side positive-current collector unit **4**" and a "top-side negative-current collector unit **5**," respectively. Similarly, positive-current collector unit **4** and negative-current collector unit **5** that are connected to intermediate stacked electrode assembly **3**A will also be referred to as an "intermediate positive-current collector unit **4**" and an "intermediate negative-current collector unit **5**," respectively. Positive-current collector unit **4** and negative-current collector unit **5** that are connected to bottom-side stacked electrode assembly **3**A will also be referred to as a "bottom-side positive-current collector unit **4**" and a "bottom-side negative-current collector unit **5**," respectively.

[0158] In battery cell **1**H, parts **412** of current-collector foils **41** in top-side positive-current collector unit **4** are connected to top **25**A of cover **2***d*. Parts **512** of current-collector foils **51** in top-side negative-current collector unit **5** and parts **412** of current-collector foils **41** in intermediate positive-current collector unit **4** overlap on top of the other so as to be in contact with each other in D**1** direction. Similarly, parts **512** of current-collector foils **51** in intermediate negative-current collector unit **5** and parts **412** of current-collector foils **41** in the bottom-side positive-current collector unit **4** overlap on top of the other so as to be in contact with each other in D**1** direction. Parts **512** of current-collector foils **51** in the bottom-side negative-current collector unit **5** are connected to bottom **21**A of main unit **2***c*.

[0159] Since stacked electrode assembly **3**A has separator layers **35**, instead of separators **33**, stacked electrode assembly **3**A can be subjected to discharge and charge tests prior to be accommodated into exterior case **2**A. Due to this, only stacked electrode assemblies **3**A that are determined to be non-defective are accommodated in exterior case **2**A, thereby ensuring the quality of battery cell **1**H. Furthermore, battery cell **1**H yields the same advantages effects as those of battery cell **1** according to Embodiment 1. Moreover, the variations of Embodiment 1 described above are also applicable to battery cell **1**H, as appropriate.

[0160] Battery cell **1**H includes multiple stacked electrode assemblies **3**A. Therefore, battery cell **1**H can exhibit performance equivalent to or better than battery cell **1** even though the number of positive electrodes **31** and negative electrodes **32** included in each stacked electrode assembly **3**A is reduced to be less than the number of stacked electrode assemblies **3** included in battery cell **1**. Furthermore, since the number of positive electrodes **31** and negative electrodes **32** included in stacked electrode assembly **3**A can be reduced as the above, the rejection rate of stacked electrode assemblies **3**A can be lowered.

Embodiment 4

[0161] Embodiments 1 to 3 have been described with reference to battery cells **1** and **1**A to **1**H including stacked electrode assemblies **3** and **3**A. In the present embodiment, a battery cell includes a wound electrode assembly.

[0162] FIG. **14** is a diagram showing a battery cell **1**P according to the present embodiment. As shown in FIG. **14**, battery cell **1**P includes an exterior case **2**, a wound electrode assembly **3**B, a positive-current collector unit **4**, and a negative-current collector unit **5**.

[0163] Battery cell **1**P differs from battery cells **1** and **1**A to **1**H according to Embodiments 1 to 3 in that the battery cell **1**P includes wound electrode assembly **3**B, instead of stacked electrode assemblies **3** and **3**A. Furthermore, battery cell **1**P differs from battery cells **1** and **1**A to **1**H according to Embodiments 1 to 3 in that the battery cell **1**P does not include insulating sheet **9**.

[0164] Wound electrode assembly **3**B has an insulative outer body **37**. Wound electrode assembly **3**B has a winding axis extending in D**3** direction (see FIG. **6**) perpendicular to D**1** direction and D**2** direction, and is configured of a stack including a band positive electrode, a band negative electrode, and a band separator being wound in a spiral shape about the winding axis. Specifically, wound electrode assembly **3**B includes the stack wound in the spiral shape and an electrolyte solution accommodated within outer body **37**.

[0165] In wound electrode assembly **3**B, the positive electrodes and the negative electrodes are alternately stacked from the winding axis toward the outer periphery side. Therefore, it may be said that, in wound electrode assembly **3**B, the positive electrodes and the negative electrodes are alternately stacked at least in D**1** direction.

