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(54) **BATTERY AND METHOD OF MANUFACTURING BATTERY**

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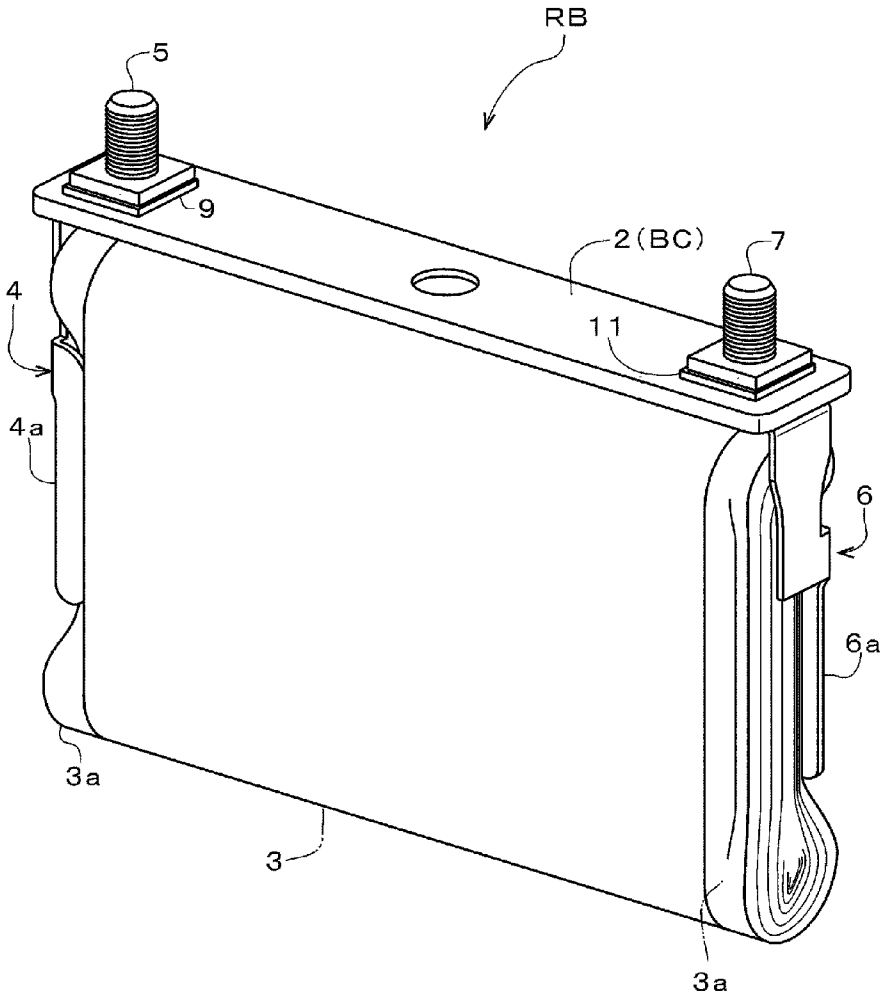
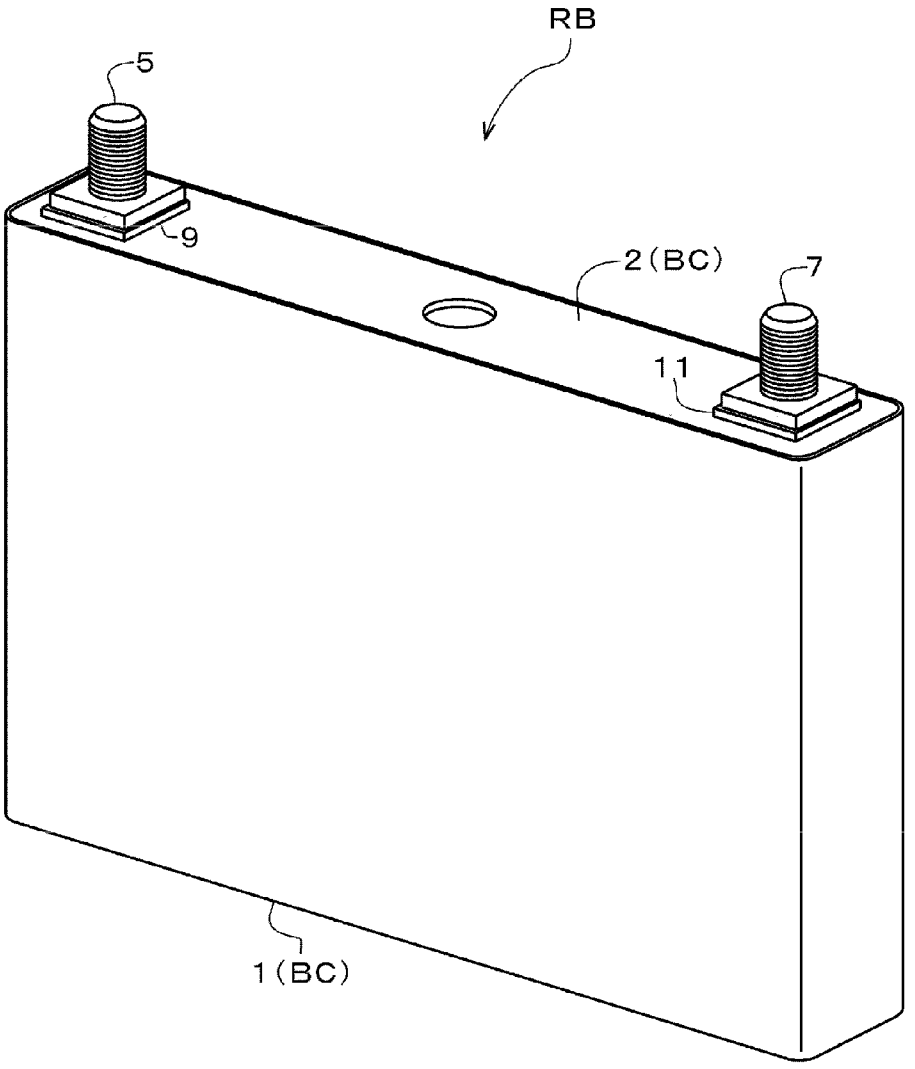
(57) **ABSTRACT**

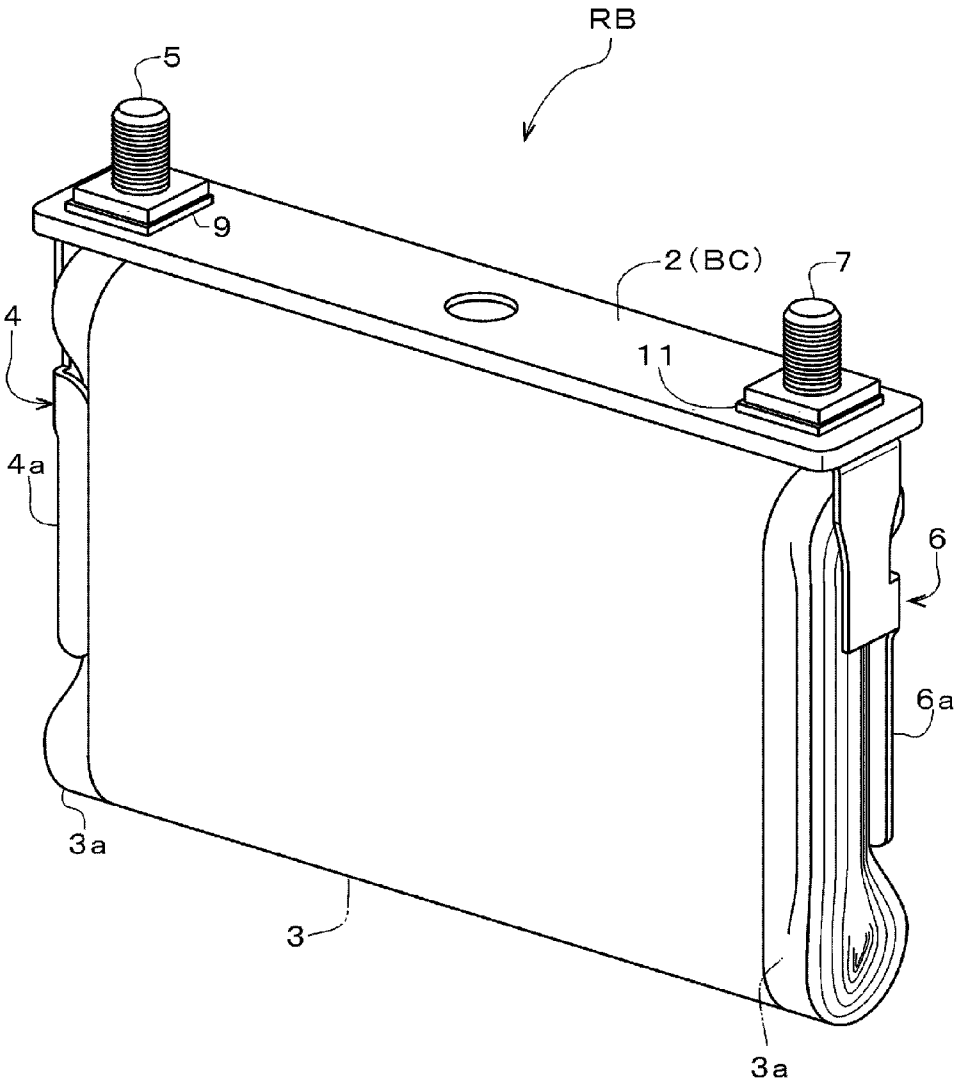
The present invention maintains a power generating element in a flat shape as far as possible to thereby improve workability in a manufacturing process. In a battery including a power generating element formed into a flat shape and housed in a container, the power generating element formed by winding a foil-shaped positive electrode plate **24***a* and a foil-shaped negative electrode plate **24***b*, with separator **25** sandwiched therebetween, about a winding core **21** having flexibility, a thin-plate-shaped member TP having higher rigidity than the winding core is attached to at least one of opposite end portions in a direction of a winding axis of the

