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TADA et al.

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(2021.01)

(57) **ABSTRACT**

In this secondary battery, in a direction perpendicular to a first sealing plate, a surface of a first region on the first sealing plate side protrudes to the first sealing plate side with respect to each of a surface of a second region on the first sealing plate side and a surface of a third region on the first sealing plate side, and in a direction perpendicular to the first sealing plate, in a surface of a second current collecting member on an electrode assembly side, a fourth region is provided with a recess recessed to the first sealing plate side with respect to each of a fifth region and a sixth region, and at least a portion of the first region is disposed in the recess.

(30) **Foreign Application Priority Data**

Feb. 15, 2024 (JP) 2024-021238

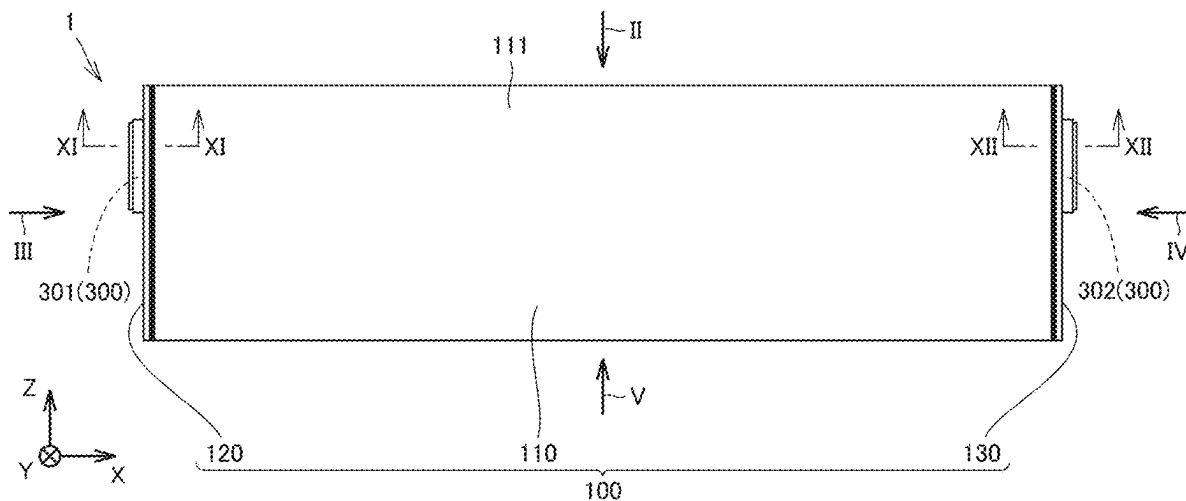


FIG.2

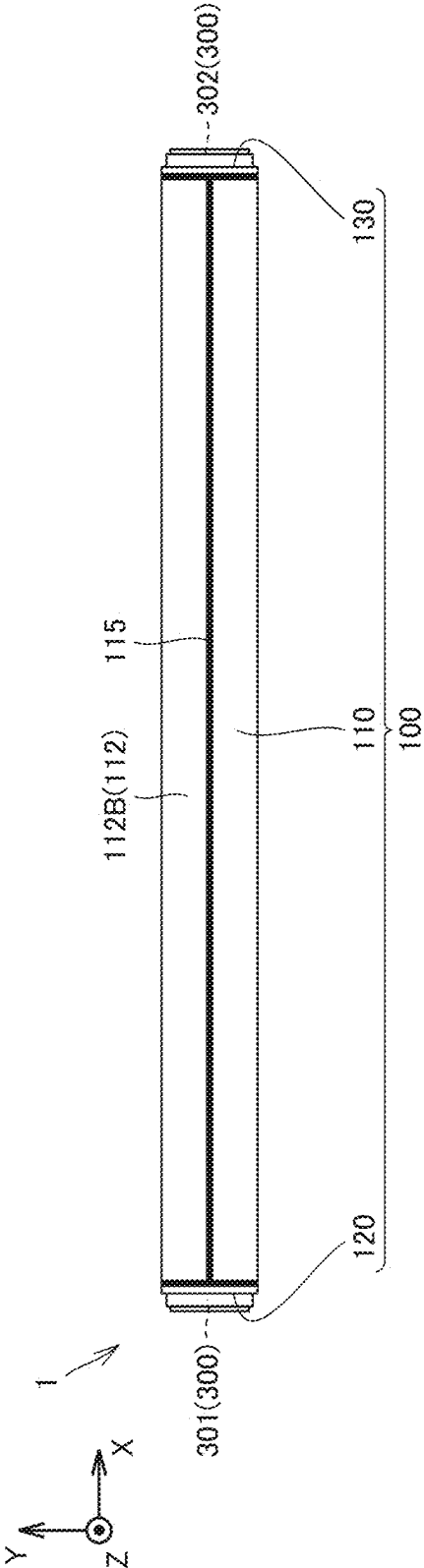


FIG.3

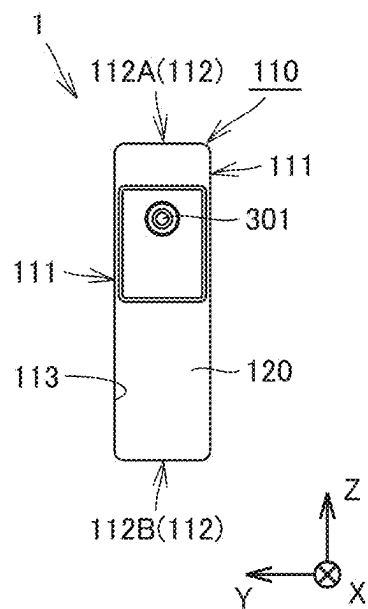


FIG.4

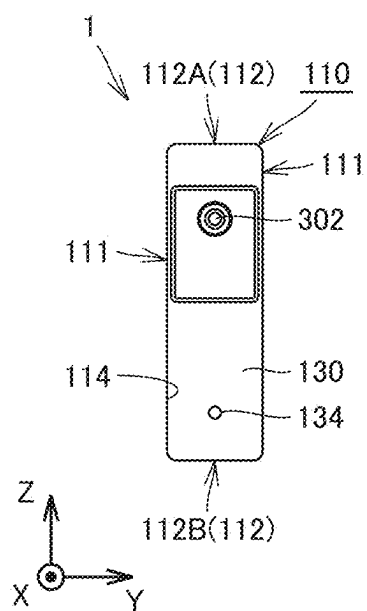


FIG.5

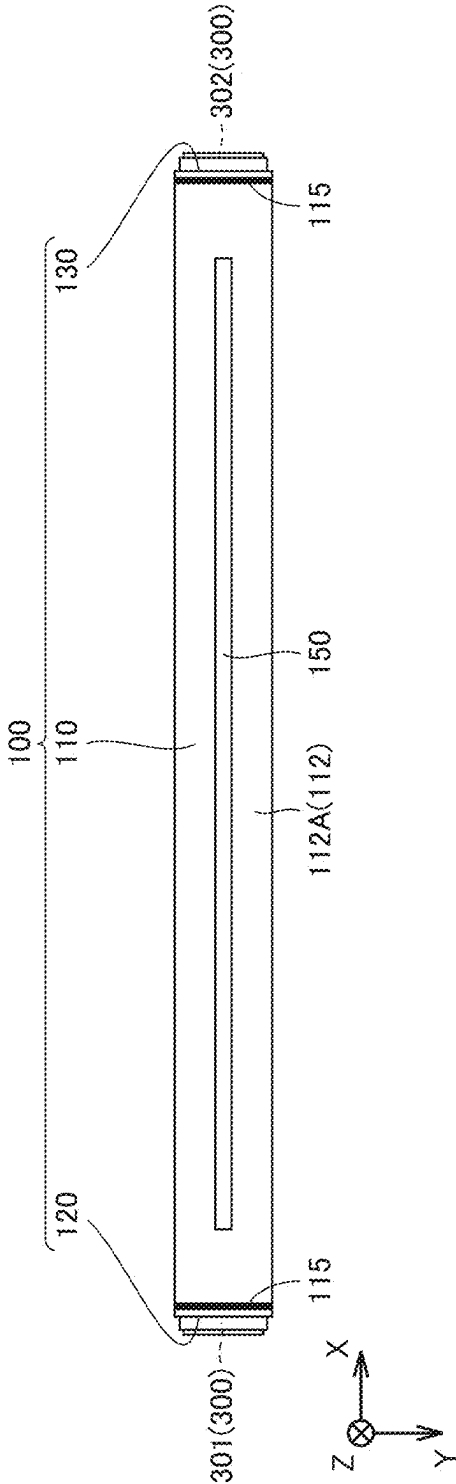


FIG. 7

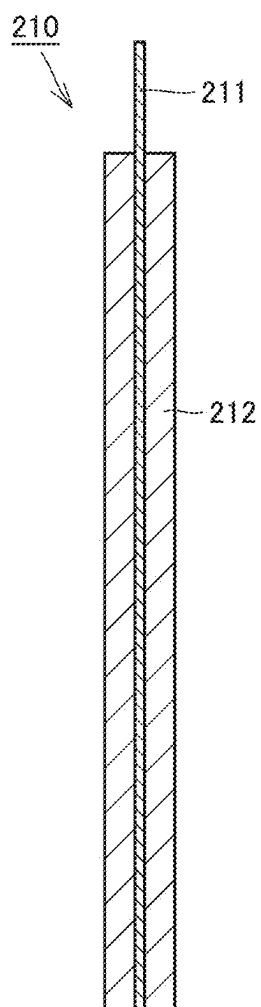


FIG.8

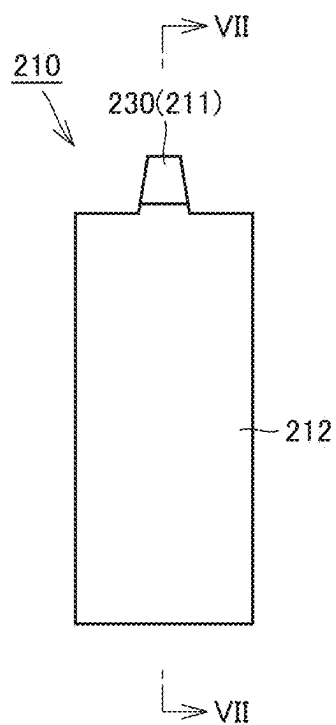


FIG. 9

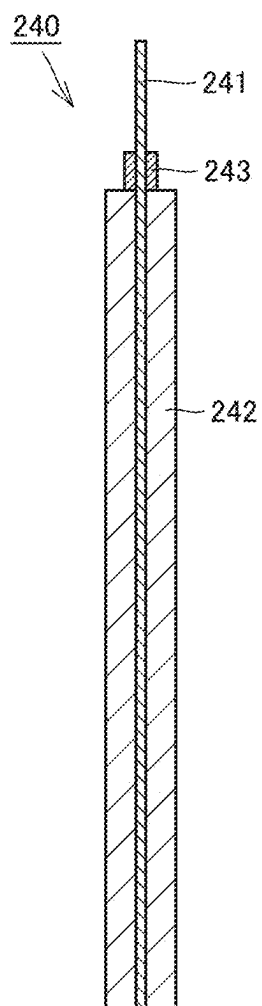
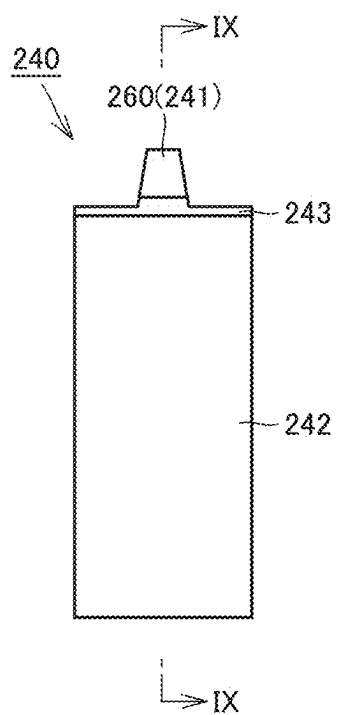
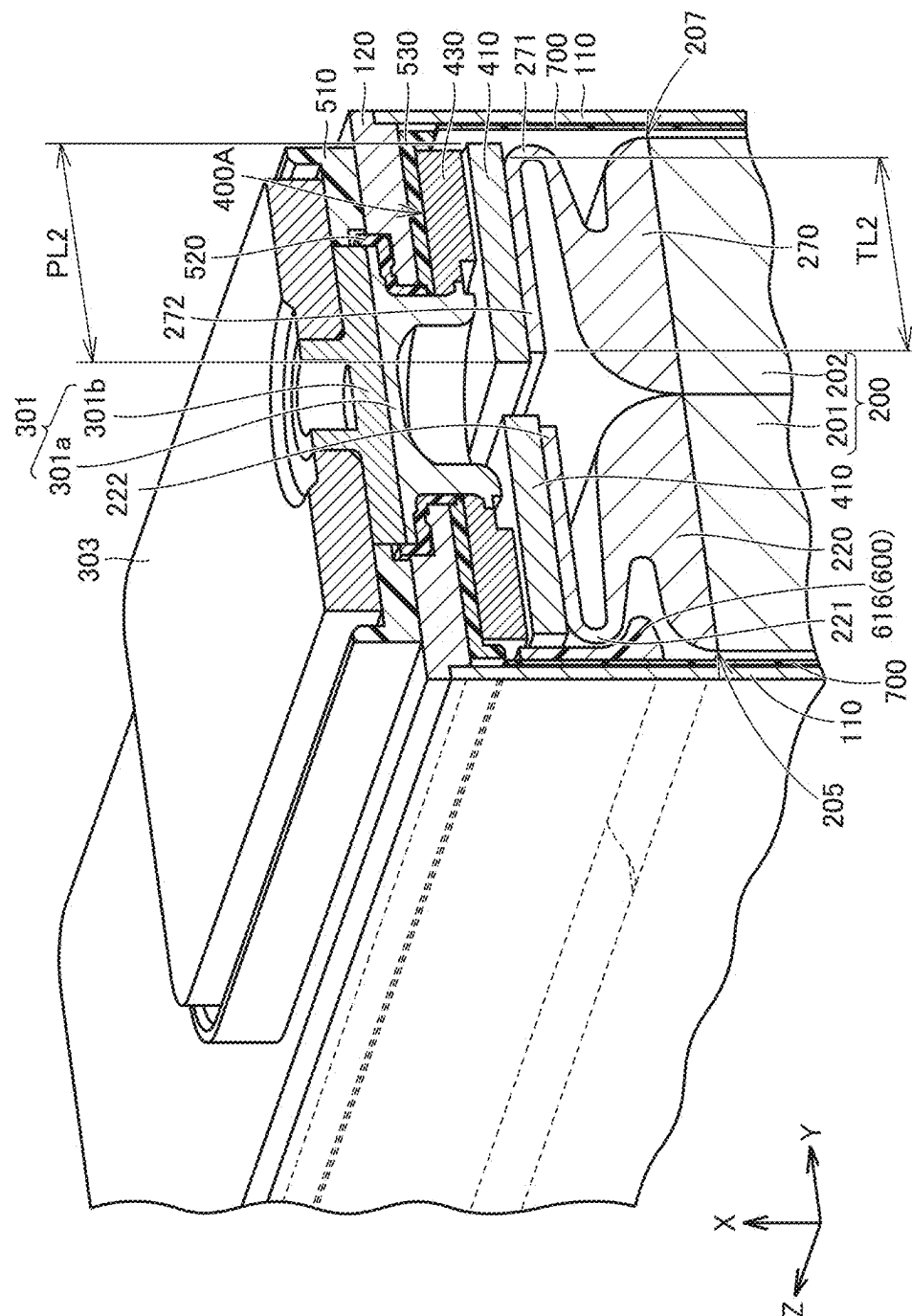


