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(54) Title: A CYLINDRICAL SECONDARY CELL COMPRISING AN ENCLOSURE WITH A BRIM AND A LID WITH A FLANGE

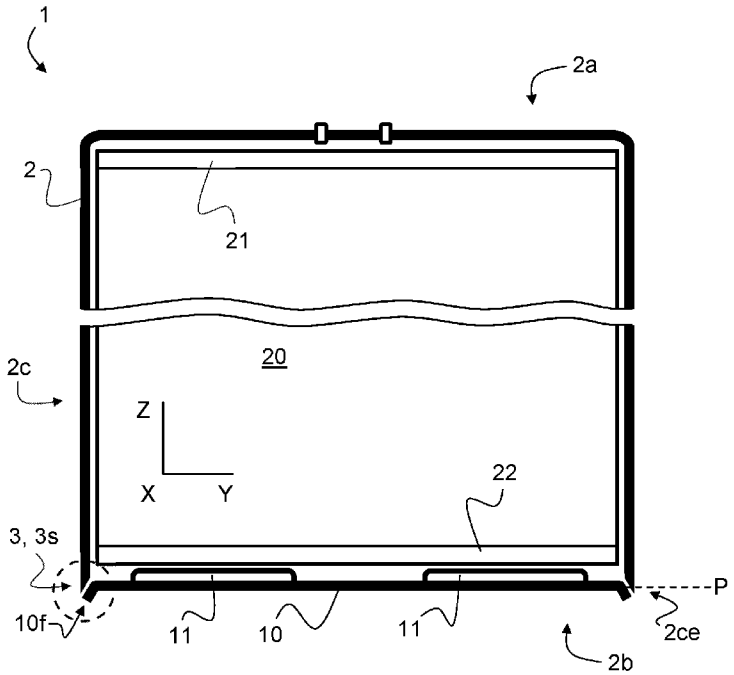

Fig 1

(57) Abstract: This disclosure presents a cylindrical secondary cell (1) comprising a cylindrical enclosure (2) comprising a first enclosure end (2a), a second enclosure end (2b) and an enclosure sidewall (2c) extending between the enclosure ends (2a, 2b), wherein at least one enclosure end (2b) is open and comprises a brim (3). The cell (1) further comprises a lid (10) to be attached to the cylindrical enclosure (2) at the open enclosure end (2b). The brim (3) comprises an attachment surface (3s) that extends non-perpendicular to the enclosure sidewall (2c), and the lid (10) comprises a flange (10f) that, when attached to the cylindrical enclosure (2), extends non-perpendicular to the enclosure sidewall (2c) to match the attachment surface (3s) of the brim (3). Further, a method of manufacturing a cylindrical secondary cell is presented.

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A CYLINDRICAL SECONDARY CELL COMPRISING AN ENCLOSURE WITH A BRIM AND A LID WITH A FLANGE

TECHNICAL FIELD

The present disclosure generally pertains to cylindrical secondary cells, e.g. for battery systems or vehicles, and more precisely to a cylindrical secondary cell having an enclosure with an open end to which a lid is attached.

BACKGROUND

In addressing climate change, there is an increasing demand for rechargeable batteries, e.g. to enable electrification of transportation and to supplement renewable energy. Currently, lithium-ion batteries are becoming increasingly popular. They represent a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging.

As the demand for rechargeable batteries increases, more and more focus is being placed on production speed and cost. To achieve an effective production of rechargeable batteries, the design of the batteries as well as their manufacturing process can be optimized.

Another aspect to consider is that the rechargeable batteries must be safe to use. Therefore, rechargeable batteries have at least one vent for releasing gas when the pressure inside the batteries rises above an allowed level.

A rechargeable battery, often referred to as a secondary battery, typically comprises one or more secondary cells electrically connected to each other.

SUMMARY

It is in view of the above considerations and others that the embodiments of the present invention have been made. The present disclosure aims at providing highly reliable secondary cells that are efficient in manufacture. The number of components is to be reduced and the assembly thereof is to be simplified.

According to one aspect of the present disclosure, a cylindrical secondary cell is provided. The cylindrical secondary cell comprises

- a cylindrical enclosure comprising a first enclosure end, a second enclosure end and an enclosure sidewall extending between the enclosure ends, wherein at least one enclosure end is open and comprises a brim, and
- a lid to be attached to the cylindrical enclosure at the open enclosure end,

wherein

- the brim comprises an attachment surface that extends non-perpendicular to the enclosure sidewall, and
- the lid comprises a flange that, when attached to the cylindrical enclosure, extends non-perpendicular to the enclosure sidewall to match the attachment surface of the brim.

According to another aspect of the present disclosure, a method of attaching the above-described lid to the above-described cylindrical enclosure is provided. The method comprises positioning a weld where the attachment surface meets the flange. In other words, the weld is positioned at a weld interface between the attachment surface and the flange.

Positioning the weld may comprise optically scanning the enclosure end and the lid to automatically position the weld with a high accuracy. The scanning may be facilitated by the weld interface being at least partly visible. In addition, with such a weld interface the weld may be visually inspected after welding. Several advantages related to manufacturing may result from the flange extending non-perpendicular to the enclosure sidewall to match the attachment surface of the brim, as detailed below.