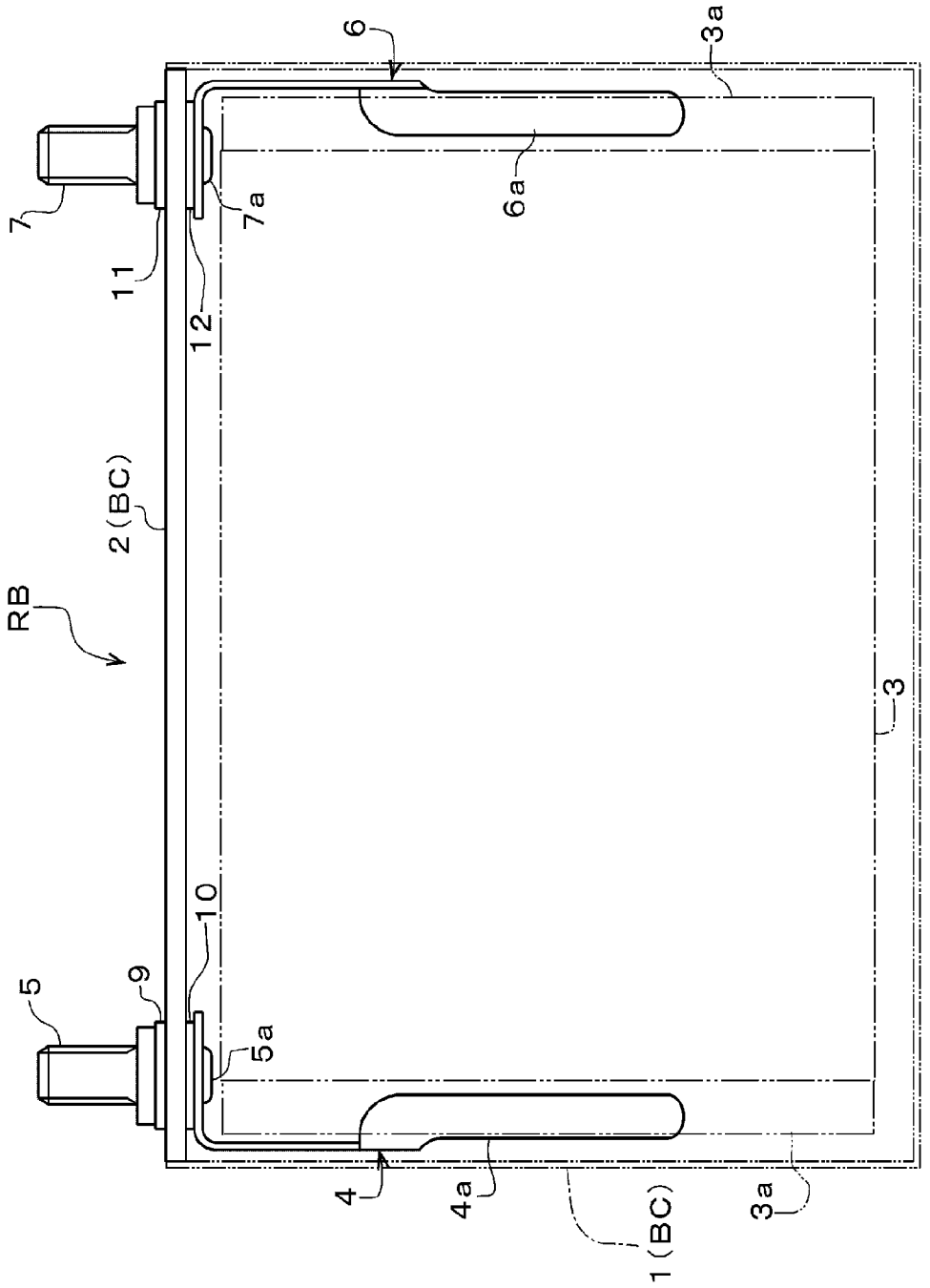


[Fig. 1]



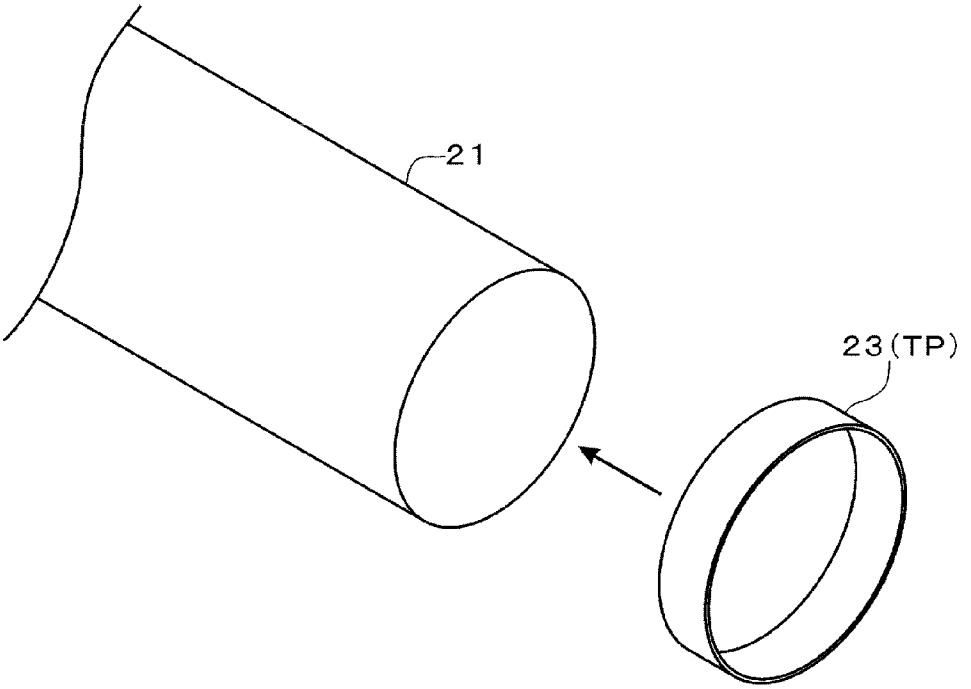
[Fig. 2]