FIG.10



1
 2
 3
 4
 5



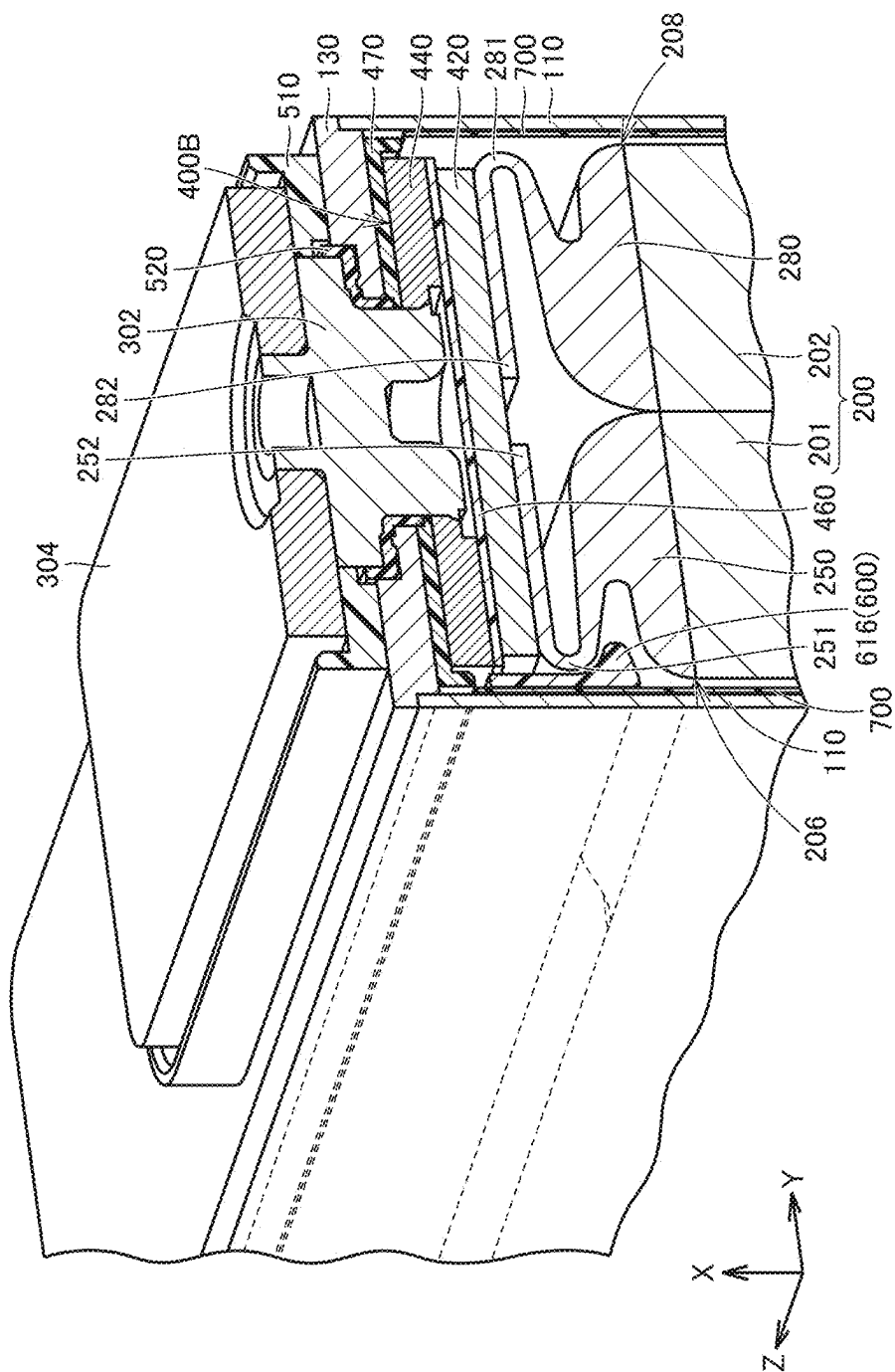


FIG.13

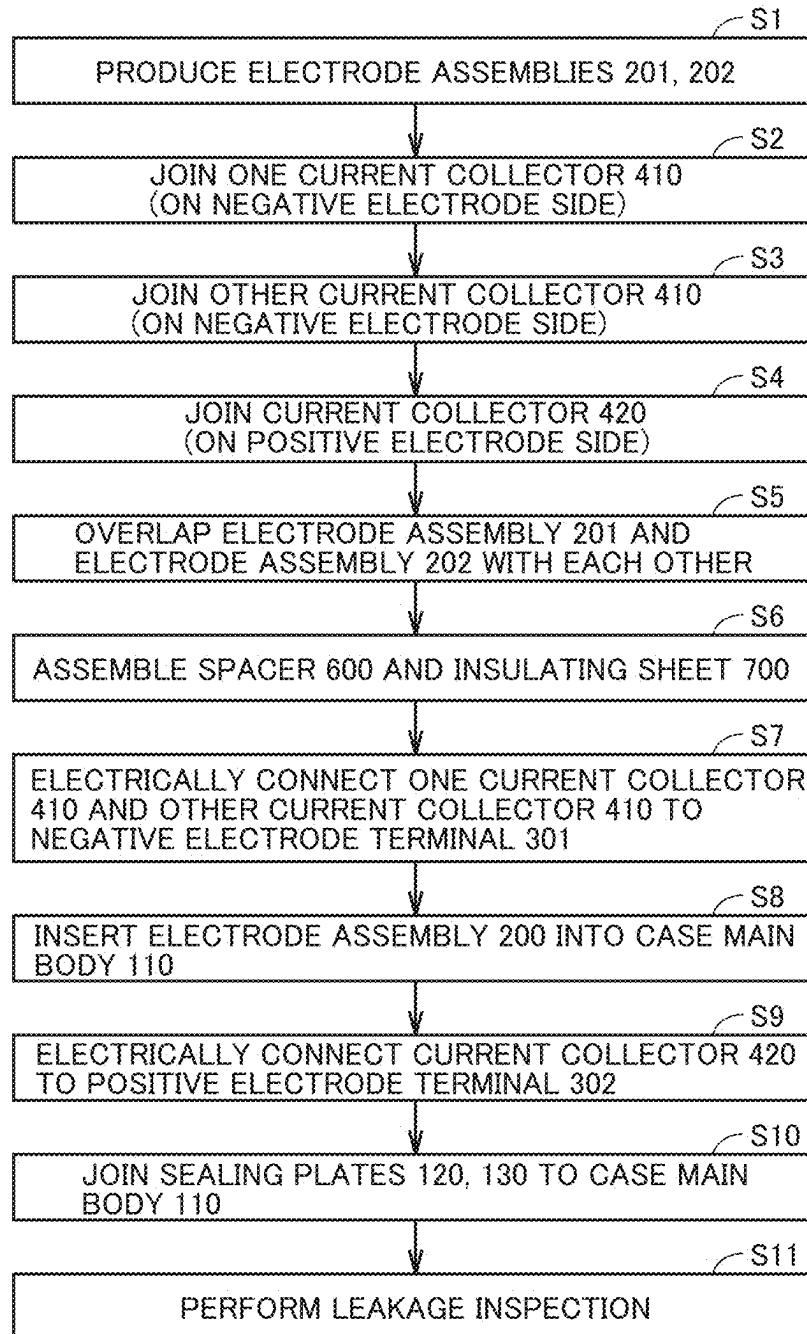


FIG.14

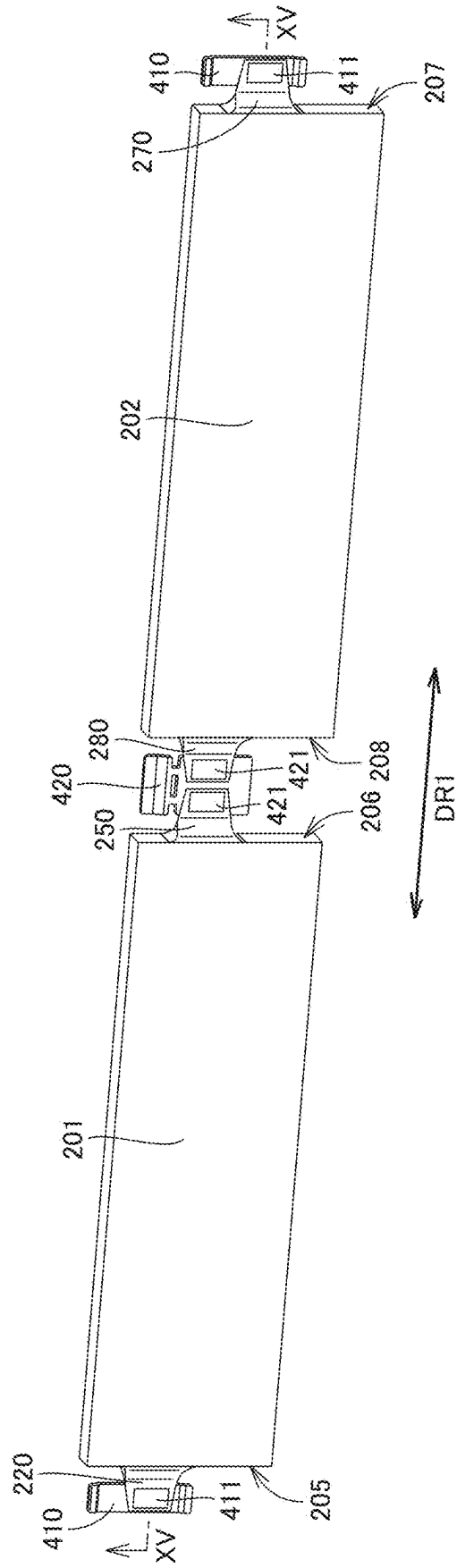


FIG.15

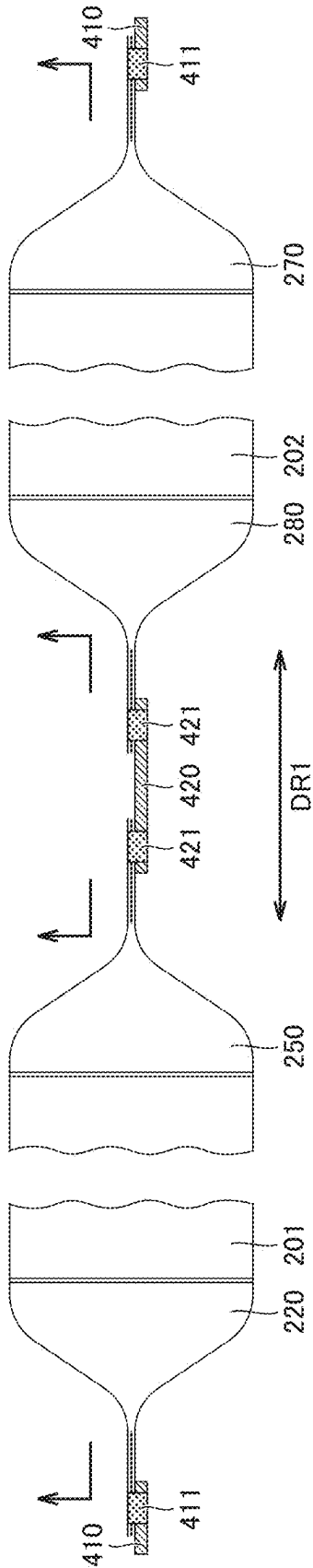


FIG.16

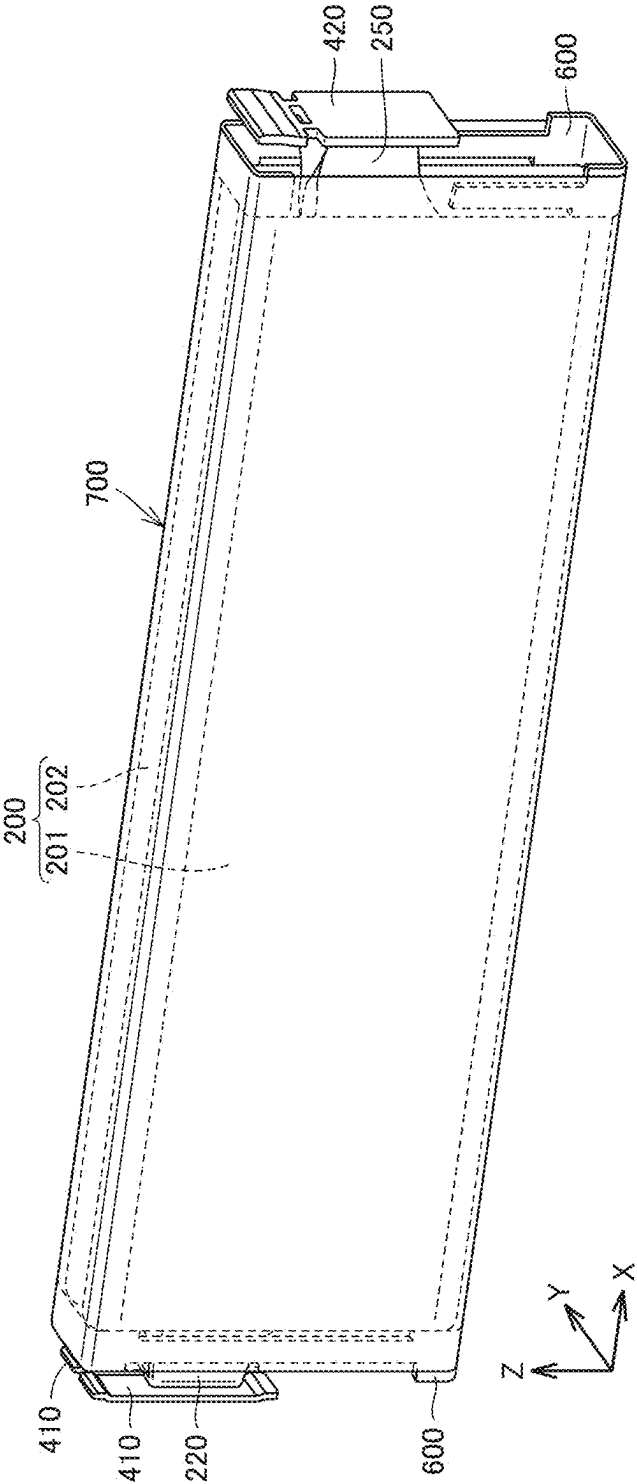


FIG.17

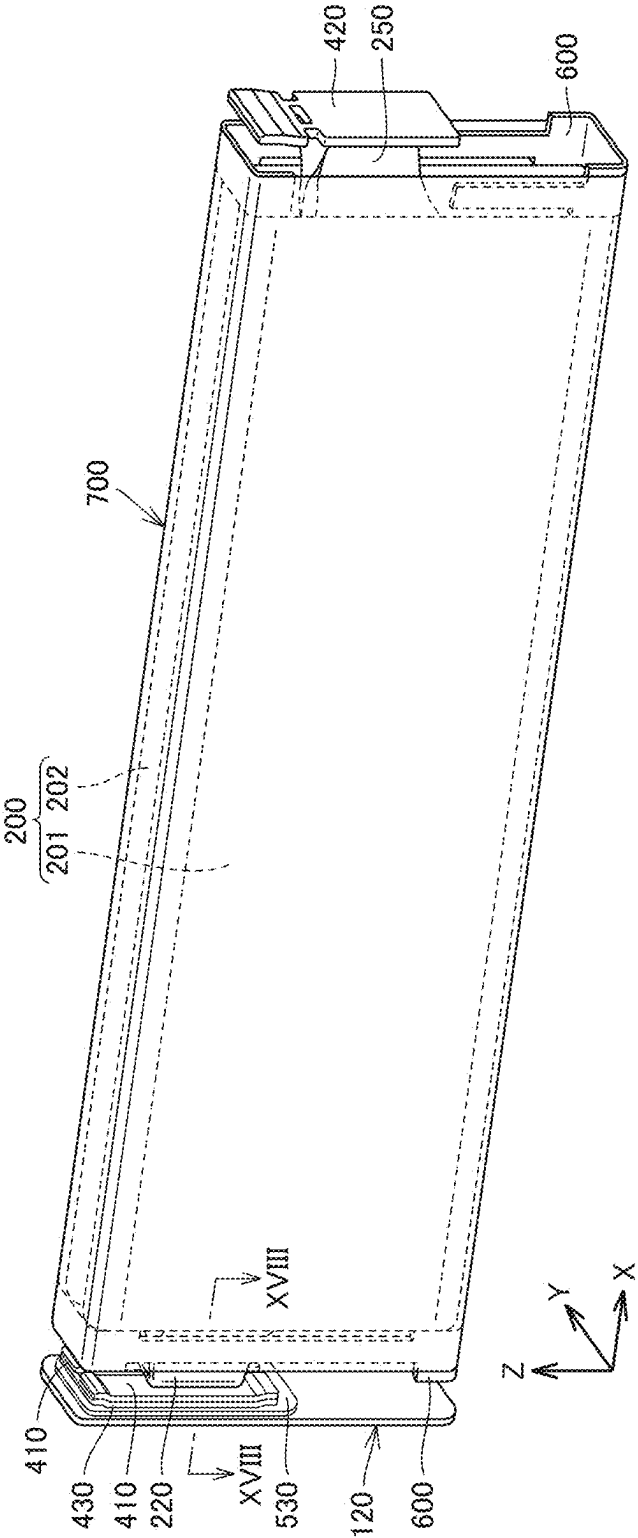


FIG.18

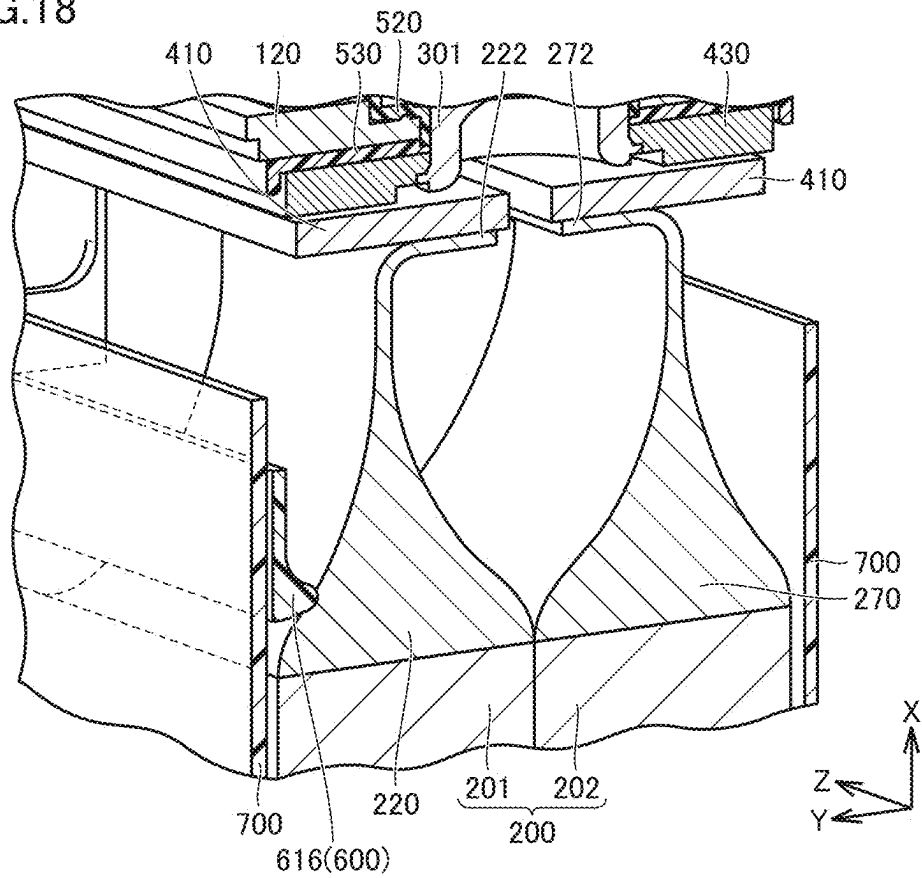


FIG.19

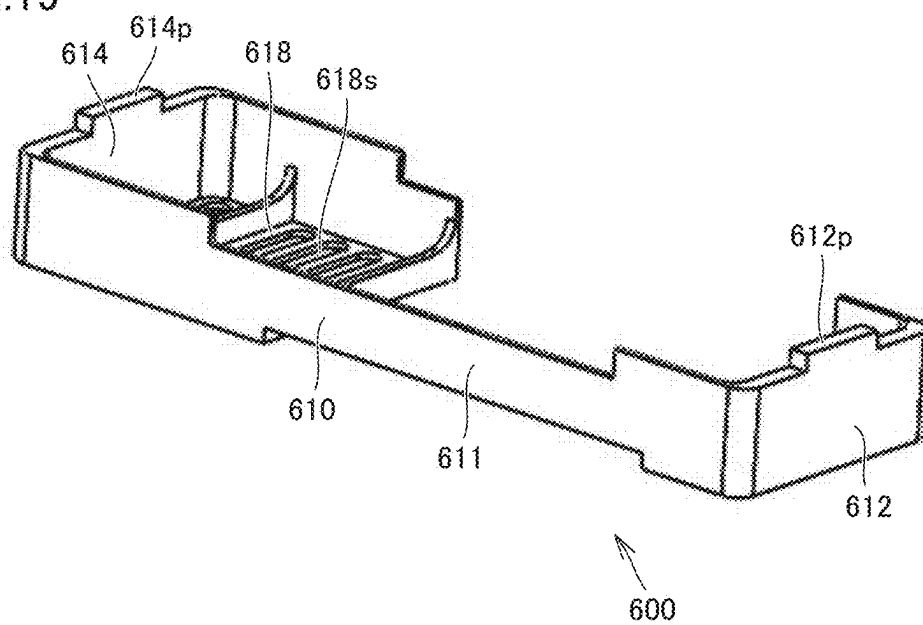


FIG.20