A laser beam that forms the weld may for example be substantially aligned with the extension of the attachment surface. The laser beam may extend in parallel with the attachment surface. In another example, the laser beam is substantially orthogonal to the attachment surface. During welding, the cylindrical secondary cell may be rotated around its longitudinal axis.

According to a further aspect of the present disclosure, a battery system comprising the herein described cylindrical secondary cell is provided. According to a further aspect, a vehicle comprising the herein described cylindrical secondary cell is provided.

Advantages associated with the present disclosure, and additional conceivable features, will become clear from the following description of embodiments and examples.

BRIEF DESCRIPTION OF THE DRAWINGS

The embodiments disclosed herein are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings. Like reference numerals refer to corresponding parts throughout the drawings, in which

Figure 1 schematically illustrates a cylindrical secondary cell, comprising a cylindrical enclosure and a lid, in cross-section,

Figure 2 is an enlarged view of the encircled area of figure 1,

Figure 3 discloses an alternative embodiment of figure 2, and

Figures 4-5 illustrate methods of attaching the lid of figure 1 to the cylindrical enclosure, and

Figure 6 shows a lid of the cylindrical secondary cell of figure 1 in more detail.

DETAILED DESCRIPTION

Embodiments of the present disclosure will now be described more fully hereinafter. The invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those persons skilled in the art.

Figure 1 shows a cylindrical secondary cell 1 (hereinafter referred to as cell) in a cross-sectional side view. In the exemplified embodiment, the cell 1 is circular cylindrical. The cell 1 comprises a cylindrical enclosure 2 having a first enclosure end 2a, an opposite second enclosure end 2b and an enclosure sidewall 2c that extends between the enclosure ends 2a, 2b.

In the exemplified embodiment, the first and second enclosure ends 2a, 2b are circular. The enclosure sidewall 2c is circular cylindrical. The cell 1, and thus its enclosure sidewall 2c, may be elongate and extend along a longitudinal axis (Z-axis in figure 1). The enclosure ends 2a, 2b may extend in planes (XY-planes in figure 1) that are perpendicular to the longitudinal axis.

As is illustrated, the first enclosure end 2a, or first enclosure end side (top side in figure 1), may be closed and formed in one piece with the enclosure sidewall 2c. The second enclosure end 2b may be open and a separate lid 10 may, as shown, be attached to the cylindrical

enclosure 2 at the open enclosure end 2b. Thus, the lid 10 may form the second enclosure end side (bottom side in figure 1). Alternatively, both ends sides may be formed by respective lids.

The open end of the cylindrical enclosure 2, in the present case the second enclosure end 2b, comprises a brim 3. The brim 3 is thus the edge of the enclosure sidewall 2c that surrounds the second enclosure end 2b. In other words, the cylindrical enclosure 2 defines the brim 3. Referring to figure 1, the cylindrical enclosure 2 may be seen as an upside-down cup or a can and the brim 3 is the bottom edge of the cup or can. The brim 3 may alternatively be referred to as a free edge of the cylindrical enclosure. The brim 3 encircles an open end 2b of the cylindrical enclosure 2.

In typical embodiments, as is illustrated in figure 1, the enclosure sidewall 2c is essentially straight. In particular an end section 2ce of the enclosure sidewall 2c that leads to the brim 3 is essentially straight. By straight is here meant that the enclosure sidewall 2c, or the enclosure sidewall end section 2ce, extends in parallel with the longitudinal axis (Z-axis in figure 1) of the cell 1. The enclosure sidewall 2c, or at least the enclosure sidewall end section 2ce, may thus be free from flanges, beading grooves and radius changes.

The enclosure sidewall end section 2ce may be defined as the section of the enclosure sidewall 2c that comprises the brim 3. The enclosure sidewall end section 2ce may be defined as the ultimate portion of the enclosure sidewall 2c at its open end 2b. The enclosure sidewall end section 2ce may constitute the ultimate few percent, such as the ultimate 10 percent, or ultimate 5 percent, of the enclosure sidewall 2c at its open end 2b.

In some embodiments, the enclosure sidewall 2c may at its open end 2b (lower end in figures 1-3, upper end in figures 4-5) extend at a small angle (not shown) to the longitudinal axis of the cell 1. In other words, the enclosure sidewall end section 2ce may extend at a small angle to the longitudinal axis of the cell 1. The enclosure 2 may be somewhat reduced or, typically, expanded at the open enclosure end 2b. This may result from the manufacturing of the enclosure 2. Since the enclosure sidewall end section 2ce may deviate somewhat from the longitudinal axis, it may be appropriate to define the enclosure sidewall 2c and its end section 2ce as essentially straight. However, in some embodiments, the enclosure sidewall 2c and its end section 2ce may be straight, i.e. fully aligned with the longitudinal axis.

The lid 10 is attached to the brim 3. More precisely, the brim 3 comprises an attachment surface 3s to which the lid 10 is attached. During assembly, the lid 10 may be held or clamped towards the attachment surface 3s and simultaneously secured thereto by welding, typically laser welding.