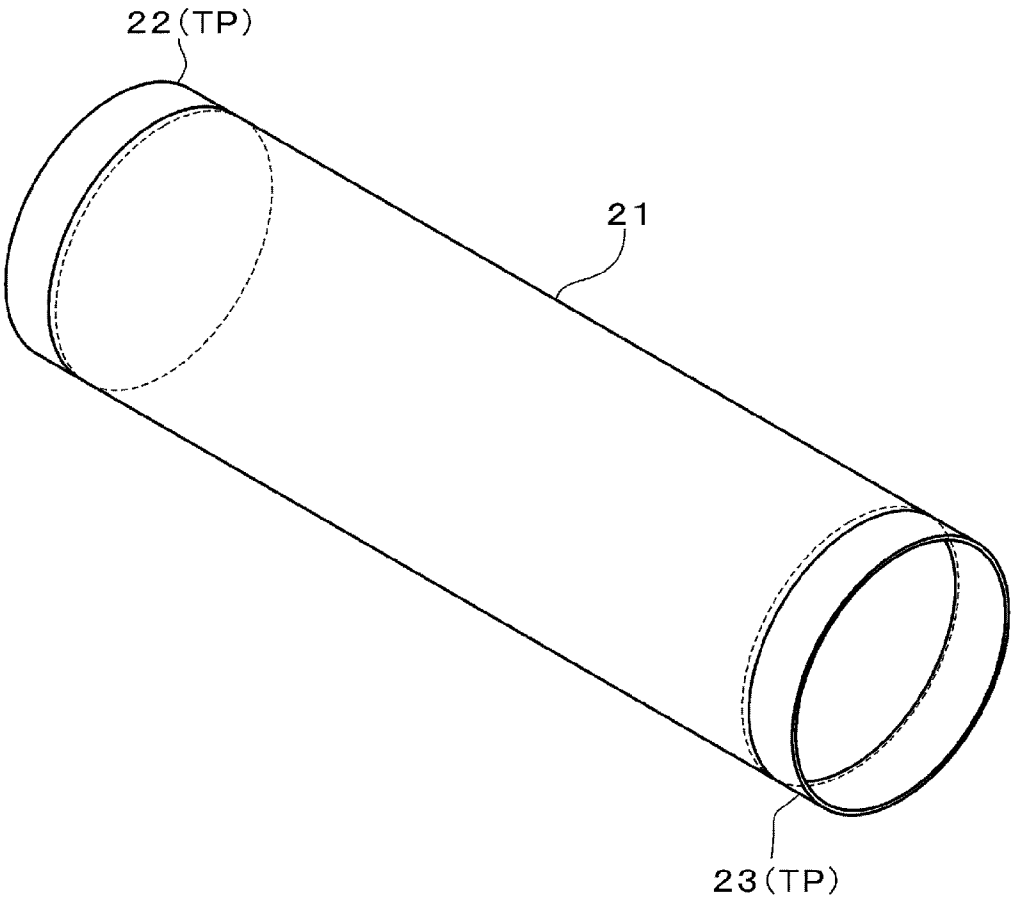


[Fig. 3]

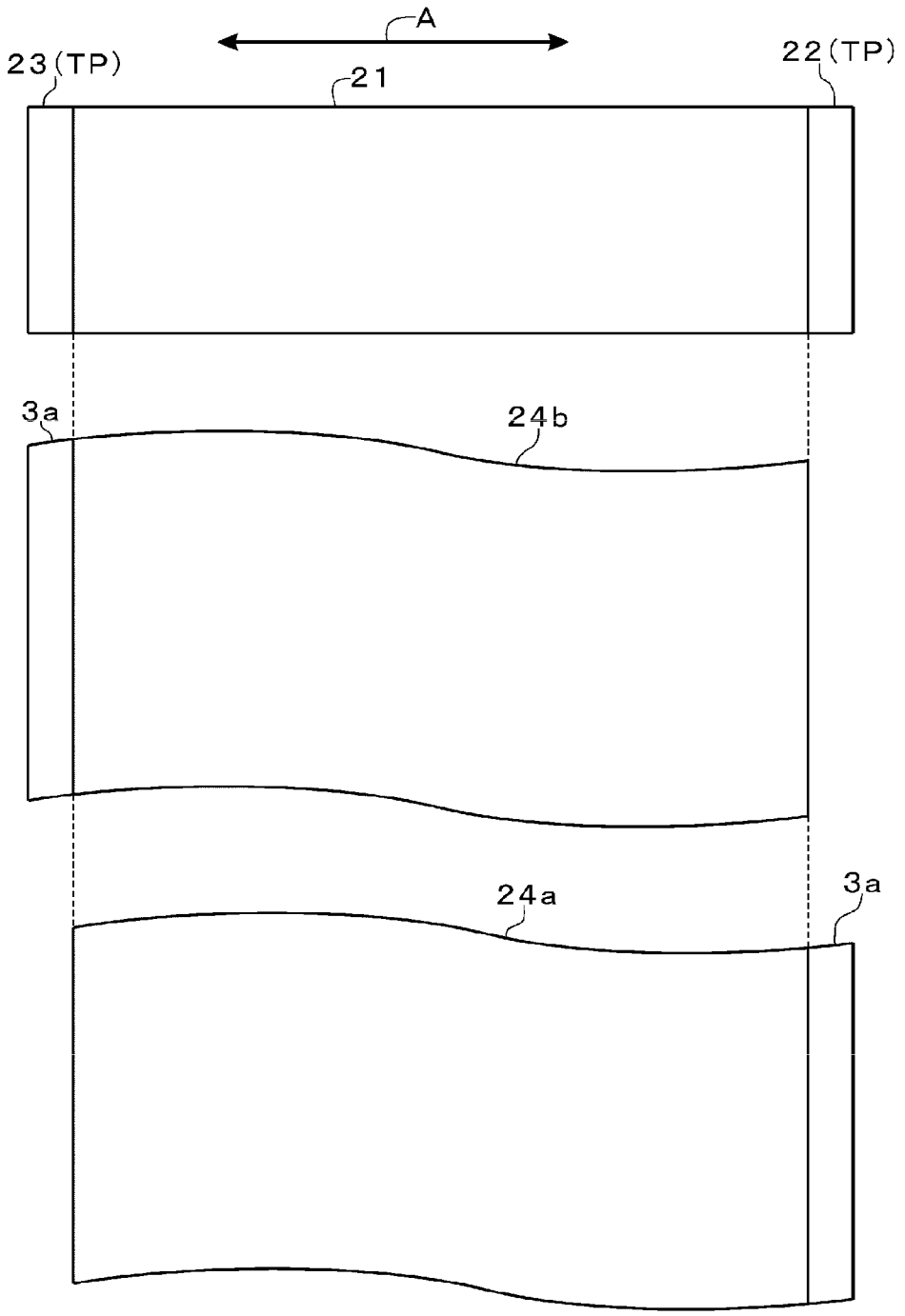
[Fig. 4]



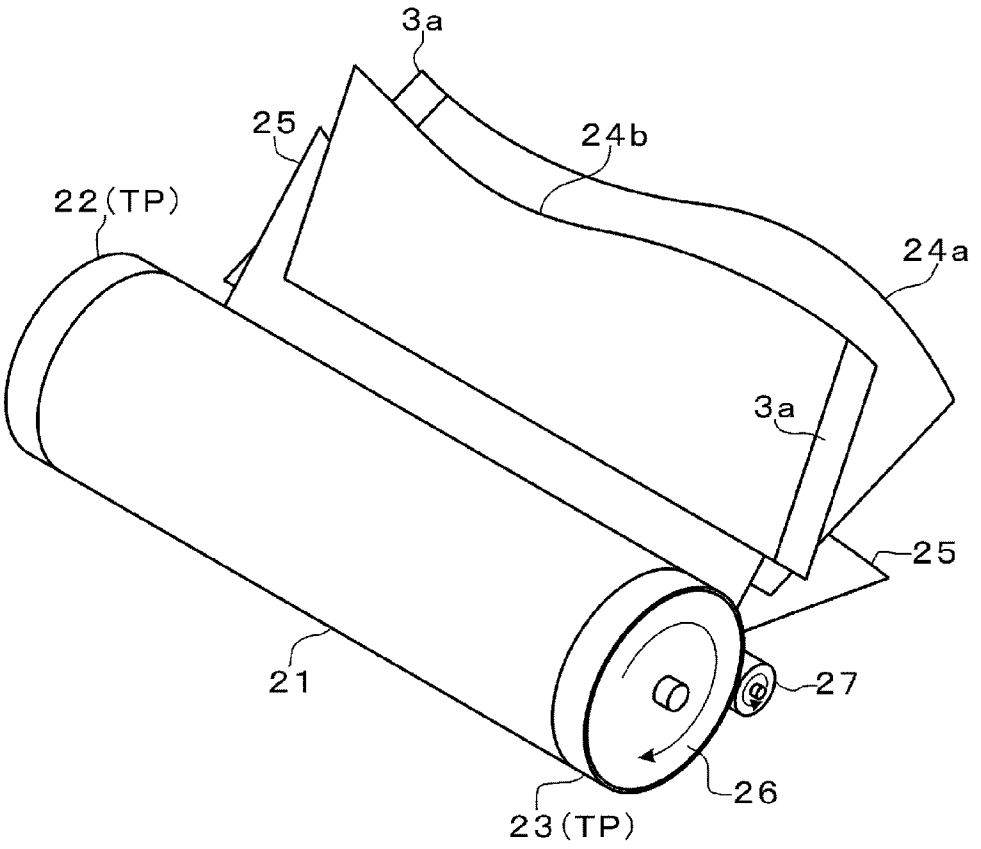
[Fig. 5]