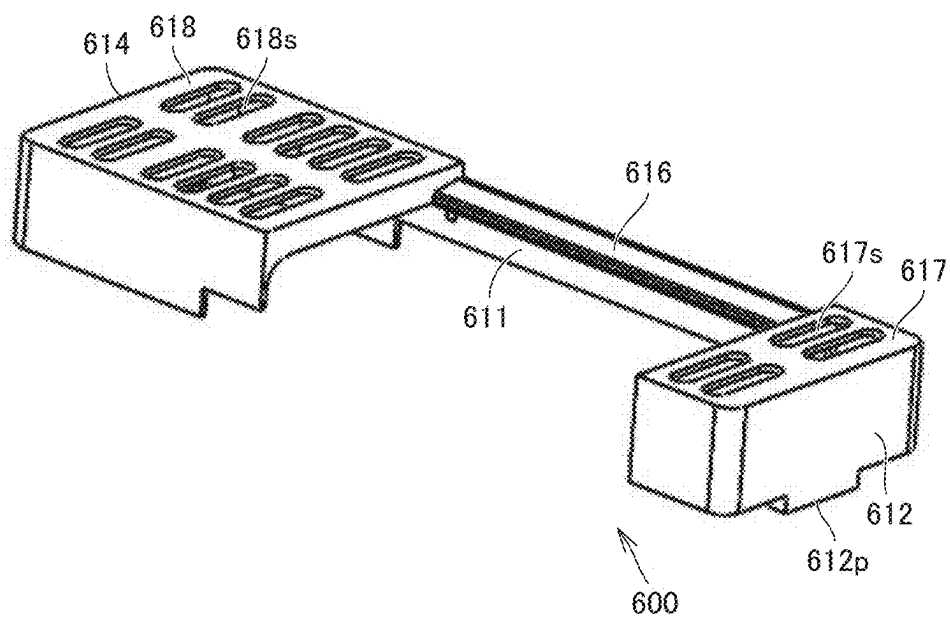


FIG.21

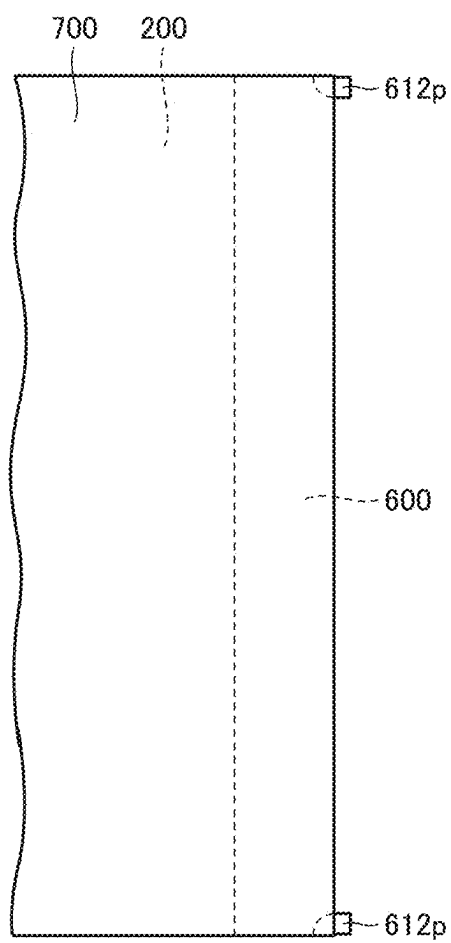


FIG.22

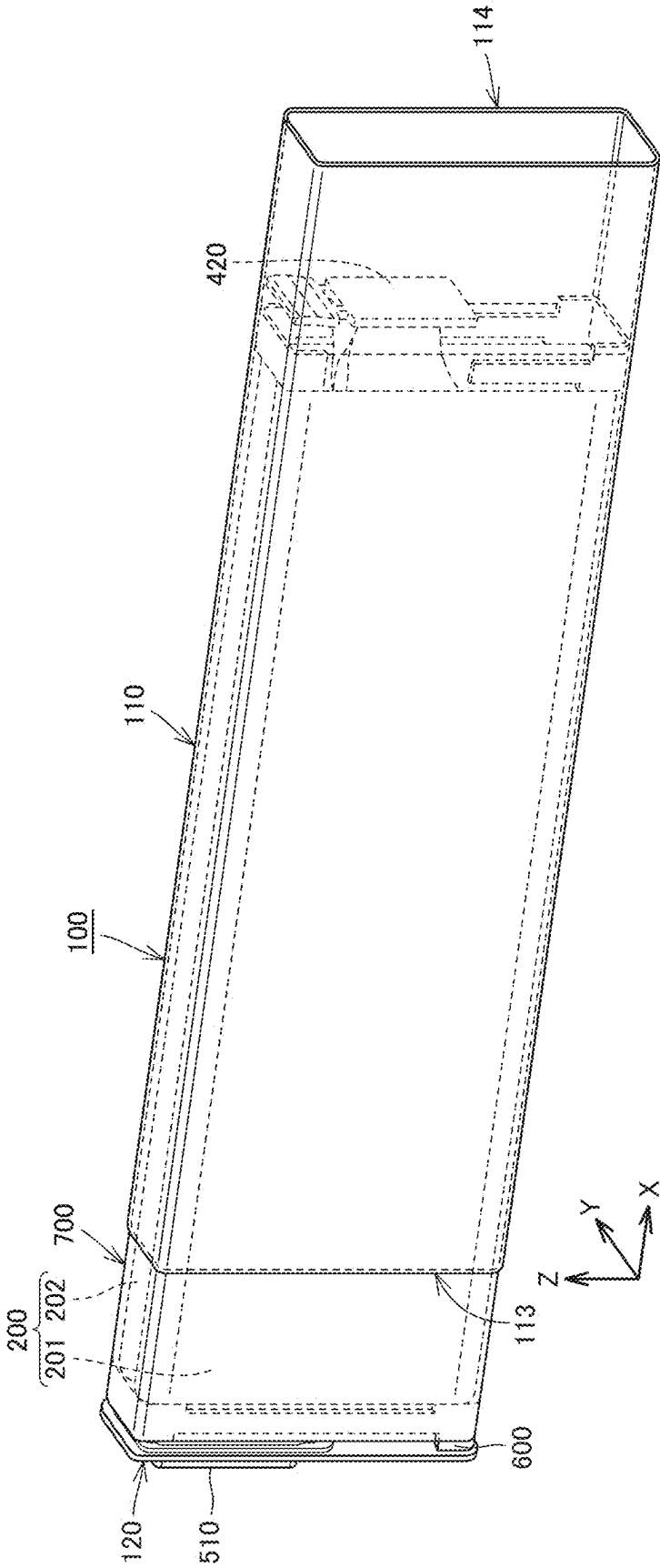


FIG.23

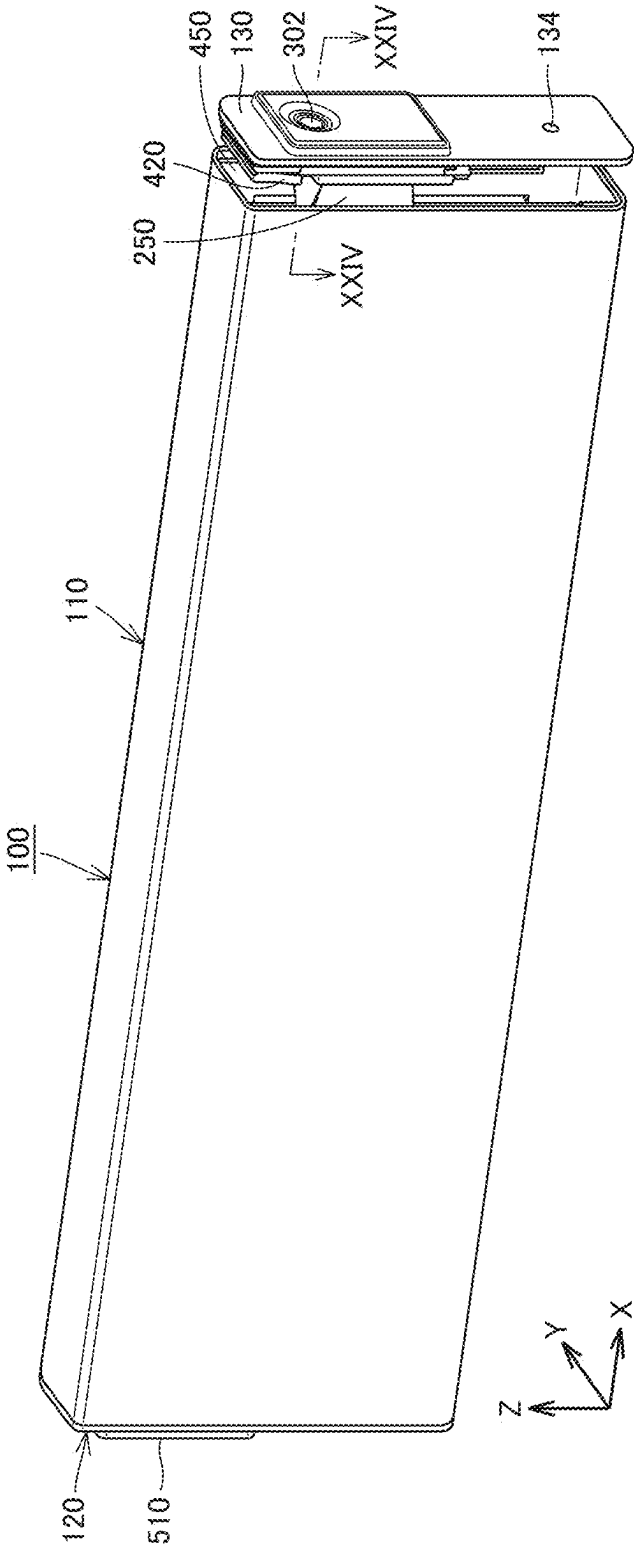


FIG.24

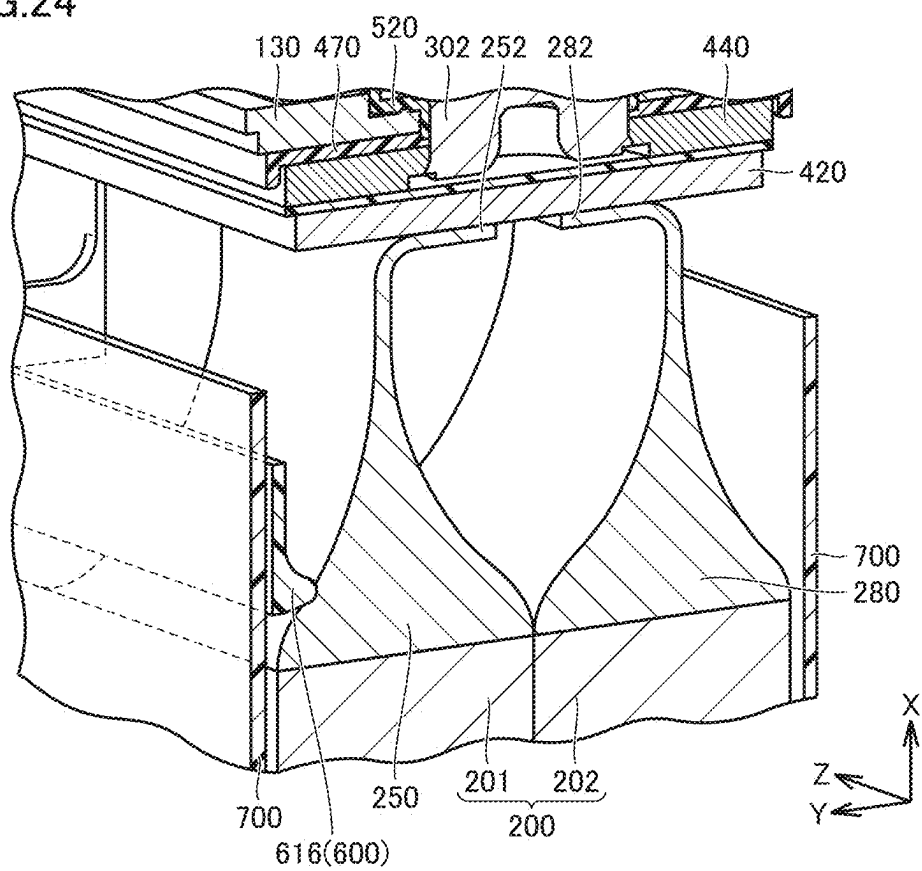


FIG.25

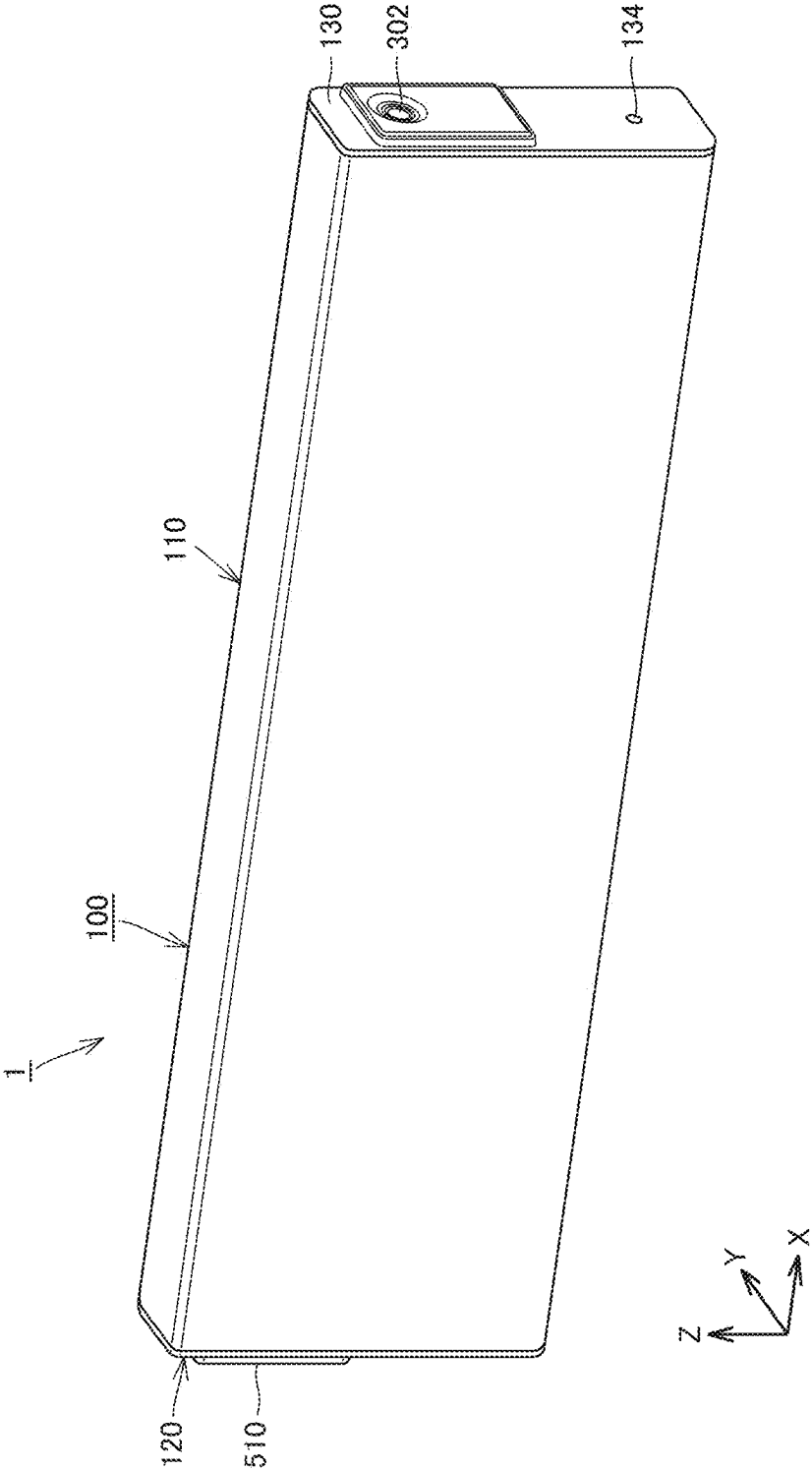


FIG.26

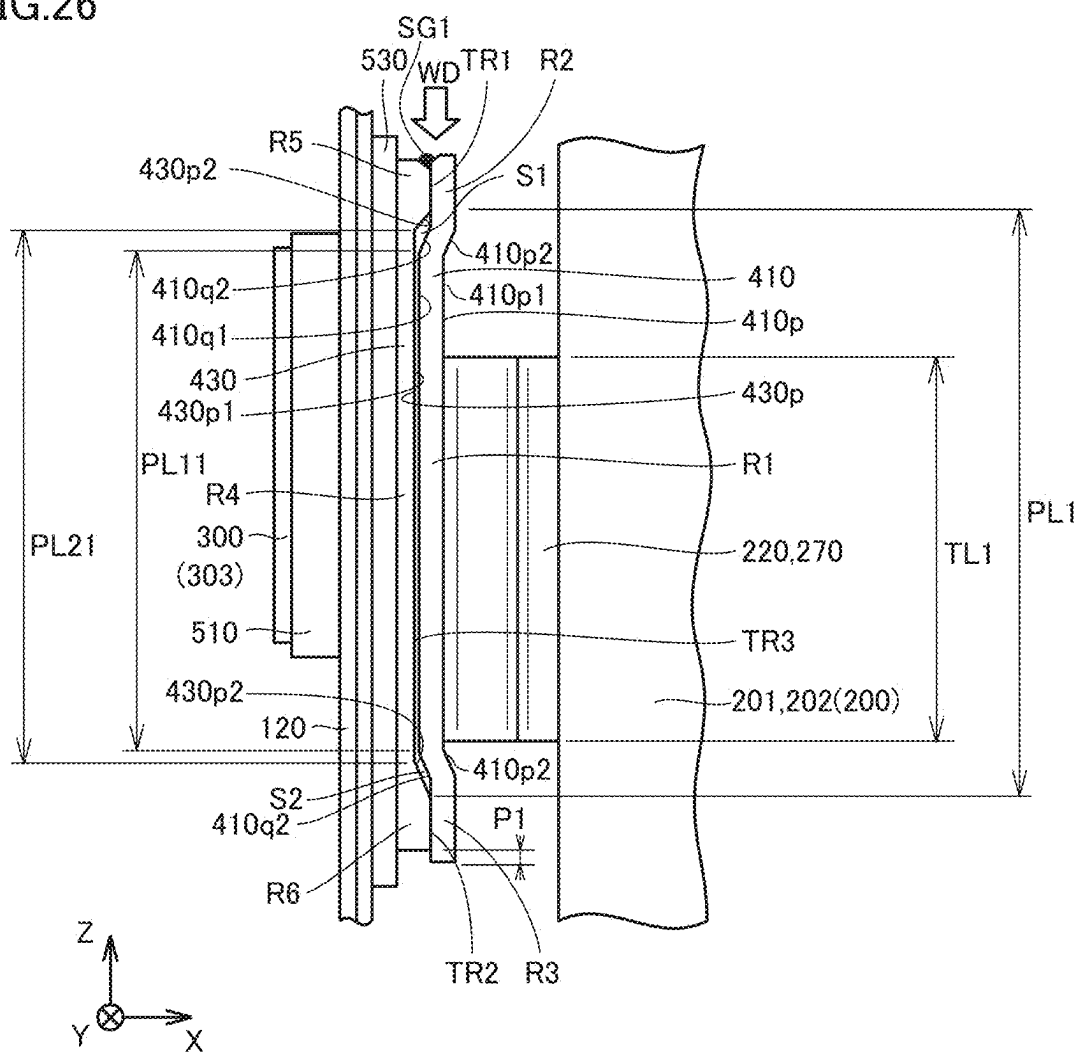


FIG.27

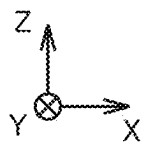
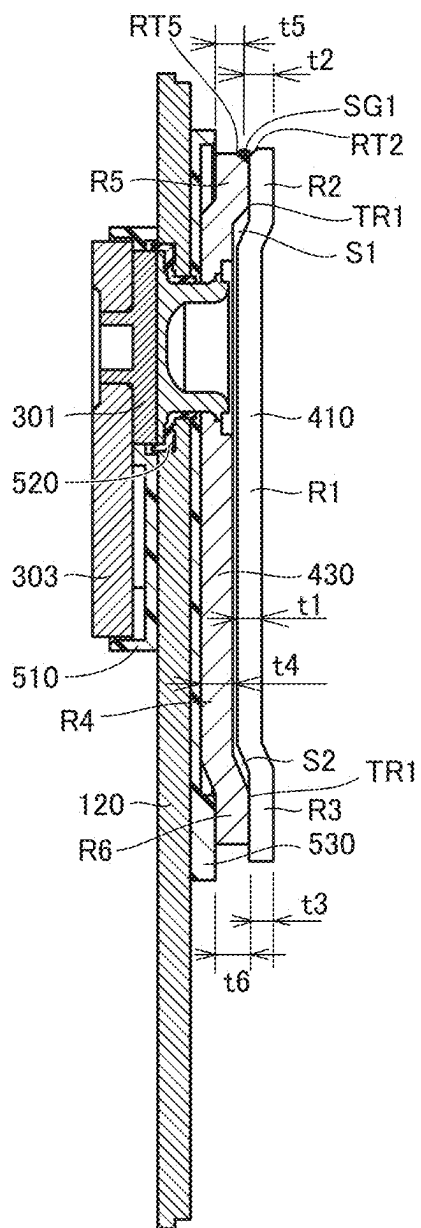