Figures 2 and 3 illustrate the attachment interface between the lid 10 and the brim 3, i.e. the encircled area of figure 1. If the lid 10 is attached to be brim 3 by welding, the attachment interface may be referred to as a weld interface 30, indicated in figure 4. Figure 2 discloses an embodiment identical to that of figure 1, where the attachment surface 3s is straight (as seen in axial cross-section) and extends non-perpendicular to the enclosure sidewall 2c. In other words, the attachment surface 3s extends at an angle α to the enclosure sidewall 2c. Thus, the attachment surface 3s extends at an angle to the longitudinal axis (Z-axis in figure 1) of the cell 1. In figures 1 and 2, the (straight) entire attachment surface 3s extends continuously at the same angle α. Said angle may be referred to as an attachment surface angle α.

Now, in order to securely attach the lid 10 to the attachment surface 3s, the lid 10 comprises a flange 10f that extends non-perpendicular to the enclosure sidewall 2c, thus at an angle θ to the to the enclosure sidewall 2c. Said angle may be referred to as a flange angle θ. As is illustrated, the attachment surface 3s and the flange 10f may both extend at the same, or essentially the same, angles α, θ to the to the enclosure sidewall 2c. In other words, the extension of the flange 10f matches the attachment surface 3s. In this way, a relatively large contact surface is obtained, which ensures a highly reliable attachment between the flange 10f and the lid 10 by a subsequent weld. Further, since the flange angle θ matches the attachment surface angle α, no or only a simple fixture may be required during welding.

Turning now to figure 3, an alternative embodiment of the attachment surface 3s is illustrated. Here, as a result of the enclosure 2 manufacturing, the attachment surface 3s is not straight but convex. Compared to figures 1 and 2, even though the attachment surface 3s is convex it may be defined as essentially extending at an angle α to the enclosure sidewall 2c, as is indicated (dashed lines) in figure 3. In any case, the attachment surface 3s of figure 3 clearly extends non-perpendicular to the enclosure sidewall 2c. Again, the lid flange 10f that extends non-perpendicular to the enclosure sidewall 2c matches the attachment surface 3s and a highly reliable attachment between the flange 10f and the lid 10 may be achieved by welding. In

addition, as mentioned above, no or only a simple fixture may be required during welding. During welding, a convex attachment surface 3s may at least partly melt and thus a relatively large contact surface between the brim 3 and the lid 10 may be attained. As a convex attachment surface melts, capillary forces may act to evenly distribute the melted material to provide a large contact surface.

The attachment surface angle α, and the flange angle θ, may be in the range of 5 to 80 degrees. In the exemplified embodiment, the angles are approximately 30 degrees. In other embodiment, the attachment surface angle α, and the flange angle θ, are approximately 75 degrees or in the range of 50 to 80 degrees.

The flange 10f is attached, or secured, to the attachment surface 3s by welding. Typically, there is no other attachment between the lid 10 and the cylindrical enclosure 2. Thus, the lid 10 may be attached to the cylindrical enclosure 2 solely by the attachment between the flange 10f and the attachment surface 3s.

Figure 4 illustrates the lid 10 being attached to be brim 3 by welding. More precisely, the flange 10f of the lid 10 being welded to the attachment surface 3s of the brim 3. During assembly, the open end 2b of the cylindrical enclosure 2 may be oriented upwards, as is the case in figure 4. As is illustrated, the laser beam may be aligned with the attachment surface 3s. In the present example, the laser beam extends in parallel with the attachment surface 3s. Thus, the laser beam may extend substantially aligned with, or fully aligned with, the above-defined attachment surface angle α.

As is illustrated in figures 1 to 5, the flange 10f and the attachment surface 3s may extend essentially in parallel. In practise, a certain deviation may acceptable as such deviation may be reduced or eliminated by a deformation, bending, of the flange 10f by clamping the lid 10 towards the cylindrical enclosure 2 during welding. A certain deviation may further be accepted as the flange 10f and the attachment surface 3s may at least partially melt during welding, such that a large weld interface is obtained. As is also illustrated, the extension or length of the attachment surface 3s may be substantially equal to the extension or length of the flange 10f, which may be beneficial for maximising the usable volume of the cylindrical secondary cell 1. The entire attachment surface 3s may be welded to the flange 10f, in order to securely attach the attachment surface 3s to the flange 10f. The entire flange 10f may be welded to the

attachment surface 3s, in order to securely attach the flange 10f to the attachment surface 3s. The entire attachment surface 3s may be welded to the entire flange 10f, in order to securely attach the attachment surface 3s and the flange 10f to one another.

As is illustrated, the weld interface 30 between the attachment surface 3s and the flange 10f may be at least partly visible. In the example of figure 4, the weld interface is at least partly visible from the outside of the cylindrical secondary cell 1. A visible weld interface may be visually inspected after welding to ensure a good weld quality. Further, a visible weld interface may be beneficial as it may facilitate automated welding, wherein the weld interface may be optically scanned to position the weld. A computer-controlled apparatus may both optically scan the weld interface and accurately perform the welding. During welding, the cylindrical secondary cell 1 may be rotated, or the welding apparatus may be moved.

Thus, the dimensions and orientations of the flange 10f and of the attachment surface 3s may be configured to simplify welding and provide a secure weld.

Figure 5 illustrates another example of how the lid 10 is attached to be brim 3 by welding. In this example, the laser beam is substantially orthogonal to the attachment surface. As is apprehended from figure 5, depending on the selected position of the weld interface, the weld interface may or may not be visible from the outside of the cylindrical secondary cell 1. As is illustrated, the laser head (or similar) from which the laser beam originates may be positioned radially internally and/or externally to the cylindrical secondary cell 1.