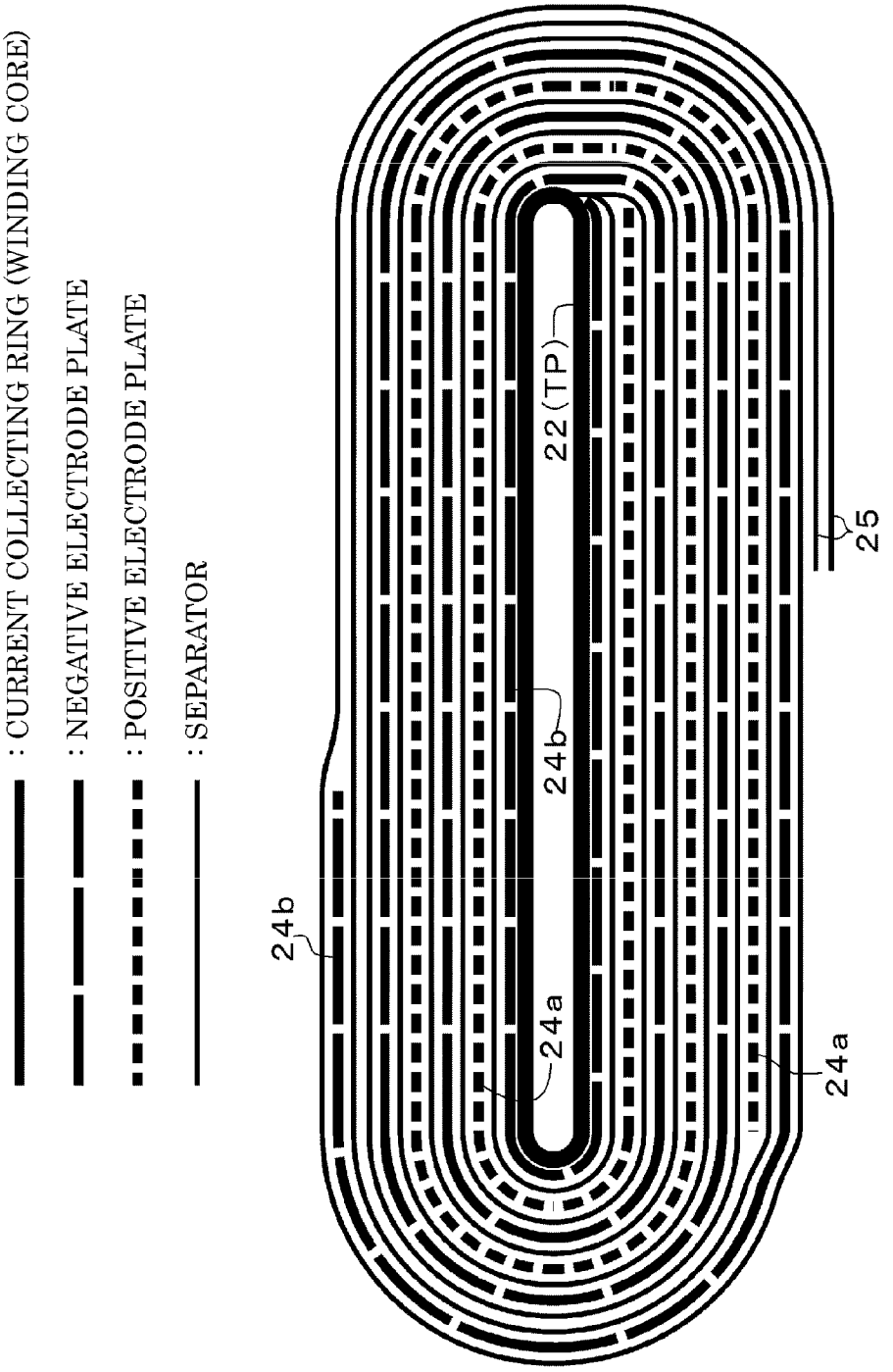
[Fig. 6]



[Fig. 7]



[Fig. 8]


: CURRENT COLLECTING RING (WINDING CORE)
: NEGATIVE ELECTRODE PLATE
: POSITIVE ELECTRODE PLATE
: SEPARATOR
22(TP)
24b
24a
24b
24a
25

BATTERY AND METHOD OF MANUFACTURING BATTERY

TECHNICAL FIELD

[0001] The present invention relates to a battery in which a power generating element formed by winding a long foil-shaped positive electrode plate and a long foil-shaped negative electrode plate, with separator sandwiched therebetween, about a cylindrical winding core having flexibility is formed in a flat shape and housed in a container and relates to a method of manufacturing the battery.

BACKGROUND ART

[0002] In the battery, the power generating element is formed by winding the long foil-shaped positive electrode plate and the long foil-shaped negative electrode plate, with the separators sandwiched therebetween, about the winding core to thereby increase areas of the positive and negative plates facing each other to maximize energy density of the battery.

[0003] As the power generating element formed by winding the foil-shaped positive electrode plate and the like about the winding core in this manner, in many cases, the foil-shaped positive electrode plate and the like are wound about the circular cylindrical winding core, the power generating element in a circular columnar shape as a whole, in its unchanged shape, is housed into a battery case, and the battery case is also formed in a circular columnar shape adapted to the shape of the power generating element.

[0004] On the other hand, as described in the following Patent Document 1, forming a power generating element into a flat shape and also forming a battery case for housing the power generating element into a thin shape are widely practiced.

[0005] By the formation of the battery case into the thin shape in this manner, it is possible to efficiently dispose the battery in a small space.

[0006] As a manufacturing process of this type of power generating element in the flat shape, the foil-shaped positive electrode plate and the like are wound about the cylindrical winding core and then the wound object is flattened into the flat shape in many cases.

PRIOR ART DOCUMENT

Patent Document

[0007] Patent Document 1: JP-A-2000-340263

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0008] However, the wound object formed by winding the foil-shaped positive electrode plate and the like about the winding core has a certain degree of resiliency and therefore returns from the flat shape in the flattened state to a partway expanded shape. If the power generating element returns to the expanded shape, workability in an assembly process for attaching the power generating element and other members such as current collectors and other work is deteriorated.

[0009] The present invention has been made with such circumstances in view and its object is to maintain a power generating element in a flat shape as far as possible to thereby improve workability in a manufacturing process.

Means for Solving the Problems

[0010] In accordance with a first aspect of the present application, a battery is provided, the battery including a power generating element formed into a flat shape and housed in a container, the power generating element formed by winding a long foil-shaped positive electrode plate and a long foil-shaped negative electrode plate, with a separator sandwiched therebetween, about a cylindrical winding core having flexibility, wherein a thin-plate-shaped member having higher rigidity than the winding core is attached to at least one of opposite end portions in a direction of a winding axis of the flat winding core.

[0011] In other words, in order to suppress expansion of the winding core having the flexibility and positioned at a central portion of the power generating element and after the power generating element is formed into the flat shape, the thin-plate-shaped member having the high rigidity is attached to at least one of the opposite end portions of the winding core formed into the flat shape.

[0012] This thin-plate-shaped member has a strong force for maintaining itself in a attached posture and therefore the expansion of the winding core is suppressed even if the thin-plate-shaped member receives external force acting in an expanding method from the winding core.

[0013] In accordance with a second aspect of the present application, in addition to the structure of the above-described first invention, the thin-plate-shaped member having the higher rigidity than the winding core is attached, while bent together with the winding core, at least to a bent portion of at least one of the opposite end portions in the direction of the winding axis of the flat winding core.