[0166] In this example, four current-collector foils **41** are connected to the band positive electrode. Each current-collector foil **41** functions as a positive tab of wound electrode assembly **3**B. Similarly, four current-collector foils **51** are connected to the band negative electrode. Each current-collector foil **51** functions as a negative tab of wound electrode assembly **3**B.

[0167] Battery cell **1**H having the above configuration yields the same advantages effects as those of battery cell **1** according to Embodiment 1. Moreover, the variations of Embodiment 1 described above are applicable to battery cell **1**G, as appropriate.

Embodiment 51

[0168] Embodiments 1 to 3 have been described with reference to stacked electrode assemblies **3** and **3**A as monopolar-type electrode assemblies. The present embodiment will be described with reference to a stacked electrode assembly being of a bipolar type.

[0169] FIG. **15** is a diagram showing a battery cell **1**Q according to the present embodiment. As shown in FIG. **15**, battery cell **1**Q includes an exterior case **2**, a stacked electrode assembly **3**C, a positive-current collector unit **4**B, and a negative-current collector unit **5**B. Battery cell **1**Q differs from battery cells **1** and **1**A to **1**H according to Embodiments 1 to 3 in that the battery cell **1**Q includes stacked electrode assembly **3**C, instead of stacked electrode assemblies **3** and **3**A.

[0170] Furthermore, battery cell **1**Q differs from battery cells **1** and **1**A to **1**H according to Embodiments 1 to 3 in that the battery cell **1**Q includes positive-current collector unit **4**B and negative-current collector unit **5**B, instead of positive-current collector units **4** and **4**A and negative-current collector units **5** and **5**B. Battery cell **1**Q differs from battery cells **1** and **1**A to **1**H according to Embodiments 1 to 3 in that the battery cell **1**Q does not include insulating sheet **9**.

[0171] Similarly to stacked electrode assembly **3**, a constraint force (a pressure) in D**1** direction is applied by a cover **2***b* and a main unit **2***a* to stacked electrode assembly **3**C. An electrolyte solution is injected in exterior case **2**.

[0172] Stacked electrode assembly **3**C is a bipolar-type electrode assembly. Stacked electrode assembly **3**C includes multiple bipolar electrodes **350** and multiple separators **360**. In stacked electrode assembly **3**C, bipolar electrodes **350** are stacked in D**1** direction via separators **360**.

[0173] Each bipolar electrode **350** has a current-collector foil **351**, a positive electrode **352**, and a negative electrode **353**. Positive electrode **352** is formed on one surface of current-collector foil **351**. Negative electrode **353** is formed on the other surface of current-collector foil **351**. In this example, positive electrode **352** is formed on the cover **2***b*-side surface of current-collector foil **351**. Positive electrode **352** is formed on the main unit **2***a*-side surface of current-collector foil **351**.

[0174] Positive-current collector unit **4**B and negative-current collector unit **5**B function as current collector units for stacked electrode assembly **3**C. Specifically, positive-current collector unit **4**B and negative-current collector unit **5**B function as terminating electrodes of stacked electrode assembly **3**C.

[0175] Positive-current collector unit **4**B is stacked on bipolar electrode **350** on the top **25** side in D**1** direction, via separator **360**. Furthermore, positive-current collector unit **4**B is in contact with inner wall surface **251** of top **25**. Negative-current collector unit **5**B is stacked on bipolar electrode **350** on the bottom **21** side in D**1** direction, via separator **360**. Furthermore, negative-current collector unit **5**B is in contact with inner wall surface **211** of bottom **21**.

[0176] Specifically, positive-current collector unit **4**B has a current-collector foil **481** and a negative electrode **483**. One surface of current-collector foil **481** is in contact with inner wall surface **251** of top **25**. Negative electrode **483** is in contact with the other surface of current-collector foil **481**. Negative electrode **483** of positive-current collector unit **4**B and positive electrode **352** of bipolar electrode **350** adjacent to positive-current collector unit **4**B are opposite to each other via separator **360**.

[0177] Negative-current collector unit **5**B has a current-collector foil **581** and a positive electrode **582**. One surface of current-collector foil **581** is in contact with inner wall surface **211** of bottom **21**. Positive electrode **582** is formed on the other surface of current-collector foil **581**. Positive electrode **582** of negative-current collector unit **5**B and negative electrode **353** of bipolar electrode **350** adjacent to negative-current collector unit **5**B are opposite to each other via separator **360**.