FIG.28

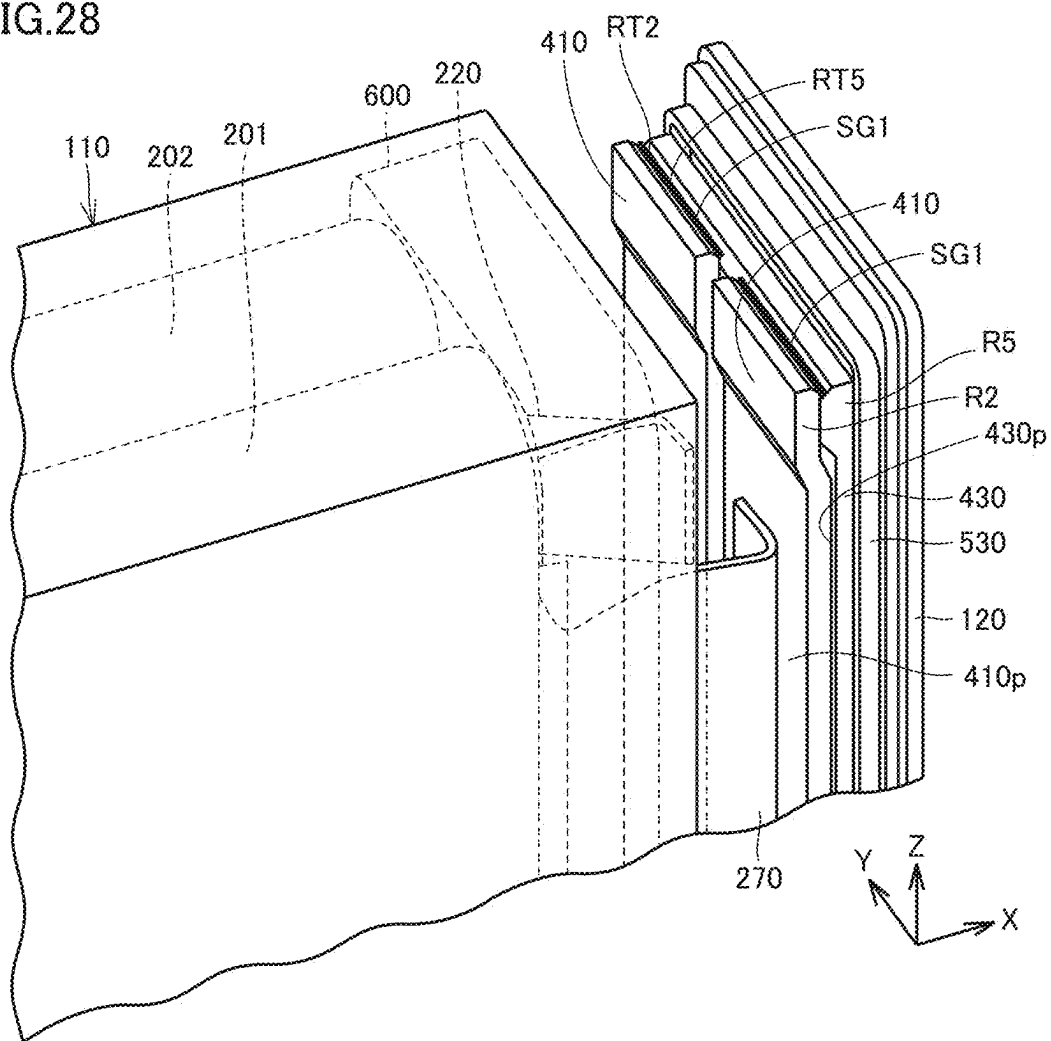


FIG.29

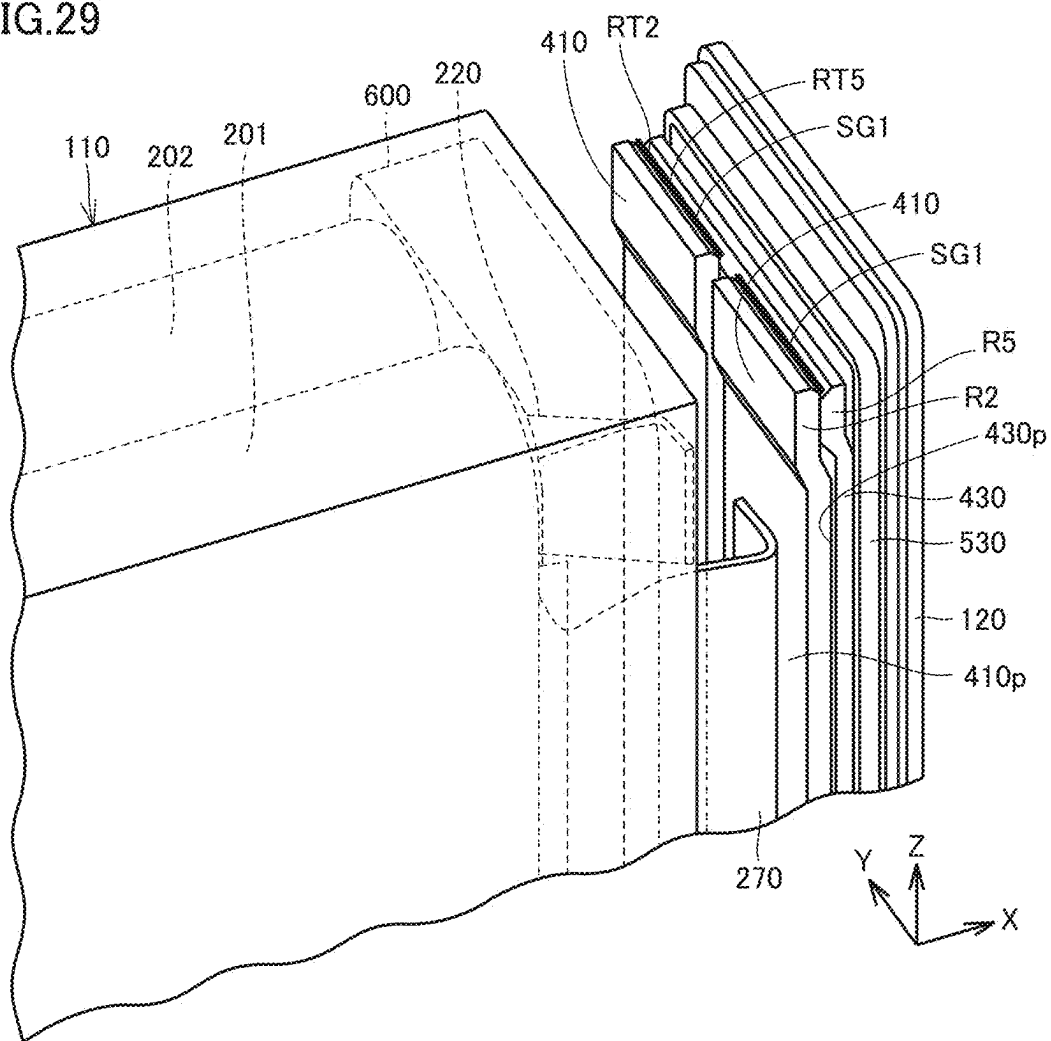


FIG. 30

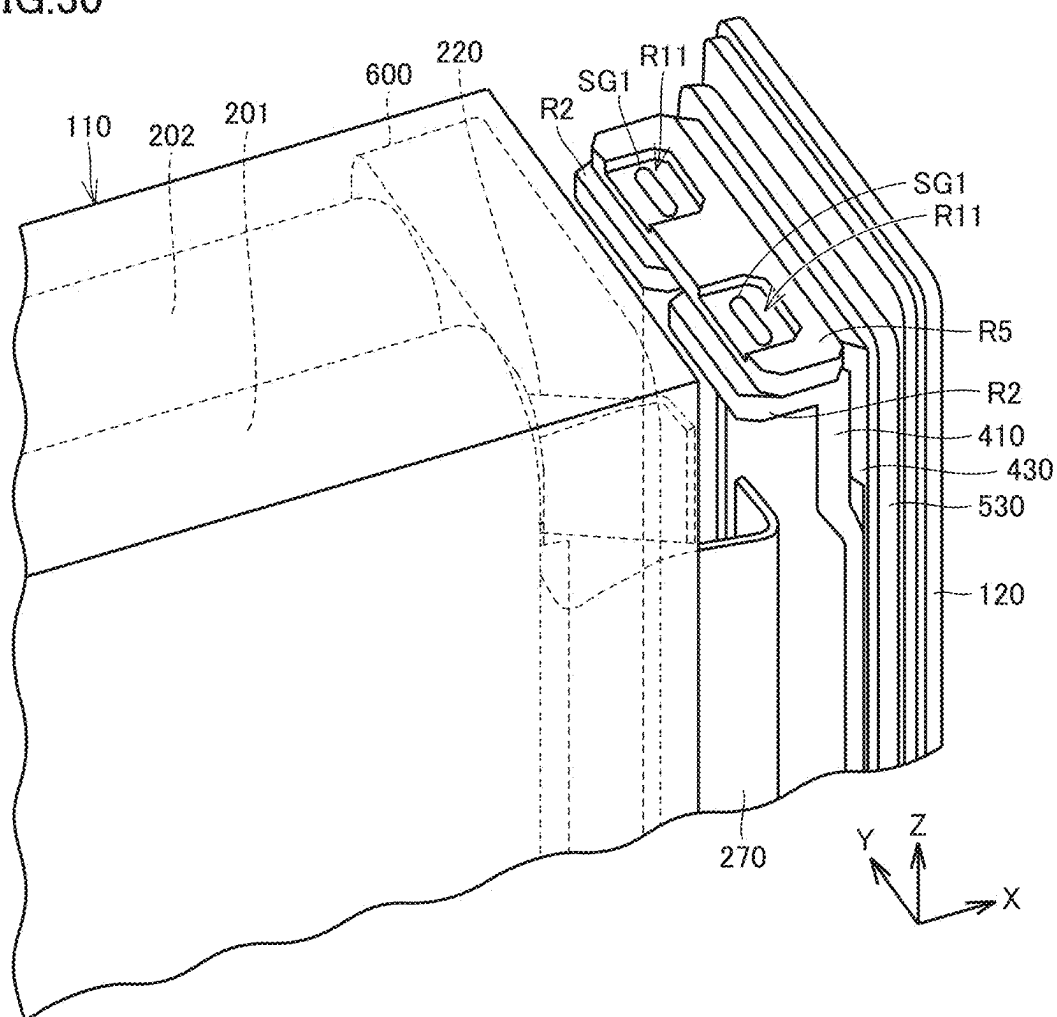


FIG.31

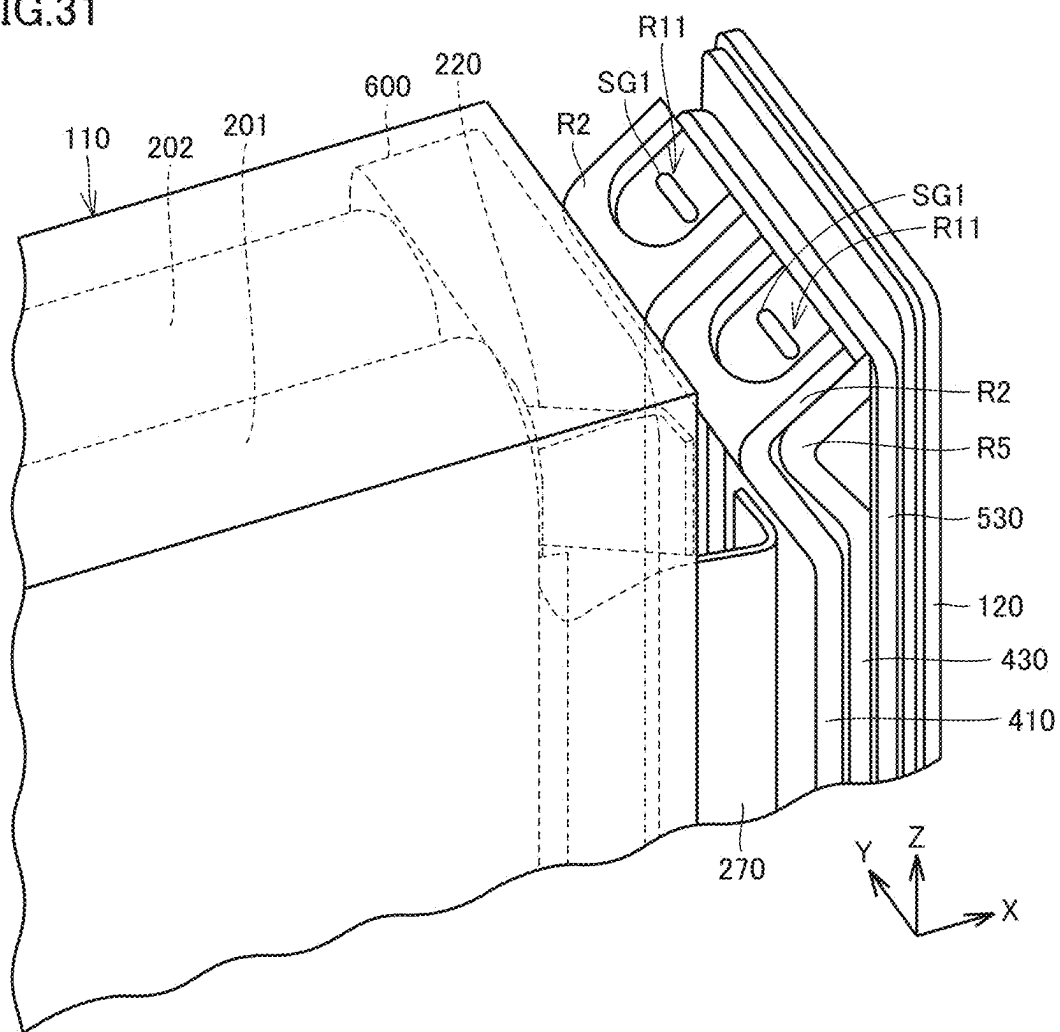


FIG.32

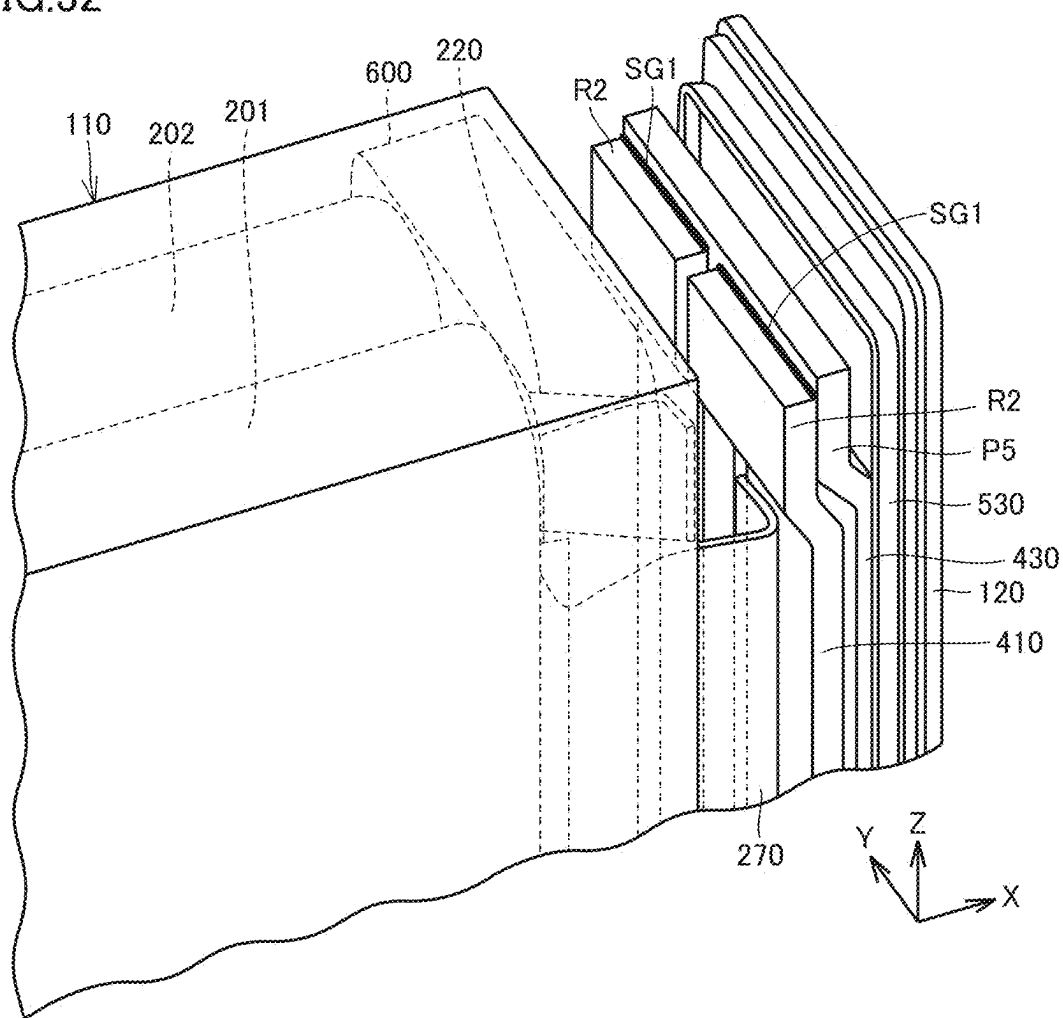
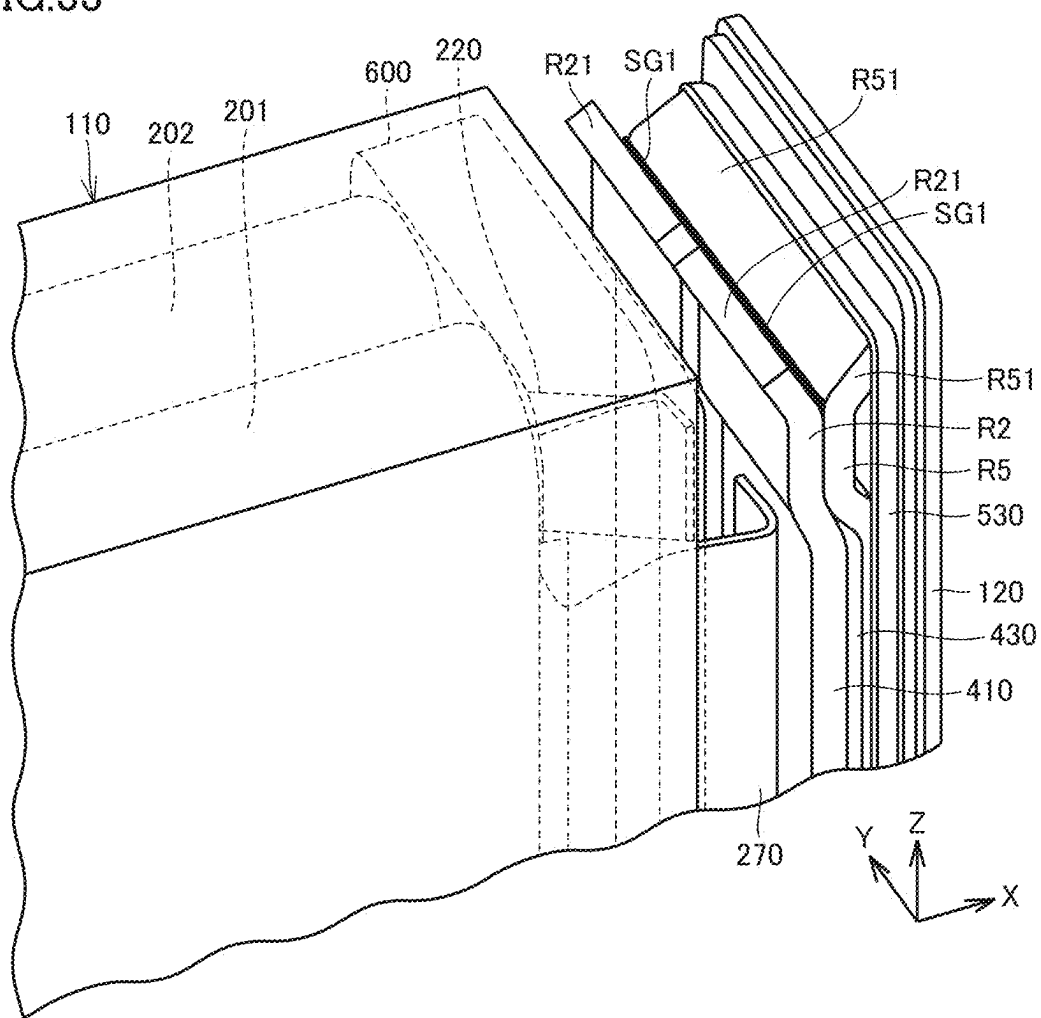


FIG.33



SECONDARY BATTERY

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This nonprovisional application is based on Japanese Patent Application No. 2024-021238 filed on Feb. 15, 2024 with the Japan Patent Office, the entire contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present technology relates to a secondary battery.

Description of the Background Art

[0003] Japanese Patent No. 4537353 discloses a prismatic battery in which a positive electrode terminal is provided on a side surface on one side and a negative electrode terminal is provided at an end portion on the other side in a battery case.

SUMMARY OF THE INVENTION

[0004] A secondary battery having a higher volume energy density and higher reliability has been required, and there is room for further improvement in terms of a structure of a current collecting portion and an assembling method.

[0005] An object of the present technology is to provide a secondary battery having higher volume energy density and higher reliability.

[0006] The present technology provides the following secondary battery.

[0007] [1] A secondary battery comprising: an electrode assembly including a first electrode and a second electrode having a polarity different from a polarity of the first electrode; a case main body provided with a first opening; a first sealing plate that seals the first opening; a first electrode tab electrically connected to the first electrode; a first current collecting member electrically connected to the first electrode tab; a second current collecting member joined to the first current collecting member; and a first electrode terminal electrically connected to the second current collecting member and provided on the first sealing plate, wherein the first current collecting member includes a first region, a second region, and a third region, the first region is disposed between the second region and the third region, the second current collecting member includes a fourth region, a fifth region, and a sixth region, the fourth region is disposed between the fifth region and the sixth region, the first electrode tab is connected to the first region, in a direction perpendicular to the first sealing plate, a surface of the first region on the first sealing plate side protrudes to the first sealing plate side with respect to each of a surface of the second region on the first sealing plate side and a surface of the third region on the first sealing plate side, and in the direction perpendicular to the first sealing plate, in a surface of the second current collecting member on the electrode assembly side, the fourth region is provided with a recess recessed to the first sealing plate side with respect to each of the fifth region

and the sixth region, and at least a portion of the first region is disposed in the recess.

[0008] [2] The secondary battery according to [1], wherein a first abutment region in which the second region and the fifth region are in abutment with each other is formed, and a second abutment region is formed at at least one of a position between the first region and the fourth region and a position between the third region and the sixth region, the second abutment region being a region in which corresponding ones of the first region, the fourth region, the third region, and the sixth region are in abutment with each other.

[0009] [3] The secondary battery according to [2], wherein a joining portion at which the first current collecting member and the second current collecting member are joined to each other is provided at an end portion of the first abutment region.

[0010] [4] The secondary battery according to [3], wherein a first clearance is present in a vicinity of an end portion of the first abutment region opposite to the end portion at which the joining portion is formed.

[0011] [5] The secondary battery according to any one of [2] to [4], wherein the second abutment region is formed between the third region and the sixth region.

[0012] [6] The secondary battery according to any one of [1] to [5], wherein a thickness of the fourth region is smaller than each of a thickness of the fifth region and a thickness of the sixth region.

[0013] [7] The secondary battery according to any one of [1] to [6], wherein a portion of the first current collecting member to which the first electrode tab is connected is present close to the third region with respect to the second region.

[0014] [8] The secondary battery according to any one of [1] to [7], wherein an end portion of the third region protrudes outward with respect to an end portion of the sixth region in a long-side direction of the first sealing plate.

[0015] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 is a front view showing a configuration of a secondary battery according to an embodiment.

[0017] FIG. 2 is a diagram showing a state in which the secondary battery shown in FIG. 1 is viewed in a direction of arrow II.

[0018] FIG. 3 is a diagram showing a state in which the secondary battery shown in FIG. 1 is viewed in a direction of arrow III.

[0019] FIG. 4 is a diagram showing a state in which the secondary battery shown in FIG. 1 is viewed in a direction of arrow IV.

[0020] FIG. 5 is a diagram showing a state in which the secondary battery shown in FIG. 1 is viewed in a direction of arrow V.

[0021] FIG. 6 is a front cross sectional view of the secondary battery shown in FIG. 1.

[0022] FIG. 7 is a cross sectional view of a negative electrode plate.

[0023] FIG. 8 is a front view showing the negative electrode plate.

[0024] FIG. 9 is a cross sectional view of a positive electrode plate.

[0025] FIG. 10 is a front view showing the positive electrode plate.

[0026] FIG. 11 is a cross sectional view of the secondary battery shown in FIG. 1 along XI-XI.

[0027] FIG. 12 is a cross sectional view of the secondary battery shown in FIG. 1 along XII-XII.

[0028] FIG. 13 is a flowchart showing a method of manufacturing a secondary battery according to one embodiment.

[0029] FIG. 14 is a perspective view showing a state before two electrode assemblies included in the secondary battery according to one embodiment are overlapped with each other.

[0030] FIG. 15 is a cross sectional view of each of the electrode assemblies and current collectors shown in FIG. 14 along XV-XV.

[0031] FIG. 16 is a perspective view showing a state of attaching a holder and a spacer to the electrode assembly.

[0032] FIG. 17 is a perspective view showing a state of attaching a sealing plate to the current collectors on the negative electrode side.

[0033] FIG. 18 is a cross sectional view of each of the electrode assemblies and the current collectors shown in FIG. 17 along XVIII-XVIII.

[0034] FIG. 19 is a first perspective view showing an implementation of the spacer.

[0035] FIG. 20 is a second perspective view showing the implementation of the spacer.

[0036] FIG. 21 is a side view showing a positional relation between the spacer and an insulating sheet.