[0014] In other words, in order to suppress expansion of the winding core having the flexibility and positioned at the central portion of the power generating element after the power generating element is formed into the flat shape, the thin-plate-shaped member having the high rigidity is attached, in the bent posture similarly to the winding core, to at least the bent portion of the flat winding core.

[0015] This thin-plate-shaped member has the strong force for maintaining itself in the bent posture and therefore the expansion of the winding core is further suppressed even if the thin-plate-shaped member receives the external force acting in the expanding direction from the winding core.

[0016] In accordance with a third aspect of the present invention, in addition to the structure of the above-described first or second invention, a non-coating portion not applied with an active material is formed at one of end portions in a width direction of at least one of the foil-shaped positive electrode plate and the foil-shaped negative electrode plate, the non-coating portion is in the state of protruding in the direction of the winding axis from the separator and is wound about the winding core, and the non-coating portions are bundled and fixed to the thin-plate-shaped members.

[0017] In other words, how to lead out electric wiring is a problem when the long foil-shaped electrode plates are wound about the winding core to form the power generating element. One of methods is to carry out the electric wiring by forming the portion not applied with the active material at one of the end portions in the width direction of the foil-shaped electrode plate and bundling the non-coating portions on each circumference.

[0018] If the non-coating portion is fixed to the thin-plate-shaped member positioned at the center in bundling the non-

coating portions in this manner, it is possible to further reliably maintain the power generating element in the flat shape.

[0019] In accordance with a fourth aspect of the present invention, in addition to the structure of the above-described third invention, the thin-plate-shaped members are attached to the opposite end portions in the direction of the winding axis of the winding core, non-coating portion not applied with the active material is formed at one end in the width direction of the foil-shaped positive electrode plate and the foil-shaped negative electrode plate, the non-coating portion of the foil-shaped positive electrode plate and the non-coating portion of the foil-shaped negative electrode plate are in the state of protruding from opposite sides in the direction of the winding axis and are wound about the winding core, and the non-coating portion of the foil-shaped positive electrode plate and the non-coating portion of the foil-shaped negative electrode plate are fixed to the separate thin-plate-shaped members.

[0020] In other words, the non-coating portion of the foil-shaped positive electrode plate and the non-coating portion of the foil-shaped negative electrode plate are allocated to the opposite portions in the direction of the winding axis and the non-coating portions are bundled and fixed to the thin-plate-shaped members at the opposite end portions in the direction of the winding axis.

[0021] As a result, it is possible to further reliably maintain the power generating element in the flat shape.

[0022] In accordance with a fifth aspect of the present application, in addition to the structure of any one of the above-described first to fourth inventions, the thin-plate-shaped member is attached without protruding in a direction of a normal to an outer peripheral face of the winding core from the outer peripheral face.

[0023] In other words, in order to secure required rigidity, a relatively thick member as compared with the winding core and the like is employed as the thin-plate-shaped member.

[0024] If such a thick member is provided to form a step on the outer peripheral face of the winding core, wound positions on each circumference may be slightly shifted to cause winding deviation when the foil-shaped positive electrode plate and the like are wound about the winding core. However, if the step of the thin-plate-shaped member does not directly appear on the outer peripheral face of the winding core as described above, wound postures of the foil-shaped positive electrode plate and the like are stabilized.

[0025] In accordance with a sixth aspect of the present invention, in addition to the structure of the third or fourth invention, further includes a current collector for electrically connecting an electrode terminal disposed outside the container and the power generating element, wherein the current collector, the non-coating portion, and the thin-plate-shaped member are fixed while the non-coating portion is sandwiched between the current collector and the thin-plate-shaped member.

[0026] In other words, the current collector is provided for electrically connecting the power generating element and the electrode terminal disposed outside the container of the battery.

[0027] If the above-described thin-plate-shaped member is not provided, the current collector and the power generating element are connected by carefully inserting the current collector into a gap in the non-coating portion so as not to damage the non-coating portion of the power generating element, bundling the non-coating portions and the current collector together, and fixing the non-coating portion and the current collector by welding, for example, which requires troublesome work.

[0028] On the other hand, if the fixing operation is carried out while the non-coating portion is sandwiched between the thin-plate-shaped member and the current collector, the current collector is disposed outside the layers of the non-coating portion, which makes the fixing operation easy.

[0029] In accordance with a seventh aspect of the present invention, in addition to the structure of the above-described sixth invention, the non-coating portion is fixed to the thin-plate-shaped member while pinching the thin-plate-shaped member from opposite sides of the thin-plate-shaped member, and the current collector is attached to only one side of the non-coating portion pinching the thin-plate-shaped member from the opposite sides.

[0030] In other words, if the above-described thin-plate-shaped member is not provided, a tip end portion of the current collector and to be connected to the non-coating portion needs to be divided into a plurality of portions and the plurality portions need to be inserted between the layers of the non-coating portion so as to further reliably connect the current collector and the non-coating portion, which complicates the connecting work.

[0031] On the other hand, if the non-coating portions are bundled and fixed to the thin-plate-shaped member, the current collector and the non-coating portion need to be connected to each other at only one position.

[0032] In accordance with an eighth aspect of the present invention, in addition to the structure of any one of the above-described first to seventh inventions, the thin-plate-shaped member is formed into a ring shape so as to be attached along an entire circumference of the end portion in the direction of the winding axis of the cylindrical winding core.

[0033] In other words, it is effective to dispose the thin-plate-shaped member only around the bent portion of the winding core in order to maintain the flat shape of the power generating element. However, if the thin-plate-shaped member is provided to the entire circumference of the end portion in the direction of the winding axis, it increases the effect of maintaining the power generating element in the flat shape. Moreover, it is unnecessary to consider which positions in a circumferential direction should be bent in forming the power generating element into the flat shape, which further improves workability.

[0034] In accordance with a ninth aspect of the present invention, a method of manufacturing a battery is provided, the battery including a power generating element formed into a flat shape and housed in a container, the power generating element formed by winding a long foil-shaped positive electrode plate and a long foil-shaped negative electrode plate, with a separator sandwiched therebetween, about a cylindrical winding core having flexibility, the method including: a winding core forming step for attaching a thin-plate-shaped member having higher rigidity than the winding core to at least one of opposite end portions in a direction of a winding axis of the winding core; an electrode plate winding step for winding the long foil-shaped positive electrode plate and the long foil-shaped negative electrode plate, with the separator sandwiched therebetween, about the winding core attached with the thin-plate-shaped member; and a pressing step for pressing the foil-shaped positive electrode plate and the foil-

shaped negative electrode plate, which are wound about the winding core, in a direction orthogonal to the direction of the winding axis into a flat shape.

[0035] In other words, in forming the power generating element into the flat shape in the above-described pressing step, the thin-plate-shaped member attached to the winding core in the above-described winding core forming step is pressed together with the winding core. The thin-plate-shaped member has a strong force for maintaining itself in the pressed posture and therefore the expansion of the winding core is suppressed even if the thin-plate-shaped member receives an external force acting in an expanding direction from the winding core after the power generating element is formed into the flat shape.

[0036] In accordance with a tenth aspect of the present invention, in addition to the structure of the above-described ninth invention, the foil-shaped positive electrode plate and the foil-shaped negative electrode plate, which are wound about the winding core, is pressed in the direction orthogonal to the direction of the winding axis into the flat shape with the thin-plate-shaped member existing at least at a bent portion in the pressing step.

[0037] In other words, in forming the power generating element into the flat shape in the above-described pressing step, the thin-plate-shaped member attached to the winding core in the above-described winding core forming step is pressed and bent together with the winding core. As a result, the thin-plate-shaped member has a strong force for maintaining itself in the bent posture and therefore the expansion of the winding core is suppressed even if the thin-plate-shaped member receives an external force acting in an expanding direction from the winding core after the power generating element is formed into the flat shape.

[0038] In accordance with an eleventh aspect of the present invention, in addition to the structure of the above-described tenth invention, the thin-plate-shaped member is attached to the winding core without protruding in a direction of a normal to an outer peripheral face of the winding core from the outer peripheral face in the winding core forming step.

[0039] As a result, in the plate winding step, the step of the thin-plate-shaped member does not directly appear on the outer peripheral face of the winding core and therefore it is possible to wind the foil-shaped positive electrode plate and the like while suppressing the winding deviation as far as possible.