In typical embodiments, the extension of the flange 10f is two to five times the material thickness of the cylindrical enclosure 2. In the illustrated examples (figures 2 to 5), the extension of the flange 10f is approximately 2.5 times the material thickness of the cylindrical enclosure 2. Thus, the flange 10f may be relatively small, as compared to the overall dimension of the lid 10. As is to be apprehended, a small flange 10f may be beneficial for maximising the usable volume inside the cylindrical secondary cell 1.

As is illustrated, the cell 1 may be configured such that the lid 10 does not protrude radially beyond the cylindrical enclosure 2. This may be beneficial as a great number of cells 1 are typically arranged next to one another or in a holder structure in a secondary battery. In this connection, a protruding lid may impede an assembly process or a tight arrangement of cells.

Referring to figures 1 to 5, the attachment surface 3s may extend along the entire brim 3. The attachment surface 3s may extend along the entire brim 3 in the circumferential direction and in the radial direction. In other words, the entire brim 3 may constitute the attachment surface 3s.

Referring to figures 1 and 6, the lid 10 may be one-piece. As is also illustrated, the lid 10 may form a continuous surface that closes the cylindrical enclosure 2. In other words, the lid 10 may be gas-tight.

Figure 1 illustrates a cell 1 of a type that has both a positive terminal and a negative terminal at one and the same end 2a (the top end in figure 1) of the cylindrical secondary cell 1. The first enclosure end 2a comprises a central terminal through-hole for the positive terminal. The negative terminal is electrically connected to the cylindrical enclosure 2. More precisely, the negative terminal is formed by the top surface of the cylindrical enclosure 2 that surrounds the terminal through-hole. Thus, the entire cylindrical enclosure 2 (apart from the positive terminal at the top end) may be the negative terminal.

A cell 1 having both terminals at one end may bring advantages as regards electrically connecting the cell to a load. Conductors electrically connecting the terminals to the load may be positioned on the same end, the terminal end (top side in figure 1), of the cell. The opposite end, which may be referred to as the electrolyte-filling end (bottom end in figure 1), of the cell 1 may be dedicated to electrolyte filling and venting. An overpressure may be generated within the cell during operation, in particular upon malfunction of the cell or of the load connected to the cell. Such malfunction may require a release of gas and/or other ejecta out of the cell, and it may be advantageous to direct the released gas and/or other ejecta away from the conductors, i.e. at the end opposite to the terminal end.

A number of cells 1 may be positioned at a low position in an electric vehicle. The cells 1 may be arranged with the terminal ends directed upwards and the electrolyte-filling ends (bottom end in figure 1) directed downwards. Upon malfunction, for example resulting from a faulty electric vehicle charger or a faulty cell 1, a release of gas and/or other ejecta from the electrolyte-filling end(s) will be advantageously directed downwards towards the ground beneath the vehicle. In other applications, the electrolyte-filling ends may be directed towards a desired location such that any gas and/or other ejecta will not cause damages or injuries.

As is illustrated in figure 1, the cell 1 may comprise an electrode roll 20. The electrode roll 20 comprises a first and a second rolled conductive sheet 21, 22 and separating means (not shown). The separating means may also be termed separator. The conductive sheets 21, 22 and the separating means are rolled to form a circular cylindrical roll. The conductive sheets 21, 22 are coated with electrode coatings and on assembly of the cell 1, the cylindrical enclosure 2 is filled with an electrolyte. The coatings on the conductive sheets 21, 22 act as cathode and anode, respectively. The cathode, anode and electrolyte provide electrochemical energy storage. This principle is known per se, and the electrode roll 20 is commonly referred to as a jellyroll.

The rolled conductive sheets 21, 22 of the electrode roll 20 may be axially offset in relation to one another, and each conductive sheet may comprise an end section that is not coated with electrode coating. Via the non-coated end sections, the respective ends of the electrode roll may be efficiently electrically connected to a respective assigned terminal of the cell 1. This design is known per se and commonly referred to as a tabless cell.

As is illustrated in figure 1, one 22 of the rolled conductive sheets may be in electrical contact, more precisely in direct electrical contact, with the lid 10. Direct electrical contact may be referred to as physical contact.

Turning to figure 6, the lid 10 may be configured to be arranged in direct electrical contact with the rolled conductive sheet 22. Typically, the lid 10 is welded, e.g. laser welded, to the rolled conductive sheet 22. Thus, no additional separate component needs to be arranged to make contact with the rolled conductive sheet 22.

As is shown in figure 6, and also in figure 1, the lid 10 may comprise at least one recessed contact portion 11 that is configured to form the direct electrical contact with the rolled conductive sheet 22. Typically, the above-mentioned weld is arranged within the at least one recessed contact portion 11.

Furthermore, the lid 10 may, as is shown in figure 6, comprise a groove or notch 12 for providing an opening in the lid 10 if the pressure inside the cylindrical enclosure 2 reaches a threshold value. In such a situation, gas and/or other ejecta may be released out of the cell 1 through the opening formed in the lid 10. The opening formed in the lid 10 as a result of the groove or notch 12 breaking may be referred to as a vent opening.