[0037] FIG. 22 is a perspective view showing a state of inserting the electrode assemblies into a case main body.

[0038] FIG. 23 is a perspective view showing a state of attaching a sealing plate to the current collectors on the positive electrode side.

[0039] FIG. 24 is a cross sectional view of each of the electrode assemblies and the current collectors shown in FIG. 23 along XXIV-XXIV.

[0040] FIG. 25 is a perspective view showing a configuration of the secondary battery.

[0041] FIG. 26 is a side view showing only a negative-electrode-side connection structure on the first sealing plate side.

[0042] FIG. 27 is a longitudinal cross sectional view showing only the negative-electrode-side connection structure other than a negative electrode tab group and the electrode assemblies.

[0043] FIG. 28 is a perspective view showing a state before fixing the sealing plate to the case main body.

[0044] FIG. 29 is a first perspective view showing another implementation of a joining portion of the current collector.

[0045] FIG. 30 is a second perspective view showing the other implementation of the joining portion of the current collector.

[0046] FIG. 31 is a third perspective view showing the other implementation of the joining portion of the current collector.

[0047] FIG. 32 is a fourth perspective view showing the other implementation of the joining portion of the current collector.

[0048] FIG. 33 is a fifth perspective view showing the other implementation of the joining portion of the current collector.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0049] Hereinafter, embodiments of the present technology will be described. It should be noted that the same or corresponding portions are denoted by the same reference characters, and may not be described repeatedly.

[0050] In the embodiments described below, when reference is made to number, amount, and the like, the scope of the present technology is not necessarily limited to the number, amount, and the like unless otherwise stated particularly. Further, in the embodiments described below, each component is not necessarily essential to the present technology unless otherwise stated particularly. Further, the present technology is not limited to one that necessarily exhibits all the functions and effects stated in the present embodiment.

[0051] In the present specification, the terms “comprise”, “include”, and “have” are open-end terms. That is, when a certain configuration is included, a configuration other than the foregoing configuration may or may not be included.

[0052] In the present specification, when geometric terms and terms representing positional/directional relations are used, for example, when terms such as “parallel”, “orthogonal”, “obliquely at 45°”, “coaxial”, and “along” are used, these terms permit manufacturing errors or slight fluctuations. In the present specification, when terms representing relative positional relations such as “upper side” and “lower side” are used, each of these terms is used to indicate a relative positional relation in one state, and the relative positional relation may be reversed or turned at any angle in accordance with an installation direction of each mechanism (for example, the entire mechanism is reversed upside down).

[0053] In the present specification, the term “secondary battery” is not limited to a lithium ion battery, and may include other secondary batteries such as a nickel-metal hydride battery and a sodium-ion battery. In the present specification, the term “electrode” may collectively represent a positive electrode and a negative electrode.

[0054] In the figures, when an electrode assembly included in the secondary battery is a stacked type electrode assembly, an X direction is defined as a long-side direction of a stacked surface, whereas when the electrode assembly is a wound type electrode assembly, the X direction is defined as a direction along a winding axis thereof. Further, a Y direction is defined as a short-side direction of the electrode assembly when viewed in the X direction, and a Z direction is defined as a long-side direction of the electrode assembly when viewed in the X direction. In order to facilitate understanding of the invention, the size of each configuration in the figures may be illustrated to be changed from its actual size.

[0055] In the specification of the present application, the first direction (X direction) may be referred to as a “width direction” of each of the secondary battery, the electrode assembly, and the case main body, the second direction (Z direction) may be referred to as a “height direction” of the secondary battery or the case main body, and the third direction (Y direction) may be referred to as a “thickness direction” of the secondary battery or the case main body.

Embodiment: Overall Configuration of Battery

[0056] FIG. 1 is a front view of a secondary battery 1 according to the present embodiment. FIGS. 2 to 5 are diagrams showing states of secondary battery 1 shown in FIG. 1 when viewed in directions of arrows II, III, IV, and V respectively. FIG. 6 is a front cross sectional view of secondary battery 1 shown in FIG. 1.

[0057] Secondary battery 1 can be mounted on a battery electric vehicle (BEV), a plug-in hybrid electric vehicle (PHEV), a hybrid electric vehicle (HEV), or the like. It should be noted that the purpose of use of secondary battery 1 is not limited to the use on a vehicle.

[0058] As shown in FIGS. 1 to 6, secondary battery 1 includes a case 100, an electrode assembly 200, electrode terminals 300, and current collectors 400. Case 100 includes a case main body 110, a sealing plate 120 (first sealing plate), and a sealing plate 130 (second sealing plate).

[0059] When forming a battery assembly including secondary battery 1, a plurality of secondary batteries 1 are stacked in the thickness direction of each of the plurality of secondary batteries 1. Secondary batteries 1 stacked may be restrained in the stacking direction (Y direction) by a restraint member to form a battery module, or the battery assembly may be directly supported by a side surface of a case of a battery pack without using the restraint member.

[0060] Case main body 110 is constituted of a member having a tubular shape, preferably, a prismatic tubular shape. Thus, secondary battery 1 having a prismatic shape is obtained. Case main body 110 is composed of a metal. Specifically, case main body 110 is composed of aluminum, an aluminum alloy, iron, an iron alloy, or the like.

[0061] As shown in FIGS. 1 and 2, sealing plate 120 (first wall) and sealing plate 130 (second wall) are provided at respective end portions of the case main body. Case main body 110 can be formed to have a prismatic tubular shape in, for example, the following manner: end sides of a plate-shaped member having been bent are brought into abutment with each other (joining portion 115 illustrated in FIG. 2) and are joined together (for example, laser welding). Each of the corners of the “prismatic tubular shape” may have a shape with a curvature. Moreover, the secondary battery in the present technology is not necessarily limited to the prismatic secondary battery.