Advantages of the Invention

[0040] According to the first invention, the thin-plate-shaped member attached to the winding core has the strong force for maintaining itself in the attached posture and therefore the expansion of the winding core is suppressed even if the thin-plate-shaped member receives the external force acting in the expanding direction from the winding core. As a result, it is possible to maintain the power generating element in the flat shape as far as possible to thereby improve workability in the manufacturing process.

[0041] According to the second invention, the thin-plate-shaped member attached to the winding core and in the bent posture has the strong force for maintaining itself in the bent posture and therefore the expansion of the winding core is suppressed even if the thin-plate-shaped member receives the external force acting in the expanding direction from the winding core. Accordingly, it is possible to maintain the power generating element in the flat shape as far as possible to thereby further improve workability in the manufacturing process.

[0042] According to the third invention, by bundling the non-coating portions and fixing them to the thin-plate-shaped member, it is possible to further reliably maintain the power generating element in the flat shape to thereby further improve the workability.

[0043] According to the fourth invention, because the non-coating portions are bundled and fixed to the thin-plate-shaped members at the opposite end portions in the direction of the winding axis, it is possible to further reliably maintain the power generating element in the flat shape.

[0044] According to the fifth invention, because the step of the thin-plate-shaped member does not directly appear on the outer peripheral face of the winding core to thereby stabilize the wound postures of the foil-shaped positive electrode plate and the like, it is possible to stably form the power generating element into a desired outer shape.

[0045] According to the sixth invention, because the fixing work is carried out while the non-coating portion is sandwiched between the thin-plate-shaped member and the current collector, the current collector is disposed outside the layers of the non-coating portion, which makes the fixing operation easy and further increases efficiency in the assembly work of the battery.

[0046] According to the seventh invention, by bundling the non-coating portions and fixing them to the thin-plate-shaped member, the current collector and the non-coating portion need to be connected to each other at only one position, which further increases efficiency in the assembly work of the battery.

[0047] According to the eighth invention, by providing the thin-plate-shaped member to the entire circumference of the end portion in the direction of the winding axis, the effect of maintaining the power generating element in the flat shape is exerted more reliably. Moreover, it is unnecessary to consider which positions in the circumferential direction should be bent in forming the power generating element into the flat shape, which further improves workability in the assembly action of the power generating element.

[0048] According to the ninth invention, in forming the power generating element into the flat shape in the assembly step of the power generating element which is a part of the assembly process of the battery, the thin-plate-shaped member attached to the winding core is pressed together with the winding core. The thin-plate-shaped member has the strong force for maintaining itself in the pressed posture and therefore the expansion of the winding core is suppressed even if the thin-plate-shaped member receives the external force acting in the expanding direction from the winding core.

[0049] According to the tenth invention, in forming the power generating element into the flat shape in the assembly step of the power generating element which is the part of the assembly process of the battery, the thin-plate-shaped member attached to the winding core is pressed and bent together with the winding core. As a result, the thin-plate-shaped member in the bent posture has the strong force for maintaining itself in the bent posture due to its high rigidity and therefore the expansion of the winding core is suppressed even if the thin-plate-shaped member in the bent posture receives the external force acting in the expanding direction from the winding core.

[0050] Accordingly, it is possible to maintain the power generating element in the flat shape as far as possible to thereby improve workability in the manufacturing process.

[0051] According to the eleventh invention, the step of the thin-plate-shaped member does not directly appear on the outer peripheral face of the winding core and therefore it is possible to wind the foil-shaped positive electrode plate and the like while suppressing the winding deviation as far as possible to thereby smoothly carry out the assembly work of the power generating element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0052] FIG. **1** is an external perspective view of a battery according to an embodiment of the present invention.

[0053] FIG. **2** is a perspective view of an inner structure of the battery according to the embodiment of the invention.

[0054] FIG. **3** is a front view of an inner structure of the battery according to the embodiment of the invention.

[0055] FIG. **4** is a perspective view showing assembly of a winding core according to the embodiment of the invention.

[0056] FIG. **5** is a perspective view of the winding core according to the embodiment of the invention.

[0057] FIG. **6** is a drawing showing positional relationships between the winding core and plates according to the embodiment of the invention.

[0058] FIG. **7** is a perspective view showing a form of winding of the electrode plates and the like about the winding core according to the embodiment of the invention.

[0059] FIG. **8** is a schematic diagram showing the form of winding of the electrode plates and the like about the winding core according to the embodiment of the invention.

MODE FOR CARRYING OUT THE INVENTION

[0060] An embodiment of a battery according to the present invention will be described below based on the drawings.

[0061] Although a nonaqueous electrolyte secondary battery (more specifically, a lithium ion battery) will be described as an example in the embodiment, the invention can be applied to secondary batteries other than the nonaqueous electrolyte secondary battery and primary batteries as well.

[Structure of Nonaqueous Electrolyte Secondary Battery]

[0062] As shown in perspective views in FIGS. **1** and **2** and a front view in FIG. **3**, the nonaqueous electrolyte secondary battery RB in the present embodiment has a case BC formed by placing and welding a lid portion **2** substantially in a shape of a flat plate onto an open face of a can body **1** in a cylindrical shape with a bottom (more specifically, a rectangular cylindrical shape with a bottom). The lid portion **2** is formed into a strip-shaped rectangle and the case BC has a shape of a flat rectangular parallelepiped in its entirety. FIG. **2** shows an inner structure of the case BC by removing the can body **1** from the completed secondary battery RB (shown in FIG. **1**). In FIG. **3**, the can body **1** and a power generating element **3** (described later) are shown by two-dot chain lines so that an inside of the case BC can be seen through them.

[0063] In the case BC, the power generating element **3** and current collectors **4** and **6** shown in FIGS. **2** and **3** are housed while immersed in an electrolyte solution. Therefore, the case BC serves as a container for housing the power generating element **3**.

[0064] As will be described later in detail below, the power generating element **3** is formed by applying an active material each on a pair of electrode plates including a foil-shaped positive electrode plate and a foil-shaped negative electrode plate and winding the electrode plates with separators sandwiched therebetween.

[0065] The power generating element **3** has a portion of the foil-shaped positive electrode plate, not applied with the active material, and extending out from a side to be welded to the current collector **4** and a portion of the foil-shaped negative electrode plate, not applied with the active material, and extending out from an opposite side to be welded to the current collector **6**.

[0066] To the lid portion **2** made of metal (specifically, aluminum), the current collector **4** on a positive side and a terminal bolt **5** serving as a positive electrode terminal connected to the current collector **4**, and the current collector **6** on a negative side and a terminal bolt **7** serving as a negative electrode terminal connected to the current collector **6** are attached, and the current collectors **4** and **6** electrically connect the electrode terminals disposed outside the case BC and the power generating element **3**.

[0067] The terminal bolt **5** is attached and fixed to the lid portion **2** by pinching two pieces of packing **9** and **10**, disposed to sandwich the lid portion **2**, between a head portion of the terminal bolt **5** and the current collector **4** and caulking a rivet **5***a* formed at the head portion of the terminal bolt **5**.

[0068] The negative side has a similar structure and the terminal bolt **7** is fixed to the lid portion by pinching two pieces of packing **11** and **12**, disposed to sandwich the lid portion **2**, between a head portion of the terminal bolt **7** and the current collector **6** and caulking a rivet **7***a* formed at the head portion of the terminal bolt **7** (see FIG. **3**).

[0069] The negative-side electrode structure and the positive-side electrode structure including the terminal bolts **5** and **7** and the current collectors **4** and **6** are the same as each other and disposed symmetrically and the structures are different only in material of the metal members.

[0070] The metal members on the positive side are made of aluminum and the metal members on the negative side are made of copper. [Manufacturing Process of Secondary Battery]

[0071] Next, a manufacturing process of the secondary battery RB will be described briefly.

[0072] First, assembly of the power generating element **3** will be described.

[0073] The power generating element **3** is produced by applying a positive active material and a negative active material on front and back opposite faces of long band-shaped aluminum foil and copper foil, respectively, to form active material layers, and winding the foil-shaped positive electrode plate and the foil-shaped negative electrode plate having the active material layers about a winding core **21** shown in FIG. **5**, with the separators sandwiched therebetween. Orientations in winding are such that longitudinal sides of the foil-shaped positive electrode plate and the like are wound about the winding core **21**.