[0178] As described above, battery cell **1**Q includes: (i) stacked electrode assembly **3**C in which negative electrodes **353** and positive electrodes **352** are alternately stacked in D**1** direction; (ii) negative-current collector unit **5**B connected to one negative electrode **353**; (iii) positive-current collector unit **4**B connected to one positive electrode **352**; (iv) and exterior case **2** accommodating stacked electrode assembly **3**C, negative-current collector unit **5**B, and positive-current collector unit **4**B. Exterior case **2** includes main unit **2***a* and cover **2***b*. Current-collector foil **581** of negative-current collector unit **5**B is located between main unit **2***a* and stacked electrode assembly **3**C in D**1** direction, and is electrically connected to main unit **2***a*. Current-collector foil **481** of positive-current collector unit **4**B is located between cover **2***b* and stacked electrode assembly **3**C in D**1** direction, and is electrically connected to cover **2***b*.

[0179] With such a configuration, negative-current collector unit **5**B can allow main unit **2***a* of exterior case **2** to function as a negative terminal. Positive-current collector unit **4**B can allow cover **2***b* of exterior case **2** to function as a positive terminal.

[0180] Furthermore, negative-current collector unit **5**B connects to main unit **2***a* through current-collector foil **581** that is located between main unit **2***a* and stacked electrode assembly **3**C in D**1** direction. Positive-current collector unit **4**B connects to cover **2***b* through current-collector foil **481** that is located between cover **2***b* and stacked electrode assembly **3**C in D**1** direction. Accordingly, positive-current collector unit **4**B and negative-current collector unit **5**B, while being apart from each other in D**1** direction, can be brought into contact with exterior case **2**.

[0181] Therefore, according to battery cell **1**Q, the volumetric efficiency can be increased, as compared to the battery cell configuration in which only one of the negative-current collector unit and the positive-current collector unit are in contact with the exterior case.

Embodiment 61

[0182] The present embodiment will be described with reference to a battery cell having a stacked electrode assembly different from stacked electrode assembly **3** according to Embodiment 1.

[0183] FIG. **16** is a diagram showing a battery cell **1**R according to the present embodiment. As shown in FIG. **16**, battery cell **1**R includes an exterior case **2**, a stacked electrode assembly **3**D, a positive-current collector unit **4**, a negative-current collector unit **5**, an insulating material **6**, and an insulating sheet **9**. Stacked electrode assembly **3**D includes multiple electrode units **39**.

[0184] Electrode units **39** are stacked in D**1** direction. Electrode unit **39** are connected to positive-current collector unit **4** and negative-current collector unit **5**. Insulating sheet **9** is disposed between electrode unit **39** on the main unit **2***a* side and negative-current collector unit **5**. Specifically, insulating sheet **9** is disposed between electrode unit **39** on the main unit **2***a* side and part **512** (see FIG. **2**) of negative-current collector unit **5**.

[0185] FIG. **17** is a diagram showing electrode unit **39**. As shown in FIG. **17**, electrode unit **39** has multiple current-collector foils **391** for positive electrode, multiple positive electrode layers **392**, multiple separator layers **393**, multiple negative electrode layers **394**, and multiple current-collector foils **395** for negative electrode. In electrode unit **39**, current-collector foil **391**, positive electrode layer **392**, separator layer **393**, negative electrode layer **394**, and current-collector foil **395** are stacked in the listed order in D**1** direction. Separator layer **393** includes a solid electrolyte and a binder.

[0186] In this example, a current-collector foil **398** functioning as a tab of electrode unit **39** is connected to two current-collector foils **391**. A current-collector foil **399** functioning as a tab of electrode unit **39** is connected to one current-collector foil **395**. The current-collector foil **398** is connected to current-collector foil **41** (FIG. **16**). The current-collector foil **399** is connected to current-collector foil **51** (FIG. **16**).

[0187] Battery cell **1**R having such a configuration yields the same advantages effects as those of battery cell **1** according to Embodiment 1. Moreover, the variations of Embodiment 1 described above are applicable to battery cell **1**G, as appropriate.