The groove or notch 12, which may be referred to as a breakable portion, may be a weakened portion configured to break before other parts of the lid 10 (and the cylindrical enclosure 2). For example, the groove or notch 12 may be perforated, scored, notched, or have reduced thickness relative to the rest of the lid 10 and the cylindrical enclosure 2. The groove or notch 12 may be circular and may at least partly encircle a central portion of the lid 10.

The lid 10 may comprise a filling opening for the above-described electrolyte filling. The filling opening may be arranged in a recessed filling portion 13, as is shown in figure 6. The recessed filling portion 13 may be arranged in the same plane as the recessed contact portion 11. The filling opening may, as is shown, be sealed by a sealing element such as for example a rivet, such as a blind rivet. If the filling portion 13 is recessed, the sealing element may be countersunk such that it does not protrude beyond the enclosure end to which the lid 10 is attached.

The lid 10 may be generally disc-shaped. The lid 10 may have the general shape of a circular plate that extends in the below defined base plane P. In some more detail, the lid 10 may comprise a circular disc that at the radially outer end comprises the above-described flange 10f. The flange 10f may extend from the circular disc in a direction away from the cylindrical enclosure 2 (when the lid 10 is attached to the cylindrical enclosure 2). The circular disc and the flange 10f may be formed in one integral piece.

The recessed contact portion 11 or portions (there are six recessed contact portions 11 in the present embodiment) may be formed in the circular disc that extends in the below defined base plane P. The recessed contact portions 11 may be equidistantly distributed along the circumference of the lid 10. Each one of the recessed contact portions 11 may be of the same size. The recessed contact portions 11 may have essentially the same extension radially and circumferentially to facilitate welding. In other words, the recessed contact portions 11 may have similar extensions in all direction as seen in the plane (XY-plane in figure 1) that of the lid. The smallest extension of the recessed contact portions 11 may be at least 20 percent of the total extension of the lid 10.

As is denoted in figures 1 to 3 and 6, the lid may comprise a base plane P. The base plane P may alternatively be referred to as a neutral plane or an axially central plane. The flange 10f, the illustrated recessed contact portions 11 and the illustrated recessed filling portion 13 may

protrude axially from the base plane P. Referring in particular to figure 1, when the lid 10 is attached to the cylindrical enclosure 2, the base plane P of the lid 10 may be substantially aligned with the brim 3. Thus, only the optional recessed contact portions 11 (figure 1) and the optional recessed filling portion 13 may extend into the cylindrical enclosure 2. In the present examples, the lid is substantially axially aligned with the brim 3 and with the attachment surface 3s, which may maximise the usable volume of the cylindrical secondary cell 1.

The enclosure sidewall 2c, or at least the enclosure sidewall end section 2ce, may have a constant material thickness.

In figures 1 to 5, the material thickness of the cylindrical enclosure 2 and the lid 10 have been exaggerated to elucidate the features of the present disclosure. For the same reason, figures 1 to 3 illustrate a certain gap between the cylindrical enclosure 2 and the lid 10. It is to be apprehended that in actual implementations the lid 10 brought in direct contact with the cylindrical enclosure 2 before attachment by welding, see figures 4 and 5.

The material thickness of the cylindrical enclosure 2 and the material thickness of the lid 10 may be equal or essentially equal, as is illustrated. In some embodiment, the material thickness of the cylindrical enclosure 2 (or at least the enclosure sidewall 2c) exceeds the material thickness lid 10 (or at least the flange 10f) i.a. to facilitate attaching the lid 10 to the attachment surface 3s. The greater the material thickness of the enclosure sidewall 2c, the greater the length of the attachment surface 3s. For example, the material thickness of the cylindrical enclosure 2 may be two to ten times the material thickness of the lid 10. The material thickness of the cylindrical enclosure 2 may be three to six times the material thickness lid 10.

Modifications and other variants of the described embodiments will come to mind to ones skilled in the art having benefit of the teachings presented in the foregoing description and associated drawings. Therefore, it is to be understood that the embodiments are not limited to the specific example embodiments described in this disclosure and that modifications and other variants are intended to be included within the scope of this disclosure.

Furthermore, although specific terms may be employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation. Therefore, persons skilled in the art would recognize numerous variations to the described embodiments that would still fall within

the scope of the appended claims. As used herein, the terms “comprise/comprises” or “include/includes” do not exclude the presence of other elements or steps. Furthermore, although individual features may be included in different claims (or embodiments), these may possibly advantageously be combined, and the inclusion of different claims (or embodiments) does not imply that a certain combination of features is not feasible and/or advantageous. In addition, singular references do not exclude a plurality. Finally, reference numerals in the claims are provided merely as a clarifying example and should not be construed as limiting the scope of the claims in any way.

CLAIMS

1. A cylindrical secondary cell (1), comprising
   - a cylindrical enclosure (2) comprising a first enclosure end (2a), a second enclosure end (2b) and an enclosure sidewall (2c) extending between the enclosure ends (2a, 2b), wherein at least one enclosure end (2b) is open and comprises a brim (3), and
   - a lid (10) to be attached to the cylindrical enclosure (2) at the open enclosure end (2b),

   wherein
   - the brim (3) comprises an attachment surface (3s) that extends non-perpendicular to the enclosure sidewall (2c), and
   - the lid (10) comprises a flange (10f) that, when attached to the cylindrical enclosure (2), extends non-perpendicular to the enclosure sidewall (2c) to match the attachment surface (3s) of the brim (3).