[Winding Core Forming Step]

[0074] The winding core **21** is made of an electrically insulating material resistant to the electrolyte solution. To put it concretely, resin such as PPS (polyphenylene sulfide), PP (polypropylene), PET, PE (polyethylene), and PVDF (polyvinylidene fluoride) may be used and PPS is preferable from a viewpoint of heat resistance.

[0075] The winding core **21** is in a circular cylindrical shape and formed by preparing a rectangular sheet-shaped member having flexibility by using the above-described material, winding the member into the circular cylindrical shape, and fixing end edges to each other by thermal adhesion or by using tape. An axis of this circular cylindrical shape serves as a winding axis in winding the foil-shaped positive electrode plate **24***a* and the like.

[0076] Furthermore, current collecting rings **22** and **23** which are thin-plate-shaped members TP made of metal are attached to opposite end portions in an axial direction of the winding core **21**.

[0077] The current collecting rings **22** and **23** mounted to the axial opposite end portions have the same shapes and are in circular cylindrical shapes having small widths in the axial direction as shown in FIG. **4**. By forming the thin-plate-shaped members TP into ring shapes, the thin-plate-shaped members TP are mounted along entire circumferences of end portions in the axial direction of the cylindrical winding core **21**.

[0078] Dimensions of outer shapes of the current collecting rings **22** and **23** are substantially the same as a dimension of an inner diameter of the circular cylindrical winding core and the current collecting rings **22** and **23** and the winding core **21** are mounted to each other by fitting small parts of axial end portions of the current collecting rings **22** and **23** into the winding core **21** and fixing the portions of the winding core **21** and the current collecting rings **22** and **23** overlapping to each other as shown in FIGS. **4** and **5** showing states before and after the mounting. Although this fixing is carried out by thermal adhesion, the fixing may be carried out by using a tape adhesive or by pressing.

[0079] By fitting the end portions of the current collecting rings **22** and **23** into the circular cylindrical winding core **21** in this manner, the current collecting rings **22** and **23** are mounted without extending from an outer peripheral face of the winding core **21** in a direction of a normal to the outer peripheral face.

[0080] In this way, steps formed by mounting the current collecting rings **22** and **23** do not directly appear on the outer peripheral face of the winding core **21** and it is possible to suppress instability caused by the current collecting rings **22** and **23** of wound positions of the foil-shaped positive electrode plate **24***a* and the like on the outer peripheral face of the winding core **21**.

[0081] One of materials of the two current collecting rings **22** and **23** is aluminum and the other is copper, which corresponds to materials forming the foil-shaped positive electrode plate, the foil-shaped negative electrode plate, and the like.

[Plate Winding Step]

[0082] A step of winding the foil-shaped positive electrode plate **24***a*, the foil-shaped negative electrode plate **24***b*, and the separators **25** about the winding core **21** in the above-described shape is carried out as schematically shown in FIG. **7**.

[0083] FIG. **7** schematically shows a manner in which a winding roller **26** is passed through a hollow portion in the winding core **21** and the foil-shaped positive electrode plate **24***a*, the foil-shaped negative electrode plate **24***b*, and the separators **25** are fed between the winding roller **26** and a pressing roller **27** pressed against an outer peripheral face of the winding roller **26** and are wound. The winding about the winding core **21** is carried out by layering the foil-shaped negative electrode plate **24***b*, the separator **25**, the foil-shaped positive electrode plate **24***a*, and the separator **25** in this order from an inner periphery side and winding them. Longitudinal end portions (end portions on a winding starting side) of the two separators **25** are fixed to the outer periphery of the winding core **21** by using tape or by thermal adhesion. At a winding starting position shown in FIG. **7**, the winding is started while sandwiching the foil-shaped negative electrode plate **24***b* between the winding core **21** and the separator **25** and the foil-shaped positive electrode plate **24***a* between the two separators **25**.

[0084] Positional relationships in the axial direction in winding the foil-shaped positive electrode plate **24***a* and the like about the winding core **21** are set as shown in FIG. **6**. In FIG. **6**, the winding core **21** in a state where the current collecting rings **22** and **23** are mounted is shown as a basis on an upper part, the positional relationships of the foil-shaped negative electrode plate **24***b* and the foil-shaped positive electrode plate **24***a* in the axial direction of the winding core **21** (a direction of an arrow A) are shown on an intermediate part (the foil-shaped negative electrode plate **24***b*) and a lower part (the foil-shaped positive electrode plate **24***a*).

[0085] The foil-shaped negative electrode plate **24***b* has the non-coating portion **3***a* not applied with the active material at one of its end portions in a width direction (short width direction) and the non-coating portion **3***a* is set to overlap the position of the current collecting ring **23**.

[0086] The foil-shaped positive electrode plate **24***a* similarly has the non-coating portion **3***a* not applied with the active material at one of its end portions in a width direction (width direction on a short width side) and the non-coating portion **3***a* is set to overlap the position of the current collecting ring **22**. In other words, the non-coating portions **3***a* of the foil-shaped positive electrode plate **24***a* and the foil-shaped negative electrode plate **24***b* are set on opposite sides from each other in the width direction.

[0087] Although not shown in the drawings, each of the two separators **25** is set at a position substantially aligned with widths of portions of the foil-shaped positive electrode plate **24***a* and the foil-shaped negative electrode plate **24***b* excluding the non-coating portions **3***a* (i.e., portions applied with the active material). More specifically, the widths of the separators **25** are set to be slightly greater than the entire widths applied with the active material.

[0088] Therefore, both of the non-coating portions **3***a* of the foil-shaped positive electrode plate **24***a* and the foil-shaped negative electrode plate **24***b* are wound while protruding in the axial direction of the winding core **21** (i.e., a direction of a winding axis) from the separators **25** and the non-coating portion **3***a* of the foil-shaped positive electrode plate **24***a* and the non-coating portion **3***a* of the foil-shaped negative electrode plate **24***b* protrude from opposite sides of the separators **25** from each other in the direction of the winding axis.

[0089] As a result, on each of the positive side and the negative side, mutual electrical connection is achieved when the non-coating portion **3***a* is bundled and fixed as described later.

[Pressing Step]

[0090] After the predetermined lengths of foil-shaped positive electrode plate **24***a* and the like are wound in the form shown in FIG. **7**, they are detached from the winding roller **26** and formed into the flat shape by pressing in the direction of

the normal to the outer peripheral face (the direction orthogonal to the direction of the winding axis) to be the flat power generating element **3**.

[0091] FIG. **8** schematically shows, in the axial direction of the winding core **21**, a manner in which the foil-shaped positive electrode plate **24***a* and the like are wound about the winding core **21** in the flat shape.

[0092] As schematically shown in FIG. **8**, when the foil-shaped positive electrode plate **24***a* and the like wound about the winding core **21** are flattened into the flat shape, the current collecting rings **22** and **23** are also formed into thin flattened shapes.

[0093] Therefore, portions of the current collecting rings **22** and **23** exist in areas where the winding core **21** and the foil-shaped positive electrode plate **24***a* and the like are bent and the portions of the current collecting rings **22** and **23** are bent together with the winding core **21**.

[0094] The current collecting rings **22** and **23** are the thin metal plates as described above and are members having higher rigidity than the winding core **21** and having so- called higher hardness than the winding core **21**.

[0095] Therefore, if the current collecting rings **22** and **23** are flattened into the shapes as shown in FIG. **8**, they have strong forces for retaining the flattened shapes even if an external force is applied thereto.

[0096] Therefore, when the winding core **21**, the foil-shaped positive electrode plate **24***a*, and the like try to return from the flattened states to their original shapes and their forces act on the current collecting rings **22** and **23**, the current collecting rings **22** and **23** suppress the movements in expanding directions and maintain the flattened shapes.

[0097] To impart such functions to the current collecting rings **22** and **23**, the current collecting rings **22** and **23** are formed by metal plates having a thickness of about 0.2 mm to 0.5 mm.

[0098] The functions of maintaining the flat shapes performed by the current collecting rings **22** and **23** are the most effectively performed at bent portions of the current collecting rings **22** and **23** which are flattened into the flat shapes similarly to the entire power generating element **3**. It is important to attach the thin-plate-shaped member such as the current collecting rings **22** and **23**, which has higher rigidity than the winding core **21** and which is bent together with the winding core **21**, to at least any one of the bent portions.