[0062] In the present embodiment, case main body 110 is formed to be longer in the width direction (X direction) of secondary battery 1 than in each of the thickness direction (Y direction) and the height direction (Z direction) of secondary battery 1. The size (width) of case main body 110 in the X direction is preferably about 30 cm or more. In this way, secondary battery 1 can be formed to have a relatively large size (high capacity). The size (height) of case main body 110 in the Z direction is preferably about 20 cm or less, more preferably about 15 cm or less, and further preferably about 10 cm or less. Thus, (low-height) secondary battery 1 having a relatively low height can be formed, thus resulting in improved ease of mounting on a vehicle, for example.

[0063] Case main body 110 includes a pair of first side surface portions 111 and a pair of second side surface portions 112. The pair of first side surface portions 111 constitute parts of the side surfaces of case 100. The pair of second side surface portions 112 constitute the bottom surface portion and upper surface portion of case 100. The pair of first side surface portions 111 and the pair of second side surface portions 112 are provided to intersect each

other. The pair of first side surface portions 111 and the pair of second side surface portions 112 are connected at their respective end portions. Each of the pair of first side surface portions 111 desirably has an area larger than that of each of the pair of second side surface portions 112.

[0064] As shown in FIG. 5, a gas-discharge valve 150 is provided in one second side surface portion 112A of the pair of second side surface portions 112. Gas-discharge valve 150 extends in the width direction (X direction) of secondary battery 1. Gas-discharge valve 150 extends from the center of case main body 110 in the X direction to such an extent that gas-discharge valve 150 does not reach both ends of case main body 110 in the X direction. The shape of gas-discharge valve 150 can be changed appropriately.

[0065] The thickness of the plate-shaped member in gas-discharge valve 150 is thinner than the thickness of the plate-shaped member of case main body 110 other than gas-discharge valve 150. Thus, when the pressure in case 100 becomes equal to or more than a predetermined value, gas-discharge valve 150 is fractured prior to the other portions of case main body 110, thereby discharging the gas in case 100 to the outside.

[0066] As shown in FIG. 2, joining portion 115 is formed at the other second side surface portion 112B of the pair of second side surface portions 112. Joining portion 115 extends in the width direction (X direction) of secondary battery 1. At joining portion 115, the end sides of the plate-shaped member of case main body 110 are joined to each other.

[0067] As shown in FIG. 3, an opening 113 (first opening) is provided at an end portion of case main body 110 on a first side in the first direction (X direction). Opening 113 is sealed by sealing plate 120. Joining portion 115 is formed at opening 113 so as to seal opening 113. Each of opening 113 and sealing plate 120 has a substantially rectangular shape in which the Y direction corresponds to its short-side direction and the Z direction corresponds to its long-side direction. The substantially rectangular shape includes a rectangular shape or a generally rectangular shape such as a rectangular shape having corners each with a curvature.

[0068] Sealing plate 120 (first sealing plate) is provided with a negative electrode terminal 301. The position of negative electrode terminal 301 can be appropriately changed.

[0069] As shown in FIG. 4, an opening 114 (second opening) is provided at an end portion of case main body 110 on a second side opposite to the first side in the first direction (X direction). That is, opening 114 is located at an end portion opposite to opening 113, and openings 113 and 114 face each other. Opening 114 is sealed by sealing plate 130. Joining portion 115 is formed at opening 114 so as to seal opening 114. Each of opening 114 and sealing plate 130 has a substantially rectangular shape in which the Y direction corresponds to its short-side direction and the Z direction corresponds to its long-side direction.

[0070] Sealing plate 130 (second sealing plate) is provided with a positive electrode terminal 302 and an injection hole 134. The positions of positive electrode terminal 302 and injection hole 134 can be appropriately changed.

[0071] Each of sealing plate 120 and sealing plate 130 is composed of a metal. Specifically, each of sealing plate 120 and sealing plate 130 is composed of aluminum, an aluminum alloy, iron, an iron alloy, or the like.

[0072] Negative electrode terminal 301 (first electrode terminal) is electrically connected to a negative electrode of electrode assembly 200. Negative electrode terminal 301 is attached to sealing plate 120, i.e., case 100.

[0073] Positive electrode terminal 302 (second electrode terminal) is electrically connected to a positive electrode of electrode assembly 200. Positive electrode terminal 302 is attached to sealing plate 130, i.e., case 100.

[0074] Negative electrode terminal 301 is composed of a conductive material (more specifically, a metal), and can be composed of copper, a copper alloy, or the like, for example. A portion or layer composed of aluminum or an aluminum alloy may be provided at a portion of an outer surface of negative electrode terminal 301.

[0075] Positive electrode terminal 302 is composed of a conductive material (more specifically, a metal), and can be composed of aluminum, an aluminum alloy, or the like, for example.

[0076] Injection hole 134 is sealed by a sealing member (not shown). As the sealing member, for example, a blind rivet or another metal member can be used.

[0077] Electrode assembly 200 is an electrode assembly having a flat shape and having a below-described positive electrode plate and a below-described negative electrode plate stacked on each other. Specifically, electrode assembly 200 is a stacked type electrode assembly in which a plurality of positive electrode plates and a plurality of negative electrode plates are alternately stacked with below-described separators 800 being interposed therebetween. However, in the present specification, the “electrode assembly” is not limited to the stacked type electrode assembly, and may be a wound type electrode assembly in which a strip-shaped positive electrode plate and a strip-shaped negative electrode plate are wound together with a strip-shaped separator being interposed therebetween. The separator can be constituted of, for example, a microporous membrane composed of polyolefin. When the electrode assembly is the stacked type electrode assembly including the plurality of positive electrode plates and the plurality of negative electrode plates, positive electrode tabs provided on the positive electrode plates may be stacked to form a positive electrode tab group, and negative electrode tabs provided on the negative electrode plates may be stacked to form a negative electrode tab group.

[0078] As shown in FIG. 6, case 100 accommodates electrode assembly 200. FIG. 6 illustrates a first electrode assembly 201 described below. First electrode assembly 201 is accommodated in case 100 such that the long-side direction thereof is parallel to the X direction.

[0079] Specifically, one or a plurality of the stacked type electrode assemblies and an electrolyte solution (electrolyte) (not shown) are accommodated inside a below-described insulating sheet 700 disposed in case 100. As the electrolyte solution (non-aqueous electrolyte solution), it is possible to use, for example, a solution obtained by dissolving LiPF₆ at a concentration of 1.2 mol/L in a non-aqueous solvent obtained by mixing ethylene carbonate (EC), ethyl methyl carbonate (EMC), and dimethyl carbonate (DMC) at a volume ratio (25° C.) of 30:30:40. Instead of the electrolyte solution, a solid electrolyte may be used.

[0080] First electrode assembly 201 includes a main body portion having a substantially rectangular shape, a negative

electrode tab group 220 (first electrode tab group), and a positive electrode tab group 250 (second electrode tab group).

[0081] The main body portion is constituted of a below-described negative electrode plate 210 and a below-described positive electrode plate 240. Negative electrode tab group 220 is located at an end portion of first electrode assembly 201 on the first side with respect to the main body portion thereof in the first direction (X direction). The first side in the present embodiment is the sealing plate 120 side. Positive electrode tab group 250 is located at an end portion of first electrode assembly 201 on the second side with respect to the main body portion thereof in the first direction (X direction). The second side in the present embodiment is the sealing plate 130 side.

[0082] Each of negative electrode tab group 220 and positive electrode tab group 250 is formed to protrude from a central portion of electrode assembly 200 toward sealing plate 120 or sealing plate 130.

[0083] Current collectors 400 include a negative electrode current collector 400A and a positive electrode current collector 400B. Each of negative electrode current collector 400A and positive electrode current collector 400B is constituted of a plate-shaped member. Electrode assembly 200 is electrically connected to negative electrode terminal 301 and positive electrode terminal 302 through current collectors 400.

[0084] Negative electrode current collector 400A is disposed on sealing plate 120 with an insulating member composed of a resin being interposed therebetween. Negative electrode current collector 400A is electrically connected to negative electrode tab group 220 and negative electrode terminal 301. Negative electrode current collector 400A is composed of a conductive material (more specifically, a metal), and can be composed of copper, a copper alloy, or the like, for example. Details of negative electrode current collector 400A will be described later.

[0085] Positive electrode current collector 400B is disposed on sealing plate 130 with an insulating member composed of a resin being interposed therebetween. Positive electrode current collector 400B is electrically connected to positive electrode tab group 250 and positive electrode terminal 302. Positive electrode current collector 400B is composed of a conductive material (more specifically, a metal), and can be composed of aluminum, an aluminum alloy, or the like, for example. Positive electrode tab group 250 may be electrically connected to sealing plate 130 directly or via positive electrode current collector 400B. In this case, sealing plate 130 may serve as positive electrode terminal 302. Details of positive electrode current collector 400B will be described later.

Configuration of Electrode Assembly 200

[0086] FIG. 7 is a cross sectional view of negative electrode plate 210 (cross sectional view along VII-VII in FIG. 8), and FIG. 8 is a front view showing negative electrode plate 210.

[0087] As shown in FIG. 8, a negative electrode tab 230 (first electrode tab) constituted of a negative electrode core body 211 is provided at one end portion, in the width direction, of negative electrode plate 210. When negative electrode plates 210 are stacked, a plurality of negative electrode tabs 230 are stacked to form negative electrode tab group 220. The length of each of the plurality of negative

electrode tabs **230** in the plurality of negative electrode plates **210** in the protruding direction is appropriately adjusted in consideration of the state in which negative electrode tab group **220** is connected to negative electrode current collector **400A**. The shape of negative electrode tab **230** is not limited to the one illustrated in FIG. 7.

[0088] FIG. 9 is a cross sectional view of positive electrode plate **240** (cross sectional view along IX-IX in FIG. 10), and FIG. 10 is a front view showing positive electrode plate **240**.

[0089] As shown in FIG. 10, a positive electrode tab **260** (second electrode tab) constituted of a positive electrode core body **241** is provided at one end portion, in the width direction, of positive electrode plate **240** formed. When positive electrode plates **240** are stacked, a plurality of positive electrode tabs **260** are stacked to form positive electrode tab group **250**. The length of each of positive electrode tabs **260** in the plurality of positive electrode plates **240** in the protruding direction is appropriately adjusted in consideration of the state in which positive electrode tab group **250** is connected to positive electrode current collector **400B**. The shape of positive electrode tab **260** is not limited to the one illustrated in FIG. 10.

[0090] A positive electrode protective layer **243** is provided at the root of positive electrode tab **260**. Positive electrode protective layer **243** may not necessarily be provided at the root of positive electrode tab **260**.

[0091] In a typical example, the thickness of (one) negative electrode tab **230** is smaller than the thickness of (one) positive electrode tab **260**. In this case, the thickness of negative electrode tab group **220** is smaller than the thickness of positive electrode tab group **250**.

Connection Structure between Electrode Assembly **200** and Current Collector **400**

[0092] FIG. 11 is a cross sectional view of the secondary battery shown in FIG. 1 along XI-XI. As shown in FIG. 11, electrode assembly **200** includes first electrode assembly **201** and a second electrode assembly **202**. Each of first electrode assembly **201** and second electrode assembly **202** includes a positive electrode (second electrode) and a negative electrode (first electrode). Electrode assembly **200** may be constituted of three or more electrode assemblies.

[0093] Electrode assembly **200** is formed by overlapping first electrode assembly **201** and second electrode assembly **202** with each other. First electrode assembly **201** and second electrode assembly **202** are arranged side by side in the thickness direction (Y direction) of each of first electrode assembly **201** and second electrode assembly **202**.

[0094] First electrode assembly **201** includes negative electrode tab group **220**. Negative electrode tab group **220** is electrically connected to one current collector **410** (negative electrode current collector) at its first end portion **205** in the X direction. Second electrode assembly **202** includes a negative electrode tab group **270**. Negative electrode tab group **270** is electrically connected to the other current collector **410** (negative electrode current collector) at its third end portion **207** in the X direction.

[0095] Negative electrode tab group **220** has a curved portion **221** and a tip portion **222**. Curved portion **221** is a portion at which negative electrode tab group **220** is curved on the side, on which the first electrode is connected, with respect to tip portion **222**. Tip portion **222** is a portion

located at an end portion of negative electrode tab group **220** on the side opposite to the side on which the first electrode is connected.

[0096] Negative electrode tab group **270** has a curved portion **271** and a tip portion **272**. Curved portion **271** is a portion at which negative electrode tab group **270** is curved on the side, on which the first electrode is connected, with respect to tip portion **272**. Tip portion **272** is a portion located at an end portion of negative electrode tab group **270** on the side opposite to the side on which the first electrode is connected.

[0097] Negative electrode tab group **220** and negative electrode tab group **270** are curved in opposite directions such that tip portions **222**, **272** are close to each other. Tip portions **222**, **272** are separated from each other in the present embodiment; however, it is not limited to this configuration, and tip portions **222**, **272** may be in contact with each other.

[0098] Negative electrode current collector **400A** electrically connects negative electrode terminal **301** to negative electrode tab group **220** and negative electrode tab group **270**. Negative electrode current collector **400A** in the present embodiment is connected to negative electrode terminal **301** between electrode assembly **200** and sealing plate **120**.

[0099] Negative electrode current collector **400A** includes two current collectors **410** (first current collecting member) and a current collector **430** (second current collecting member).

[0100] Each of current collectors **410** is a plate-shaped member. Current collector **410** has a long-side direction in the Z direction and a short-side direction in the Y direction. Current collector **430** is a plate-shaped member. Current collector **430** has a long-side direction in the Z direction and a short-side direction in the Y direction. Current collector **410** and current collector **430** are arranged side by side in parallel in the X direction. In this way, current collector **410** and current collector **430** are constituted of separate components.

[0101] Negative electrode tab group **220** is joined to one current collector **410** at a joining location **411** (see FIG. 14) described later. Negative electrode tab group **270** is joined to the other current collector **410** at a joining location **411** (see FIG. 14) described later. Each of joining locations **411** may be formed by ultrasonic welding, resistance welding, laser welding, swaging, or the like, for example. In the present embodiment, negative electrode tab group **220** and one current collector **410** are joined by ultrasonic joining, and negative electrode tab group **270** and the other current collector **410** are joined by ultrasonic joining, for example.

[0102] Current collector **430** is joined to each of one current collector **410** and the other current collector **410** at a joining location (not shown) located at its end portion in the Z direction. Current collector **430** is connected to negative electrode terminal **301**. The connection between current collector **430** and negative electrode terminal **301** may be formed by swaging and/or welding, for example.

[0103] Negative electrode terminal **301** is located on the outer side with respect to sealing plate **120**. Negative electrode terminal **301** is connected to a plate-shaped member **303**. It should be noted that negative electrode terminal **301** preferably includes a region **301a** composed of copper or a copper alloy and a region **301b** composed of aluminum or an aluminum alloy, and region **301a** composed of copper or a copper alloy is preferably connected to current collector **430**.

[0104] Plate-shaped member 303 is located on the outer side with respect to sealing plate 120. Plate-shaped member 303 is disposed along sealing plate 120. Plate-shaped member 303 has electric conductivity. Plate-shaped member 303 is disposed to secure an area of connection with a bus bar or the like that electrically connects secondary battery 1 and another secondary battery adjacent thereto. The connection between negative electrode terminal 301 and plate-shaped member 303 can be formed by, for example, laser welding or the like.

[0105] An insulating member 510 is disposed between plate-shaped member 303 and sealing plate 120. An insulating member 520 is disposed between negative electrode terminal 301 and sealing plate 120. An insulating member 530 is disposed between current collector 430 and sealing plate 120.

[0106] It should be noted that negative electrode terminal 301 may be electrically connected to sealing plate 120. Further, sealing plate 120 may function as negative electrode terminal 301.

[0107] A below-described spacer 600 (first spacer) is disposed between sealing plate 120 and the main body portion (negative electrode tab group 220 is not included) of electrode assembly 200. Spacer 600 is composed of a resin member having an insulating property. Negative electrode tab group 220 passes internal to spacer 600, thereby protecting negative electrode tab group 220 by spacer 600. It should be noted that it is also possible to employ a configuration in which spacer 600 (first spacer) is not provided.

[0108] Although a detailed structure of spacer 600 will be described later, spacer 600 is provided with a protrusion 616 protruding in the Y direction. With this protrusion 616 of spacer 600, spacer 600 functions as a guide to facilitate curving of curved portions 221, 271 when forming curved portions 221, 271.

[0109] Insulating sheet 700 (electrode assembly holder) composed of a resin is disposed between electrode assembly 200 and case main body 110. Insulating sheet 700 may be composed of, for example, a resin. More specifically, the material of insulating sheet 700 is, for example, polypropylene (PP), polyethylene terephthalate (PET), polyphenylene sulfide (PPS), polyimide (PI), or polyolefin (PO).

[0110] FIG. 12 is a cross sectional view of the secondary battery shown in FIG. 1 along XII-XII. The connection structure between electrode assembly 200 and current collector 400 on the positive electrode side of secondary battery 1 according to the present embodiment is different from that of the configuration on the negative electrode side in the following point: a portion corresponding to one current collector 410 and the other current collector 410 on the negative electrode side is constituted of a single component.

[0111] First electrode assembly 201 includes positive electrode tab group 250. Positive electrode tab group 250 is electrically connected to current collector 420 (positive electrode current collector) at its second end portion 206 in the X direction. Second electrode assembly 202 includes a positive electrode tab group 280. Positive electrode tab group 280 is electrically connected to current collector 420 (positive electrode current collector) at its fourth end portion 208 in the X direction.

[0112] Positive electrode tab group 250 has a curved portion 251 and a tip portion 252. Curved portion 251 is a portion at which positive electrode tab group 250 is curved on the side, on which the second electrode is connected, with

respect to tip portion 252. Tip portion 252 is a portion located at an end portion of positive electrode tab group 250 on the side opposite to the side on which the second electrode is connected.