2. The cylindrical secondary cell (1) of claim 1, wherein the lid (10) is configured to be attached to the cylindrical enclosure (2) solely by an attachment between the flange (10f) and the attachment surface (3s).

3. The cylindrical secondary cell (1) of claim 1 or 2, wherein the lid (10) is configured to be attached to the cylindrical enclosure (2) by the flange (10f) being welded to the attachment surface (3s).

4. The cylindrical secondary cell (1) of claim 3, wherein the flange (10f) and the attachment surface (3s) extend substantially in parallel.

5. The cylindrical secondary cell (1) of claim 3 or 4, wherein a weld interface (30) between the flange (10f) and the attachment surface (3s), after welding, is at least partly visible such that the weld may be inspected.

6. The cylindrical secondary cell (1) of any preceding claim, wherein the attachment surface (3s) essentially extends at an angle (α) to the enclosure sidewall (2c).

7. The cylindrical secondary cell (1) of claim 6, wherein the angle (α) is in the range of 5 to 80 degrees, such as for example 50 to 80 degrees.

8. The cylindrical secondary cell (1) of any preceding claim, wherein the attachment surface (3s) is convex.

9. The cylindrical secondary cell (1) of any preceding claim, wherein the extension of the flange (10f) is two to five times the material thickness of the cylindrical enclosure (2).

10. The cylindrical secondary cell (1) of any preceding claim, wherein the flange (10f) is essentially straight.

11. The cylindrical secondary cell (1) of any preceding claim, wherein the lid (10), when attached to the cylindrical enclosure (2), does not protrude radially beyond the cylindrical enclosure (2).

12. The cylindrical secondary cell (1) of any preceding claim comprising an electrode roll (20) comprising a conductive sheet (21, 22), wherein the lid (10) is configured to be arranged in direct electrical contact with the conductive sheet (22).

13. The cylindrical secondary cell (1) of claim 12, wherein the lid (10) is configured to be arranged in direct electrical contact with the conductive sheet (22) by the lid (10) being welded to the conductive sheet.

14. The cylindrical secondary cell (1) of claim 12 or 13, wherein the lid (10) comprises at least one recessed contact portion (11) that is configured to form the direct electrical contact with the conductive sheet (22).

15. The cylindrical secondary cell (1) of any preceding claim, wherein the lid (10) comprises a groove or notch (12) configured to provide an opening in the lid (10) if the pressure inside the cylindrical enclosure (2) reaches a threshold value.

16. The cylindrical secondary cell (1) of any preceding claim, wherein the lid (10) comprises a recessed filling portion (13).

17. The cylindrical secondary cell (1) of claims 15 and 16, wherein the groove or notch (12) at least partially encircles the recessed filling portion (13).

18. The cylindrical secondary cell (1) of any preceding claim, wherein the material thickness of the enclosure sidewall (2c) exceeds the material thickness of the flange (10f).

19. The cylindrical secondary cell (1) of any preceding claim, wherein the lid (10) comprises a base plane (P) that is substantially aligned with the brim (3), when the lid (10) is attached to the cylindrical enclosure (2).

20. The cylindrical secondary cell (1) of any preceding claim, wherein the length of the attachment surface (3s) is substantially equal to the length of the flange (10f).

21. The cylindrical secondary cell (1) of any preceding claim, wherein the attachment surface (3s) extends along the entire brim (3) and the entire attachment surface (3s) is attached to the flange (10f), when the lid (10) is attached to the cylindrical enclosure (2).

22. The cylindrical secondary cell (1) of any preceding claim, wherein the lid (10) is one-piece.

23. The cylindrical secondary cell (1) of any preceding claim, wherein the first enclosure end (2a) is formed in one piece with the enclosure sidewall (2c), a positive and a negative terminal of the cylindrical secondary cell (1) are arranged at the first enclosure end (2a), the first enclosure end (2a) comprising a central terminal through-hole for one of said terminals.

24. A method of manufacturing a cylindrical secondary cell (1) of any preceding claim, comprising attaching the lid (10) to the cylindrical enclosure (2) by positioning a weld where the attachment surface (3s) meets the flange (10f), wherein the weld is formed by a laser beam that is substantially aligned with the extension of the attachment surface (3s).

25. A method of manufacturing a cylindrical secondary cell (1) of any one of claim 1 to 23, comprising attaching the lid (10) to the cylindrical enclosure (2) by positioning a weld where the attachment surface (3s) meets the flange (10f), wherein the weld is formed by a laser beam that is substantially orthogonal to the extension of the attachment surface (3s).