[Case Assembly Step]

[0099] Next, assembly of the lid portion **2** will be described.

[0100] The lid portion **2** is formed by forming electrode attaching holes for attaching the terminal bolts **5** and **7** in an aluminum plate member, and the current collectors **4** and **6** and the terminal bolts **5** and **7** are fixed to the lid portion **2**, with pieces of packing **9**, **10**, **11**, and **12** interposed therebetween, by caulking the rivets **5***a* and **7***a*.

[0101] Next, by welding and connecting the non-coating portions **3***a* of the power generating element **3** to the current collectors **4** and **6** fixed to the lid portion **2** as described above, the lid portion **2** and the power generating element **3** are integrated with each other.

[0102] As shown in FIG. **3**, the current collectors **4** and **6** are substantially formed into L shapes as a whole and connection portions **4***a* and **6***a* to be connected to the power generating element **3** are bent to be substantially parallel to flat faces of the case BC and the power generating element **3** when each of the portions are assembled.

[0103] In welding the connection portions **4***a* and **6***a* of the current collectors **4** and **6** and the non-coating portions **3***a* of the power generating element **3** to each other, on the positive side, ultrasonic welding is carried out after positioning each of the members in a state in which the non-coating portion **3***a* of the power generating element **3** is bundled about the current collecting ring **22** and the connection portion **4***a* of the current collector **4** is pushed against the non-coating portion **3***a* from outside.

[0104] On the negative side, similarly, ultrasonic welding is carried out after positioning each of the members in a state in which the non-coating portion **3***a* of the power generating element **3** is bundled about the current collecting ring **23** and the connection portion **6***a* of the current collector **6** is pushed against the non-coating portion **3***a* from outside.

[0105] As a result, the current collectors **4** and **6**, the non-coating portions **3***a*, and the current collecting rings **22** and **23** are fixed to each other in positional relationships in which the non-coating portions **3***a* are sandwiched between the current collectors **4** and **6** and the current collecting rings **22** and **23**, the current collecting rings **22** and **23** positioned at centers are pinched by the non-coating portions **3***a* from opposite sides, and the connection portions **4***a* and **6***a* of the current collectors **4** and **6** are attached to only one sides of the non-coating portions **3***a* pinching the current collecting rings **22** and **23** from the opposite sides.

[0106] As a result of the connection and fixing, the non-coating portion **3***a* of the foil-shaped positive electrode plate **24***a*, the current collecting ring **22**, and the current collector **4** are connected electrically and the non-coating portion **3***a* of the foil-shaped negative electrode plate **24***b*, the current collecting ring **23**, and the current collector **6** are connected electrically.

[0107] After attaching the members on the side of the lid portion **2** and the power generating element **3** to each other in the above-described manner, the power generating element **3** is housed into the can body **1** and the lid portion **2** and the can body **1** are welded to each other.

[0108] This completes the assembly of the case BC of the secondary battery RB.

[0109] After the assembly of the case BC is completed, the electrolyte solution is then injected into the case BC through an electrolyte solution filling inlet (not shown). When the injection of the electrolyte solution is completed, initial charge (preliminary charge) of the secondary battery RB is carried out under predetermined charge conditions and aging and the like are further carried out to complete the secondary battery RB.

Other Embodiments

[0110] Other embodiments of the invention will be listed below.

[0111] (1) Although the current collecting rings **22** and **23** are fitted and attached into the cylindrical (circular cylindrical) winding core **21** in order to provide the current collecting rings **22** and **23** to the axial opposite end portions of the cylindrical winding core **21** in the above-described embodiment, the circular cylindrical winding core **21** and the current collecting rings **22** and **23** may be attached to each other by integrally forming them by what is called insert molding.

[0112] (2) Although the thin-plate-shaped members TP are attached along the entire circumferences of the axial end portions of the winding core **21** by fitting the current collecting rings **22** and **23** into the axial end portions of the winding

core **21** in the above-described embodiment, the thin-plate-shaped members TP may be attached to portions of the axial end portions of the winding core **21** and the winding core **21** may be pressed into the flat shape so that the portions attached with the thin-plate-shaped members TP are bent in the above-described pressing step.

[0113] (3) Although the current collecting rings **22** and **23** are attached to the axial opposite end portions of the winding core **21** in the above-described embodiment, the current collecting ring may be attached to either one of the end portions.

[0114] In this case, the non-coating portion **3***a* may be provided to one of the foil-shaped positive electrode plate **24***a* and the foil-shaped negative electrode plate **24***b*.

[0115] (4) Although the above-described embodiment illustrates the case in which the current collecting ring **22** fixed to the non-coating portion **3***a* of the foil-shaped positive electrode plate **24***a* is made of aluminum and the current collecting ring **23** fixed to the non-coating portion **3***a* of the foil-shaped negative electrode plate **24***b* is made of copper, the current collecting ring **22** fixed to the non-coating portion **3***a* of the foil-shaped positive electrode plate **24***a* may be made of aluminum alloy and the current collecting ring **23** fixed to the non-coating portion **3***a* of the foil-shaped negative electrode plate **24***b* may be made of copper alloy.

DESCRIPTION OF REFERENCE SIGNS

[0116] **3** power generating element
[0117] **3***a* non-coating portion
[0118] **4**, **6** current collector
[0119] **21** winding core
[0120] **24***a* foil-shaped positive electrode plate
[0121] **24***b* foil-shaped negative electrode plate
[0122] **25** separator
[0123] BC case
[0124] TP thin-plate-shaped member

1-11. (canceled)

12. A battery comprising:

a power generating element having a flattend shape and housed in a container, the power generating element comprising a positive electrode plate and a negative electrode plate, which are wound with a separator sandwiched therebetween, and a winding core having a flattened shape;

a metal plate-shaped member attached to at least one of opposite end portions in a direction of a winding axis of the winding core; and

a current collector disposed outside the power generating element, the current collector comprising a connection plate being attached to the power generating element,

wherein the power generating element comprises a non-coating portion not applied with an active material being formed at one of end portions in a width direction of at least one of the positive electrode plate and the negative electrode plate,

the non-coating portion is in the state of protruding in the direction of the winding axis from the separator, and

the current collector, the non-coating portion, and the metal plate-shaped member are fixed while the non-coating portion is sandwiched between the connection plate of the current collector and the metal plate-shaped member.

13. The battery according to claim **12**, wherein

the current collector comprises a first plate and a second plate, a cross-section of the first and second plates, taken along a winding axis of the winding core, being an L-shape, and

the second plate of the current collector comprises the connection plate.

14. The battery according to claim **13**, wherein

the non-coating portion is fixed to the metal plate-shaped member while pinching the metal plate-shaped member from opposite sides of the metal plate-shaped member, and

the current collector is attached to only one side of the non-coating portion pinching the metal plate-shaped member from the opposites sides.

15. The battery according to claim **12**, wherein

the metal plate-shaped member comprises a first plate-shaped member attached to one end portion in a direction of a winding axis of the winding core and a second plate-shaped member attached to other end portion in a direction of a winding axis of the winding core, the non-coating portion comprises a first non-coating portion formed at one end in the width direction of the positive electrode plate and a second non-coating portion formed at one end in the width direction of the negative electrode plate,

the first non-coating portion and the second non-coating portion are in the state of protruding from opposite sides in the direction of the winding axis from the separator,

the current collector comprises a positive current collector attached to the positive electrode and a negative current collector attached to the negative electrode,

the positive current collector, the first non-coating portion, and the first metal plate-shaped member are fixed while the first non-coating portion is sandwiched between the connection plate of the positive current collector and the first metal plate-shaped member, and

the negative current collector, the second non-coating portion, and the second metal plate-shaped member are fixed while the second non-coating portion is sandwiched between the connection plate of the negative current collector and the second metal plate-shaped member.

16. The battery according to claim **12**, wherein

the metal plate-shaped member is attached without protruding in a direction of a normal to an outer peripheral face of the winding core from the outer peripheral face.

17. The battery according to claim **12**, wherein

an end portion of the metal plate-shaped member in the direction of the winding axis of the winding core is inserted into the end portion of the winding core.

18. The battery according to claim **12**, wherein

the metal plate-shaped member is attached to an entire circumference of an axial end portion of the winding core.

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