[0113] Positive electrode tab group 280 has a curved portion 281 and a tip portion 282. Curved portion 281 is a portion at which positive electrode tab group 280 is curved on the side, on which the second electrode is connected, with respect to tip portion 282. Tip portion 282 is a portion located at an end portion of positive electrode tab group 280 on the side opposite to the side on which the second electrode is connected.

[0114] Positive electrode tab group 250 and positive electrode tab group 280 are curved in opposite directions such that tip portions 252, 282 are close to each other. Tip portions 252, 272 are separated from each other in the present embodiment; however, it is not limited to this configuration, and tip portions 252, 282 may be in contact with each other.

[0115] Positive electrode current collector 400B electrically connects positive electrode terminal 302 to positive electrode tab group 250 and positive electrode tab group 280. Positive electrode current collector 400B in the present embodiment is connected to positive electrode terminal 302 between electrode assembly 200 and sealing plate 130.

[0116] Positive electrode current collector 400B includes current collector 420 and a current collector 440. Although a plate 460 is interposed as an insulating member between current collector 420 and current collector 440, current collector 420 and current collector 440 are electrically joined to each other at a position different from the cross section shown in the figure.

[0117] Current collector 420 is a plate-shaped member. Current collector 420 has a long-side direction in the Z direction and a short-side direction in the Y direction. Current collector 420 is constituted of a single component in one piece.

[0118] Positive electrode tab group 250 and positive electrode tab group 280 are joined, at below-described joining locations 421 (see FIG. 14), to current collector 420 constituted of the single component. Each of joining locations 421 may be formed by ultrasonic welding, resistance welding, laser welding, swaging, or the like, for example. In the present embodiment, positive electrode tab group 250 and positive electrode tab group 280 are joined to current collector 420 by ultrasonic joining, for example.

[0119] Current collector 440 is joined to current collector 420 at a joining location (not shown) located at its end portion in the Z direction. Current collector 440 is connected to positive electrode terminal 302. The connection between current collector 440 and positive electrode terminal 302 may be formed by swaging and/or welding, for example.

[0120] Positive electrode terminal 302 is provided to be exposed to the outside of sealing plate 130 and reach current collector 440 of positive electrode current collector 400B provided on the inner surface side of sealing plate 130. Positive electrode terminal 302 is connected to a plate-shaped member 304.

[0121] Plate-shaped member 304 is located on the outer side with respect to sealing plate 130. Plate-shaped member 304 is disposed along sealing plate 130. Plate-shaped member 304 has electric conductivity. Plate-shaped member 304 is disposed to secure an area of connection with a bus bar or the like that electrically connects secondary battery 1 and

another secondary battery adjacent thereto. The connection between positive electrode terminal 302 and plate-shaped member 304 may be formed by, for example, laser welding or the like.

[0122] An insulating member 510 is disposed between plate-shaped member 304 and sealing plate 130. An insulating member 520 is disposed between positive electrode terminal 302 and sealing plate 130. An insulating member 470 is disposed between current collector 440 and sealing plate 130.

[0123] It should be noted that positive electrode terminal 302 may be electrically connected to sealing plate 130. Further, sealing plate 130 may function as positive electrode terminal 302.

[0124] A spacer 600 (second spacer) is disposed between sealing plate 130 and the main body portion (positive electrode tab groups 250, 280 are not included) of electrode assembly 200. Spacer 600 is composed of a resin member having an insulating property. Since each of positive electrode tab groups 250, 280 passes internal to spacer 600, each of positive electrode tab groups 250, 280 is protected by spacer 600. It should be noted that it is also possible to employ a configuration in which spacer 600 (second spacer) is not provided.

[0125] Although a detailed structure of spacer 600 will be described later, spacer 600 is provided with a protrusion 616 protruding in the Y direction. With this protrusion 616 of spacer 600, spacer 600 functions as a guide to facilitate curving of curved portions 251, 281 when forming curved portions 251, 281.

[0126] Insulating sheet 700 (electrode assembly holder) composed of a resin as described above is disposed between electrode assembly 200 and case main body 110.

Manufacturing Process for Secondary Battery 1

[0127] Hereinafter, a method of manufacturing the secondary battery according to the present embodiment will be described. FIG. 13 is a flowchart showing a method of manufacturing the secondary battery according to the first embodiment. FIG. 14 is a perspective view showing a state before two electrode assemblies included in the secondary battery according to the first embodiment are overlapped with each other. FIG. 15 is a cross sectional view of each of the electrode assemblies and the current collectors shown in FIG. 14 along XV-XV.

[0128] As shown in FIG. 13, in the method of manufacturing the secondary battery according to the present embodiment, first, first electrode assembly 201 and second electrode assembly 202 are produced (step S1). Parts of the tips of negative electrode tab group 220, positive electrode tab group 250, negative electrode tab group 270, and positive electrode tab group 280 are preferably cut such that they have the same tip length when bundled.

[0129] As shown in FIGS. 13 to 15, after producing first electrode assembly 201 and second electrode assembly 202, negative electrode tab group 220 is joined to one current collector 410 (step S2). Negative electrode tab group 220 is joined to one current collector 410 at joining location 411. Next, negative electrode tab group 270 is joined to the other current collector 410 (step S3). Negative electrode tab group 270 is joined to the other current collector 410 at joining location 411.

[0130] Next, first electrode assembly 201, current collector 420, and second electrode assembly 202 are disposed

side by side in this order in the first direction (DR1 direction). Positive electrode tab group 250 is disposed on one side with respect to current collector 420 in the first direction (DR1 direction). Positive electrode tab group 250 and positive electrode tab group 280 are joined to current collector 420 with positive electrode tab group 280 being disposed on the other side with respect to current collector 420 in the first direction (DR1 direction) (step S4). Positive electrode tab group 250 and positive electrode tab group 280 are joined to current collector 420 at joining locations 421.

[0131] In the height direction of each of first electrode assembly 201 and second electrode assembly 202, each of one current collector 410, the other current collector 410 and current collector 420 is disposed on one side with respect to the center of each of first electrode assembly 201 and second electrode assembly 202. Thus, each of the current collectors can be formed to be short, thereby reducing the size of the current collector.

[0132] Each of one current collector 410, the other current collector 410, and current collector 420 is not limited to this configuration. In the height direction of each of first electrode assembly 201 and second electrode assembly 202, each of current collectors 410 and current collector 420 may be disposed at the center of a corresponding one of first electrode assembly 201 and second electrode assembly 202. In this case, in the height direction of each of first electrode assembly 201 and second electrode assembly 202, each of negative electrode tab group 220, positive electrode tab group 250, negative electrode tab group 270, and positive electrode tab group 280 is disposed at the center of a corresponding one of first electrode assembly 201 and second electrode assembly 202 so as to correspond to a corresponding one of current collectors 410 and current collector 420.

[0133] The order of the steps of joining current collectors 410 and current collector 420 to first electrode assembly 201 and second electrode assembly 202 is not limited to the one described above, and the order may be changed. Each of the respective steps of joining current collectors 410 to first electrode assembly 201 and second electrode assembly 202 is preferably performed before the below-described step of overlapping first electrode assembly 201 and second electrode assembly 202 with each other, and is preferably performed before the step of joining current collector 420 to first electrode assembly 201 and second electrode assembly 202.

[0134] Next, after joining positive electrode tab group 250 and positive electrode tab group 280 to current collector 420, positive electrode tab group 250 and positive electrode tab group 280 are bent in the thickness direction (direction orthogonal to the DR1 direction in FIGS. 14 and 15) of each of first electrode assembly 201 and second electrode assembly 202, thereby overlapping first electrode assembly 201 and second electrode assembly 202 with each other (step S5). That is, first electrode assembly 201 and second electrode assembly 202 are collected together.

[0135] Regarding the expression “overlapping the first electrode assembly and the second electrode assembly with each other”, the first electrode assembly and the second electrode assembly may be overlapped with each other directly, or another member may be disposed between the first electrode assembly and the second electrode assembly. Further, the first electrode assembly and the second electrode assembly may or may not be fixed by a tape or the like.

Further, the first electrode assembly, the current collector, and the second electrode assembly may not be disposed on a straight line in the first direction (DR1 direction), and the first electrode assembly or the second electrode assembly may be inclined with respect to the current collector in the first direction (DR1 direction).

[0136] Positive electrode tab group 250 and positive electrode tab group 280 are folded such that tip portions thereof face each other. Similarly, negative electrode tab group 220 and negative electrode tab group 270 are also folded such that tip portions thereof face each other.

[0137] Each of FIGS. 13 and 16 is a perspective view showing a state of attaching the holder and the spacer to the electrode assembly. As shown in FIG. 16, next, spacer 600 and insulating sheet 700 are assembled to electrode assembly 200 (step S6).

[0138] Insulating sheet 700 does not necessarily need to cover a whole of the surfaces of electrode assembly 200. Insulating sheet 700 preferably covers an area of about 50% or more, more preferably about 70% or more, of the outer surfaces of the electrode assembly. Insulating sheet 700 preferably covers a whole of at least four surfaces of the six surfaces of electrode assembly 200 having a substantially rectangular parallelepiped shape (flat shape) other than the two surfaces thereof on which negative electrode tab group 220 and positive electrode tab group 250 are formed respectively.

[0139] FIG. 17 is a perspective view showing a state of attaching sealing plate 120 to the current collectors on the negative electrode side. FIG. 18 is a cross sectional view of each of the electrode assemblies and the current collectors shown in FIG. 17 along XVIII-XVIII. FIGS. 19 and 20 are first and second perspective views each showing an implementation of spacer 600, and FIG. 21 is a front view showing a positional relation between spacer 600 and insulating sheet 700. It should be noted that in FIG. 18, case main body 110 is not shown.

[0140] As shown in FIGS. 19 and 20, spacer 600 is composed of a resin member having an insulating property. Spacer 600 includes: a first component 612 and a second component 614 each having three surrounding side walls; and a coupling wall 611 that couples one side wall of first component 612 and one side wall of second component 614 to each other. Protrusion 616 is provided on an inner side of coupling wall 611 so as to extend between first component 612 and second component 614 (in the Z direction).

[0141] First component 612 includes a first plate portion 617 provided to couple the three walls. First plate portion 617 is provided with a plurality of first through holes 617s each having an elliptical shape. The shape of each first through hole 617s and the number of first through holes 617s are appropriately selected, and are not limited to the shape and number shown. A first protrusion 612p protruding outward is provided in a region of first component 612 opposite to first plate portion 617 (side opposite to the electrode assembly).

[0142] Second component 614 includes a second plate portion 618 provided to couple the three walls. Second plate portion 618 is provided with a plurality of second through holes 618s each having an elliptical shape. The shape of each second through hole 618s and the number of second through holes 618s are appropriately selected, and are not limited to the shape and number shown. A second protrusion 614p protruding outward is provided in a region of second com-

ponent 614 opposite to second plate portion 618 (side opposite to the electrode assembly).

[0143] Each of first plate portion 617 and second plate portion 618 described above is located on an end surface side of the electrode assembly. Each of these plate portions may be in abutment with the end surface of the electrode assembly, or when each of these plate portions is not in abutment with the end surface, the shortest distance to the electrode assembly is preferably 2 mm or less, and is more preferably 1 mm or less. Further, since first through hole 617s and second through hole 618s are provided, when secondary battery 1 shown in FIG. 1 is placed with the Z direction corresponding to the upward direction (such a direction that opening 113 (first opening) and opening 114 (second opening) at the both ends of case main body 110 are arranged on the left and right), even if the electrolyte solution pushed out from the electrode assembly flows to outside of the through holes during charging (generally, the electrode plate is expanded), the electrolyte solution can be readily returned to inside of the electrode assembly during discharging (generally, the electrode plate is contracted).

[0144] The outer size of spacer 600 (each of the first spacer and the second spacer) is preferably smaller than the outer size of electrode assembly 200. Since insulating sheet 700 is wound around electrode assembly 200 and is also wound around spacer 600, insertability of electrode assembly 200 of case main body 110 can be improved by making the outer size of spacer 600 smaller than that of electrode assembly 200.

[0145] As shown in FIG. 21, when electrode assembly 200 is covered with insulating sheet 700, spacer 600 is also preferably covered with insulating sheet 700. In this case, each of the negative electrode tab group and the positive electrode tab group passes internal to spacer 600, thereby protecting each of the negative electrode tab group and the positive electrode tab group by spacer 600. Further, since spacer 600 is also covered with insulating sheet 700, each of the negative electrode tab group and the positive electrode tab group is further protected. It should be noted that each of first protrusion 612p and second protrusion 614p provided in spacer 600 is desirably exposed from insulating sheet 700.

[0146] As shown in FIGS. 13, 17, and 18, one current collector 410 and the other current collector 410 are electrically connected to negative electrode terminal 301 via current collector 430 after joining negative electrode tab group 220 to current collector 410, joining negative electrode tab group 270 to current collector 430, and overlapping first electrode assembly 201 and second electrode assembly 202 with each other (step S7). It should be noted that step S7 can be performed before step S6.

[0147] Specifically, negative electrode tab group 220 and negative electrode tab group 270 are folded such that tip portions 222, 272 face each other.

[0148] Each of negative electrode terminal 301 and current collector 430 is attached to sealing plate 120 with an insulating member being interposed therebetween. Current collector 430 is brought into abutment with one current collector 410 and the other current collector 410 in the X direction. It should be noted that the connecting of plate-shaped member 303 to negative electrode terminal 301 may be performed at any timing. Current collector 430 is joined to one current collector 410 and the other current collector 410 by laser welding from between sealing plate 120 and insulating sheet 700.

[0149] FIG. 22 is a perspective view showing a state of inserting the electrode assemblies into the case main body. As shown in FIGS. 13 and 22, next, after overlapping first electrode assembly 201 and second electrode assembly 202 with each other, first electrode assembly 201 and second electrode assembly 202 are inserted into case main body 110 via opening 113 with the current collector 420 side being inserted first (step S8). On this occasion, at each of the end portions of first electrode assembly 201 and second electrode assembly 202 on the negative electrode tab 230 side, first electrode assembly 201 and second electrode assembly 202 may be inserted into case main body 110 with negative electrode active material layer 212 protruding to the negative electrode tab 230 side with respect to the end portion of positive electrode active material layer 242.

[0150] Negative electrode tab group 220 and negative electrode tab group 270 are curved by bringing sealing plate 120 close to the main body portion of electrode assembly 200 (first electrode assembly 201 and second electrode assembly 202). It should be noted that sealing plate 120 and case main body 110 are preferably brought close to each other by bringing sealing plate 120 close to the main body portion of electrode assembly 200 disposed in case main body 110. As shown in FIG. 11, negative electrode tab group 220 and negative electrode tab group 270 are curved along the shape of spacer 600 such that the folded portions of curved portions 221, 271 are close to case main body 110 in the Y direction.

[0151] After bringing sealing plate 120 into abutment with case main body 110, sealing plate 120 is temporarily joined to case main body 110. By the temporary joining, sealing plate 120 is partially joined to opening 113 of case main body 110. Thus, sealing plate 120 is positioned with respect to case main body 110.

[0152] When inserting electrode assembly 200 into case main body 110, electrode assembly 200 may be pulled from the current collector 420 side, or may be pushed from each of the current collector 410 side and the current collector 430 side. When electrode assembly 200 is pressed from each of the current collector 410 side and the current collector 430 side, negative electrode tab group 220 and negative electrode tab group 270 can be curved at the same time.

[0153] FIG. 23 is a perspective view showing a state of attaching sealing plate 130 to the current collectors on the positive electrode side. FIG. 24 is a cross sectional view of each of the electrode assemblies and the current collectors shown in FIG. 23 along XXIII-XXIII. In FIG. 24, case main body 110 is not shown.

[0154] As shown in FIGS. 13, 22 and 23, current collector 420 is electrically connected to positive electrode terminal 302 after inserting first electrode assembly 201 and second electrode assembly 202 into case main body 110 (step S9).

[0155] Specifically, each of positive electrode terminal 302 and current collector 450 is attached to sealing plate 130 with an insulating member being interposed therebetween. After inserting first electrode assembly 201 and second electrode assembly 202 into case main body 110, current collector 450 is brought into abutment, in the X direction, with current collector 420 protruding from opening 114. The connecting of plate-shaped member 304 to positive electrode terminal 302 may be performed at any timing.

[0156] As shown in FIG. 24, positive electrode tab group 250 and positive electrode tab group 280 connected to current collector 420 are folded such that tip portions 252,

282 face each other. From the state shown in FIG. 24, sealing plate 130 is brought into abutment with case main body 110. On this occasion, positive electrode tab group 250 and positive electrode tab group 280 are curved by bringing sealing plate 130 and the main body portion of electrode assembly 200 close to each other. As shown in FIG. 12, positive electrode tab group 250 and positive electrode tab group 280 are curved along the shape of spacer 600 such that the folded portions of curved portions 251, 281 are close to case main body 110 in the Y direction.

[0157] After sealing plate 130 is brought into abutment with case main body 110, sealing plate 130 is temporarily welded to case main body 110. By the temporary joining, sealing plate 130 is partially joined to opening 114 of case main body 110. Thus, sealing plate 130 is positioned with respect to case main body 110.

[0158] FIG. 25 is a perspective view showing the configuration of secondary battery 1. As shown in FIGS. 13 and 25, next, sealing plate 120 and sealing plate 130 are joined to case main body 110 (step S10). Sealing plate 120 seals opening 113 of case main body 110, and sealing plate 130 seals opening 114 of case main body 110. Thus, first electrode assembly 201 and second electrode assembly 202 are accommodated in case 100.

[0159] After the above-described steps, an inspection such as a leakage inspection is performed (step S11). After the leakage inspection, secondary battery 1 is dried to remove moisture in case 100. Then, the electrolyte solution is injected into case 100 through injection hole 134. When injecting the electrolyte solution, case 100 is inclined with sealing plate 130 facing upward and sealing plate 120 facing downward, thereby injecting the electrolyte solution into case 100 via injection hole 134 of sealing plate 130. Thereafter, charging is performed to result in release of gas. For performing the charging to result in release of gas, injection hole 134 may be temporarily sealed. Thereafter, injection hole 134 is sealed, thereby completing secondary battery 1.