[0188] While the embodiments according to the present disclosure have been described above, the presently disclosed embodiments should be considered in all aspects illustrative and not restrictive. The scope of the present disclosure is defined by the appended claims. All changes which come within the meaning and range of equivalency of the appended claims are to be embraced within their scopes.

What is claimed is:

1. A battery cell, comprising:

an electrode assembly in which positive electrodes and negative electrodes are alternately stacked in a first direction;

a first current collector unit connected to at least one of the positive electrodes;

a second current collector unit connected to at least one of the negative electrodes; and

an exterior case accommodating the electrode assembly, the first current collector unit, and the second current collector unit, wherein

the exterior case includes a first casing body and a second casing body,

at least a portion of the first current collector unit is located between the first casing body and the electrode assembly in the first direction and is electrically connected to the first casing body, and

at least a portion of the second current collector unit is located between the second casing body and the electrode assembly in the first direction, and is electrically connected to the second casing body.

2. The battery cell according to claim **1**, wherein

the first casing body has

a first base connected to the at least a portion of the first current collector unit, and

a first side wall extending from an outer periphery of the first base in a first orientation of the first direction, the first orientation pointing toward the electrode assembly, wherein

the second casing body has

a second base opposite the first base and connected to the at least a portion of the second current collector unit, and

a second side wall extending from an outer periphery of the second base in a second orientation opposite the first orientation, wherein

the first side wall and the second side wall partially overlap, as viewed in a second direction perpendicular to the first direction.

3. The battery cell according to claim **2**, wherein

an insulating material is loaded between the first side wall and the second side wall.

4. The battery according to claim **2**, wherein

the first current collector unit includes a plurality of first current-collector foils which are each connected to a different positive electrode among the positive electrodes, wherein

the first current-collector foils each have

a first part extending from the positive electrode in a direction toward the first base, and

a second part which continues to the first part and extends in parallel to the first base between the first base and the electrode assembly, wherein

the second part is electrically connected to the first casing body and opposite the negative electrode in the first direction, and

the second part and the negative electrode opposite the second part in the first direction are insulated from each other.

5. The battery according to claim **2**, wherein

the second current collector unit includes a plurality of second current-collector foils which are each connected to a different negative electrode among the negative electrodes, wherein

the second current-collector foils each have

a first part extending from the negative electrode in a direction toward the second base, and

a second part which continues to the first part and extends in parallel to the second base between the second base and the electrode assembly, wherein

the second part is electrically connected to the second casing body and opposite the positive electrode in the first direction, and

the second part and the positive electrode opposite the second part in the first direction are insulated from each other.

6. The battery cell according to claim **1**, wherein

the electrode assembly further includes a separator layer between the positive electrode and the negative electrode, the separator layer including a solid electrolyte.

7. The battery cell according to claim **1**, wherein

one of the first casing body and the second casing body is a main unit of the exterior case and the other one of the first casing body and the second casing body is a cover of the exterior case.

8. A battery module, comprising

a plurality of battery cells, including the battery cell according to claim **1**, wherein

the plurality of battery cells are stacked in the first direction.

9. A battery cell manufacturing method, comprising:

mounting a battery cell having: an electrode assembly in which positive electrodes and negative electrodes are alternately stacked in a first direction; a first current collector unit connected to at least one of the positive electrodes; and a second current collector unit connected to at least one of the negative electrodes so that the first current collector unit is in contact with a first casing body of an exterior case of the battery cell in the first direction;

moving the first casing body and a second casing body of the exterior case relative to each other so that the second current collector unit is in contact with the second casing body in the first direction; and

securing one of the first casing body and the second casing body to the other one of the first casing body and the second casing body.

10. The battery cell manufacturing method according to claim **9**, wherein

the first casing body has

a first base connected to the at least a portion of the first current collector unit, and

a first side wall extending from an outer periphery of the first base in a first orientation of the first direction, the first orientation pointing toward the electrode assembly, wherein

the second casing body has
a second base opposite the first base and connected to the at least a portion of the second current collector unit, and
a second side wall extending from an outer periphery of the second base in a second orientation opposite the first orientation, wherein
the first side wall and the second side wall partially overlap, as viewed in a second direction perpendicular to the first direction,
the battery cell manufacturing method further comprising loading an insulating material between the first side wall and the second side wall.

* * * * *