[0160] The order of the step of inserting electrode assembly 200 and the step of connecting the current collectors is not limited to the above-described example. For example, after only a portion of electrode assembly 200 is inserted into case main body 110 with the end portion of negative electrode active material layer 212 (second electrode active material layer) on the opening 113 side being disposed outside case main body 110 (first step), negative electrode terminal 301 (first electrode terminal) provided on sealing plate 120 (first sealing plate) and negative electrode tab groups 220, 270 (first electrode tab) may be electrically connected to each other, and then electrode assembly 200 may be inserted into case main body 110 until the end portion of negative electrode active material layer 212 on the opening 113 side is disposed inside case main body 110 (second step). That is, negative electrode terminal 301 and electrode assembly 200 can be electrically connected to each other during the step of inserting electrode assembly 200 into case main body 110.

[0161] In the present embodiment, since first electrode assembly 201 is provided with negative electrode tab group 220 and positive electrode tab group 250 and second electrode assembly 202 is provided with negative electrode tab group 270 and positive electrode tab group 280, first electrode assembly 201 and second electrode assembly 202 can be configured to have separate electrode tabs.

[0162] With this configuration, the electrode tabs can be shortened as compared with a case where one collective electrode tab is formed by first electrode assembly 201 and second electrode assembly 202 and the electrode tab is bent.

[0163] As a result, the occupied volume of the electrode tabs can be reduced, thereby improving the energy density of secondary battery 1. Further, in the configuration in which the separate electrode tabs are respectively provided for first electrode assembly 201 and second electrode assembly 202, the electrode tabs are readily bent and the electrode tabs and the current collectors can be therefore readily joined as compared with the case where one collective electrode tab is formed by first electrode assembly 201 and second electrode assembly 202, with the result that the secondary battery can be stably manufactured. In particular, since secondary battery 1 can be stably manufactured, reliability of the connection portion between each of the electrode tabs and each of the current collectors can be increased.

Specific Configurations of Current Collector 410 and Current Collector 430

[0164] Next, a specific configuration of each of current collectors 410 (first current collecting member) and current collector 430 (second current collecting member) will be described with reference to FIGS. 26 to 28. FIG. 26 is a side view showing only the negative-electrode-side connection structure on the sealing plate 120 (first sealing plate) side, FIG. 27 is a longitudinal cross sectional view showing only the negative-electrode-side connection structure other than negative electrode tab groups 220, 270 and electrode assembly 200, and FIG. 28 is a perspective view showing a state before fixing sealing plate 120 to case main body 110.

[0165] Current collector 410 has a plate shape and includes a first region R1, a second region R2, and a third region R3. First region R1 is disposed between second region R2 and third region R3. It should be noted that negative electrode tab group 220, 270 (first electrode tab) is connected to first region R1. It should be noted that second region R2, first region R1, and third region R3 are preferably arranged in this order in the long-side direction of sealing plate 120.

[0166] Current collector 430 has a plate shape and includes a fourth region R4, a fifth region R5, and a sixth region R6. Fourth region R4 is disposed between fifth region R5 and sixth region R6.

[0167] In current collector 410, in the direction (X direction) perpendicular to sealing plate 120, a surface of first region R1 on the sealing plate 120 side protrudes to the sealing plate 120 side with respect to each of a surface of second region R2 on the sealing plate 120 side and a surface of third region R3 on the sealing plate 120 side.

[0168] A first chamfered portion RT2 is provided at a tip portion of second region R2 on the fifth region R5 side, and a second chamfered portion RT5 is provided at a tip portion of fifth region R5 on the second region R2 side.

[0169] In the present embodiment, since the whole of first region R1 protrudes to the sealing plate 120 side, a recess 410p is provided on the negative electrode tab group 220, 270 side of first region R1. Thus, negative electrode tab group 220, 270 is connected to recess 410p of first region R1. It should be noted that the negative electrode tab group 220, 270 (first electrode tab) side of first region R1 may be flat.

[0170] In current collector 430, in the direction (X direction) perpendicular to sealing plate 120, in the surface of current collector 430 on the electrode assembly 200 side, fourth region R4 is provided with a recess 430p recessed to the sealing plate 120 side with respect to each of fifth region R5 and sixth region R6.

[0171] The length (PL1) of recess 430p in the long-side direction (Z direction) is preferably larger than the length of the portion of first region R1 protruding to the sealing plate 120 side in the long-side direction (Z direction). The length of the portion of first region R1 protruding to the sealing plate 120 side in the long-side direction (Z direction) is preferably 70% or more, more preferably 80% or more, and further preferably 90% or more of the length (PL1) of recess 430p in the long-side direction (Z direction).

[0172] The first region of current collector 410 preferably has a protruding portion 410q protruding to the sealing plate 120 side, and protruding portion 410q preferably has a tip surface 410q1 located on the tip side in the protruding direction and outer side surfaces 410q2 located at both ends of tip surface 410q1 in the long-side direction thereof.

[0173] Recess 430p preferably has a bottom surface 430p1 and inner side surfaces 430p2 provided at both ends of bottom surface 430p1 in the long-side direction thereof. Tip surface 410q1 of protruding portion 410q and bottom surface 430p1 of recess 430p face each other and is in abutment with or in proximity to each other. The length (PL11) of tip surface 410q1 of protruding portion 410q of current collector 410 in the long-side direction (Z direction) is preferably 70% or more, more preferably 80% or more, and further preferably 90% or more of the length (PL12) of bottom surface 430p1 of recess 430p in the long-side direction (Z direction). It should be noted that the length of tip surface 410q1 is preferably less than 100% of bottom surface 430p1.

[0174] In recess 430p, the length (PL1) of recess 430p in the long-side direction (Z direction) may be longer than the length (TL1) of each of negative electrode tab groups 220, 270 (first electrode tab) in the long-side direction (Z direction). When each of negative electrode tab groups 220, 270 (first electrode tab) is trapezoidal in shape, the length (length in the Z direction) of each of the regions of negative electrode tab groups 220, 270 connected to current collectors 410 is defined as the length (TL1) of each of negative electrode tab groups 220, 270.

[0175] Further, referring to FIG. 11, the length (PL2) of recess 430p in the short-side direction (Y direction) is preferably longer than the length (TL2), in the width direction (Y direction), of each of the portions of negative electrode tab groups 220, 270 (first electrode tab) that are in abutment with current collectors 410. It should be noted that the entire region of current collector 430 in the short-side direction is preferably recess 430p.

[0176] In a state in which current collector 410 and current collector 430 are overlapped with each other, at least a portion of first region R1 of current collector 410 is preferably disposed in recess 430p of current collector 430. Thus, current collector 410 can be positioned with respect to current collector 430. As a result, current collector 410 and current collector 430 can be stably connected.

[0177] Preferably, in a state in which first region R1 is disposed in recess 430p, a first clearance S1 is provided on the second region side and a second clearance S2 is provided on the third region side between first region R1 and the inner side surface of recess 430p. With first clearance S1 and

second clearance S2, a slight positional deviation of first region R1 in recess 430p can be absorbed, thereby facilitating positioning of first region R1 with respect to recess 430p. It should be noted that only one of first clearance S1 and second clearance S2 may be provided.

[0178] Further, in the long-side direction (Z direction in FIG. 26) of recess 430p, each of the width of first clearance S1 (portion of the clearance with the maximum width) and the width of second clearance S2 (portion of the clearance with the maximum width) is preferably 5 mm or less, more preferably 3 mm or less, and further preferably 2 mm or less.

[0179] Further, a first abutment region TR1 in which second region R2 of current collector 410 and fifth region R5 of current collector 430 are in abutment with each other may be formed, and a second abutment region TR2 may be formed at at least one of a position between first region R1 of current collector 410 and fourth region R4 of current collector 430 and a position between third region R3 of current collector 410 and sixth region R6 of current collector 430, second abutment region TR being a region in which corresponding ones of first region R1, fourth region R4, third region R3, and sixth region R6 are in abutment with each other. Thus, current collector 410 and current collector 430 are more stably connected to each other.

[0180] In the present embodiment, second abutment region TR2 is formed between third region R3 and sixth region R6. With this configuration, an abutment state between current collector 410 and current collector 430 can be further stabilized. On this occasion, first region R1 and fourth region R4 can be avoided from being in abutment with each other. Thus, it is possible to suppress unsteadiness more effectively.

[0181] First region R1 and fourth region R4 may be in contact with each other, second region R2 and fifth region R5 may be in contact with each other, and third region R3 and sixth region R6 may be in contact with each other. With this configuration, positioning can be attained and unsteadiness can be suppressed.

[0182] The length of an abutment surface of first abutment region TR1 at which second region R2 and fifth region R5 are in abutment with each other is preferably 1 mm or more, more preferably 2 mm or more, and further preferably 3 mm or more. It should be noted that first region R1 and fourth region R4 may constitute a proximity region (proximity surface). The proximity region means a state in which they are not in abutment with each other but there is substantially no clearance formed therebetween, and is, for example, 0.5 mm or less.

[0183] A joining portion SG1 joined by welding WD is provided at an end portion (upper end portion in the figure) of first abutment region TR1. Since first abutment region TR1 is provided, the end portion of first abutment region TR1 can be stably welded. Further, after joining portion SG1 is formed, occurrence of unsteadiness of first abutment region TR1 can be suppressed even when a load is applied to first abutment region TR1.

[0184] For the welding, welding using a high energy radiation is preferable, and laser welding using laser light is more preferable. Thus, it is possible to form joining portion SG1 with high reliability in joining. On this occasion, when the high energy radiation is applied from the side surface side (upper side in FIG. 26) of each of current collector 410 and current collector 430, first chamfered portion RT2 at the tip portion of second region R2 and second chamfered

portion RT5 at the tip portion of fifth region R5 preferably form a V-shaped receiving portion because joining portion SG1 can be readily formed. It should be noted that joining portion SG1 may be formed between second region R2 and fifth region R5 through penetration welding by applying the high energy radiation to one region (current collector).

[0185] In the step of forming joining portion SG1, joining portion SG1 can be formed in the following manner: after electrode assembly 200 is inserted into case main body 110, the laser light is applied to the chamfered portion of at least one of current collector 410 and current collector 430 from between case main body 110 and sealing plate 120 in the step of joining current collector 410 and current collector 430. It should be noted that the step of forming joining portion SG1 is not limited to being performed at this timing.

[0186] Further, first clearance S1 described above may be provided in the vicinity of the end portion of first abutment region TR1 opposite to the end portion at which joining portion SG1 is formed. By providing first clearance S1, heat generated when forming joining portion SG1 can be suppressed from being transferred to each of the first region R1 side and the fourth region R4 side, thereby stably forming joining portion SG1.

[0187] In current collector 430, the thickness (t4) of fourth region R4 is preferably smaller than each of the thickness (t5) of fifth region R5 and the thickness (t6) of sixth region R6. The value of the thickness (t4) of fourth region R4/the thickness (t5) of fifth region R5 is preferably about 0.3 to 0.8, for example. The value of the thickness (t4) of fourth region R4/the thickness (t6) of sixth region R6 is preferably about 0.3 to 0.8, for example. The value of the thickness (t1) of first region R1/the thickness (t2) of second region R2 is preferably about 0.8 to 1.2, for example. The value of the thickness (t1) of first region R1/the thickness (t3) of third region R3 is preferably about 0.8 to 1.2, for example. Current collector 410 may be formed by bending a plate material.

[0188] A portion of current collector 410 to which each of negative electrode tab groups 220, 270 is connected may be present close to third region R3 (lower side in the figure) with respect to second region R2.

[0189] An end portion of third region R3 may protrude (distance Pl in the figure) outward with respect to the end portion of sixth region R6 in the long-side direction of sealing plate 120.

Other Embodiments

[0190] Other implementations of second region R2 of current collector 410 and fifth region R5 of current collector 430 will be described with reference to FIGS. 29 to 33. FIGS. 29 to 33 are first to fifth perspective views each showing another implementation of the joining portion between second region R2 of current collector 410 and fifth region R5 of current collector 430.

[0191] In the implementation of the joining portion shown in FIG. 29, fifth region R5 of current collector 430 is provided to be separated from insulating member 530 as compared with the manner of joining as shown in FIG. 28. Also in this implementation of the joining portion, the operation of joining second region R2 and fifth region R5 can be readily performed because joining portion SG1 is oriented in the Z direction. Furthermore, since joining portion SG1 is separated from insulating member 530,

insulating member 530 can be suppressed from being damaged due to an influence of heat.

[0192] In the implementation of the joining portion shown in FIG. 30, second region R2 of current collector 410 is bent perpendicularly to the electrode assembly 200 side, and fifth region R5 of current collector 430 is also bent perpendicularly to the electrode assembly 200 side along second region R2. As a result, an overlapping region R11 is provided between second region R2 and fifth region R5, and joining portion SG1 is formed in this region. With this implementation of the joining portion, the operation of joining second region R2 and fifth region R5 can be readily performed because joining portion SG1 is oriented in the Z direction. Further, since joining portion SG1 is separated from insulating member 530, insulating member 530 can be suppressed from being damaged due to an influence of heat. Further, a formation area of joining portion SG1 can be large.

[0193] In the implementation of the joining portion shown in FIG. 31, second region R2 of current collector 410 is bent to protrude to the electrode assembly 200 side, and fifth region R5 of current collector 430 is also bent to the electrode assembly 200 side along second region R2. As a result, an overlapping region R11 between second region R2 and fifth region R5 is provided to be inclined with respect to sealing plate 120, and joining portion SG1 is formed in this region R11. With this implementation of the joining portion, the operation of joining second region R2 and fifth region R5 can be readily performed because joining portion SG1 is oriented obliquely with respect to the Z direction. Further, since joining portion SG1 is separated from insulating member 530, insulating member 530 can be suppressed from being damaged due to an influence of heat.

[0194] In the implementation of the joining portion shown in FIG. 32, second region R2 of current collector 410 is provided to extend in the Z direction so as to be located close to the electrode assembly 200 side with respect to first region R1, and fifth region R5 of current collector 430 is also provided to extend in the Z direction along second region R2. Further, the end portion of fifth region R5 is provided to protrude with respect to the end portion of second region R2. As a result, joining portion SG1 can be formed at fifth region R5 protruding with respect to second region R2, with the result that the welding operation can be readily performed in an oblique direction. Further, since joining portion SG1 is separated from insulating member 530, insulating member 530 can be suppressed from being damaged due to an influence of heat.

[0195] In the implementation of the joining portion shown in FIG. 33, second region R2 of current collector 410 is provided with a first extension portion R21 extending obliquely upward from its tip to the electrode assembly 200 side, fifth region R5 of current collector 430 is separated from insulating member 530 so as to be in contact with second region R2, and the tip portion of fifth region R5 is provided with a second extension portion R51 bent toward insulating member 530. As a result, a receiving portion having a V-shaped cross section is formed by first extension portion R21 and second extension portion R51. Since the receiving portion is formed in this way, joining portion SG1 can be formed in the receiving portion, with the result that the welding operation can be readily performed. Further, since joining portion SG1 is separated from insulating

member 530, insulating member 530 can be suppressed from being damaged due to an influence of heat.

[0196] In each of the implementations disclosed in FIGS. 28 to 33, the connecting of current collector 410 and current collector 430 may be performed before electrode assembly 200 is inserted into case main body 110, or may be performed after at least a portion of electrode assembly 200 is inserted into case main body 110.

[0197] Although the current collecting structure on the negative electrode side has been illustratively described in each of the above-described embodiments, the current collecting structure described in each of the above-described embodiments can be applied to the current collecting structure on the positive electrode side. Further, in each of the above-described embodiments, it has been illustratively described that two current collectors 410 are used on the negative electrode side; however, as with the positive electrode side, only one current collector 410 may be used. Further, current collector 410 and current collector 430 may be connected to each other before electrode assembly 200 is inserted into case main body 110.

[0198] Although the embodiments of the present invention have been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation. The scope of the present invention is defined by the terms of the claims, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

What is claimed is:

1. A secondary battery comprising:

an electrode assembly including a first electrode and a second electrode having a polarity different from a polarity of the first electrode;

a case main body provided with a first opening;

a first sealing plate that seals the first opening;

a first electrode tab electrically connected to the first electrode;

a first current collecting member electrically connected to the first electrode tab;

a second current collecting member joined to the first current collecting member; and

a first electrode terminal electrically connected to the second current collecting member and provided on the first sealing plate, wherein

the first current collecting member includes a first region, a second region, and a third region,

the first region is disposed between the second region and the third region,

the second current collecting member includes a fourth region, a fifth region, and a sixth region,

the fourth region is disposed between the fifth region and the sixth region,

the first electrode tab is connected to the first region,

in a direction perpendicular to the first sealing plate,

a surface of the first region on the first sealing plate side protrudes to the first sealing plate side with respect to each of a surface of the second region on the first sealing plate side and a surface of the third region on the first sealing plate side, and

- in the direction perpendicular to the first sealing plate, in a surface of the second current collecting member on the electrode assembly side, the fourth region is provided with a recess recessed to the first sealing plate side with respect to each of the fifth region and the sixth region, and
- at least a portion of the first region is disposed in the recess.
2. The secondary battery according to claim 1, wherein a first abutment region in which the second region and the fifth region are in abutment with each other is formed, and
- a second abutment region is formed at at least one of a position between the first region and the fourth region and a position between the third region and the sixth region, the second abutment region being a region in which corresponding ones of the first region, the fourth region, the third region, and the sixth region are in abutment with each other.
3. The secondary battery according to claim 2, wherein a joining portion at which the first current collecting member

and the second current collecting member are joined to each other is provided at an end portion of the first abutment region.

4. The secondary battery according to claim 3, wherein a first clearance is present in a vicinity of an end portion of the first abutment region opposite to the end portion at which the joining portion is formed.

5. The secondary battery according to claim 2, wherein the second abutment region is formed between the third region and the sixth region.

6. The secondary battery according to claim 1, wherein a thickness of the fourth region is smaller than each of a thickness of the fifth region and a thickness of the sixth region.

7. The secondary battery according to claim 1, wherein a portion of the first current collecting member to which the first electrode tab is connected is present close to the third region with respect to the second region.

8. The secondary battery according to claim 1, wherein an end portion of the third region protrudes outward with respect to an end portion of the sixth region in a long-side direction of the first sealing plate.

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