26. A battery system comprising a cylindrical secondary cell (1) according to any one of claims 1 to 23.

27. A vehicle comprising a cylindrical secondary cell (1) according any one of claims 1 to 23.

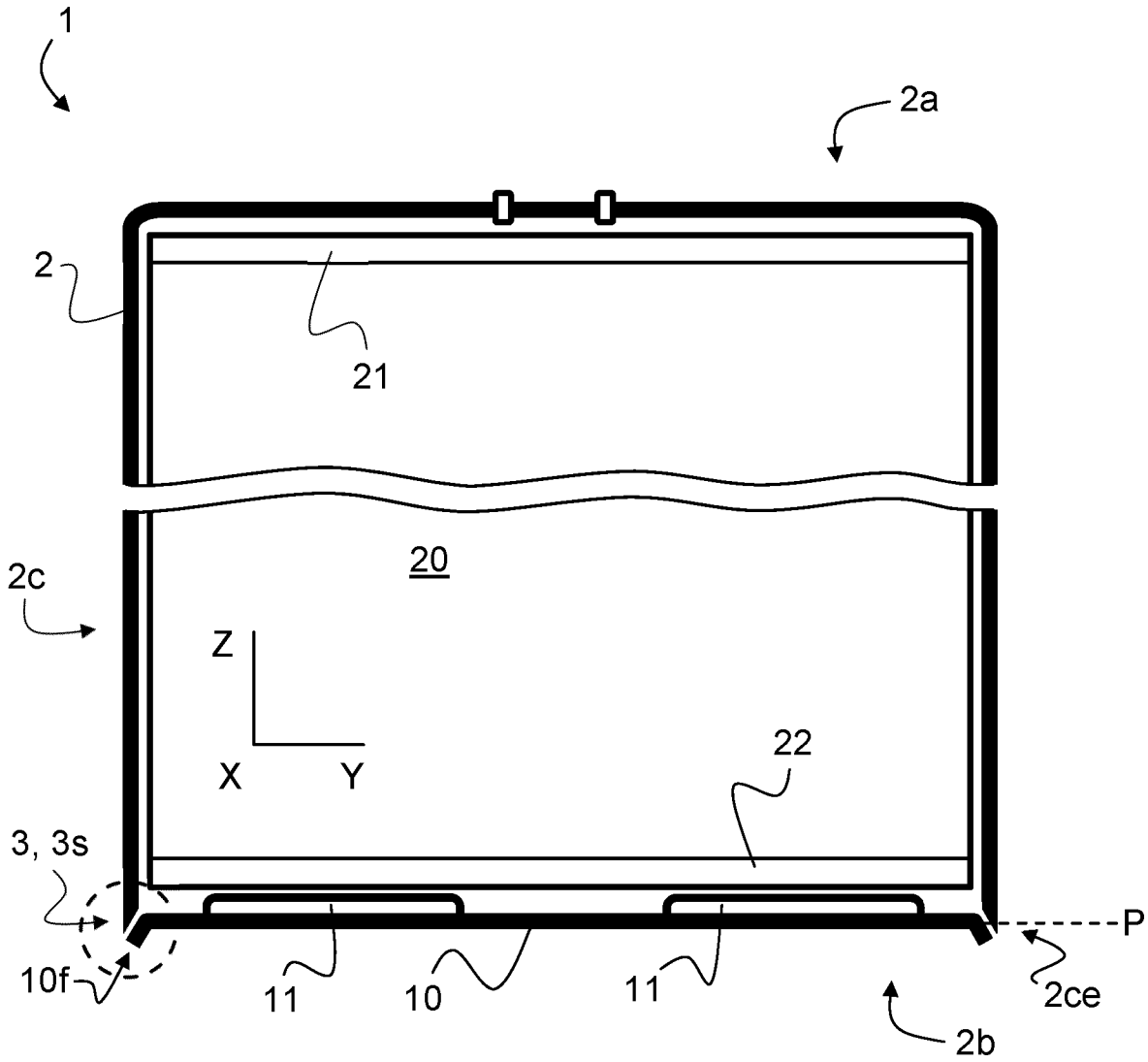

Fig 1

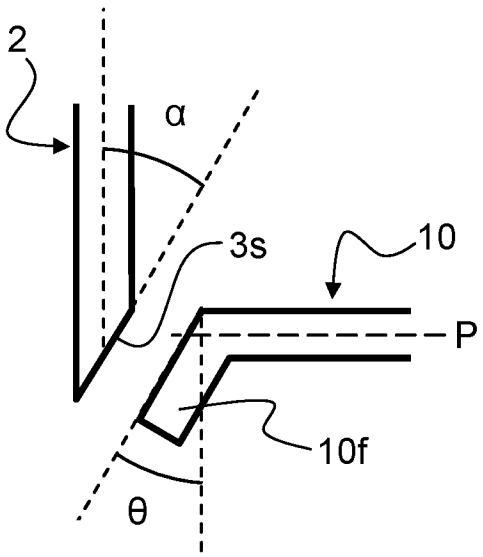

Fig 2

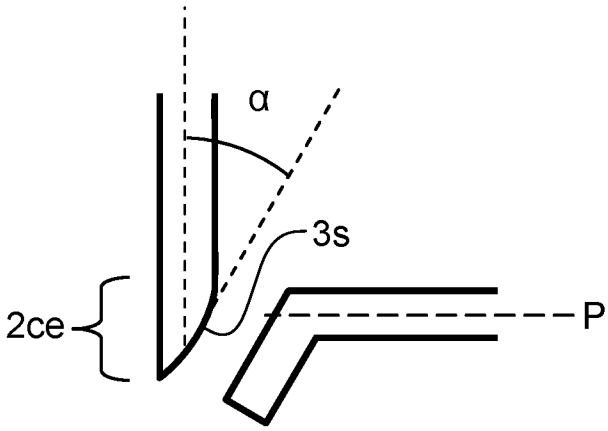

Fig 3

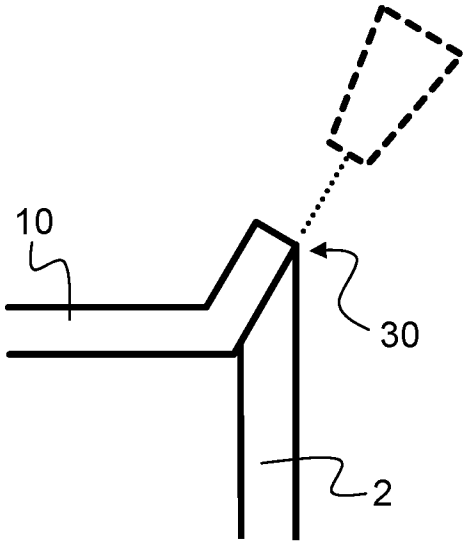

Fig 4

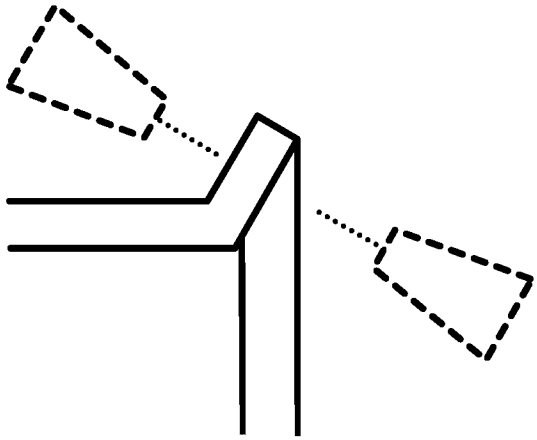

Fig 5

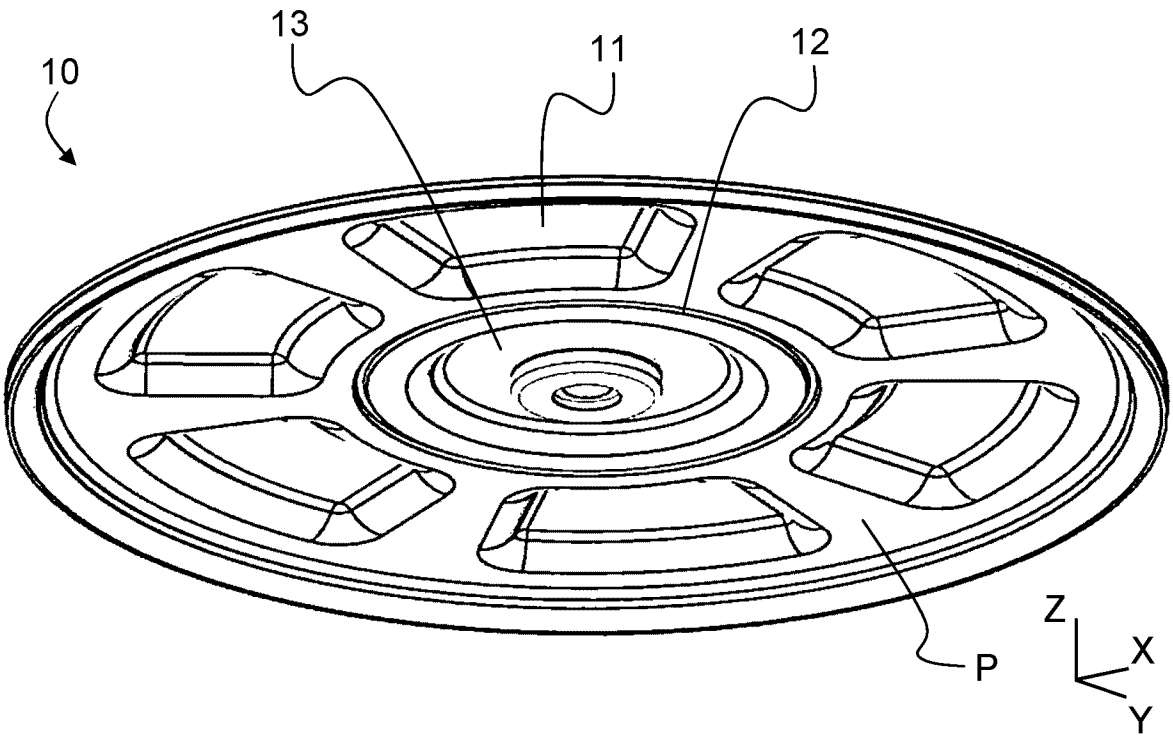

Fig 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/073518

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M50/107 H01M50/152 H01M50/169 H01M50/342
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2022/102789 A1 (SHIMIZU KAZUMICHI [JP] ET AL) 31 March 2022 (2022-03-31)	1-7, 9-11, 18-21, 24,26,27
Y	figures 1A-1F, 3B, 3C, 3F, 4-6 paragraphs [0110], [0116], [0148]	8,25
X	WO 2022/113716 A1 (MURATA MANUFACTURING CO [JP]) 2 June 2022 (2022-06-02) figures 1-6	1-7, 9-11,20, 21,24
Y	JP 2013 093208 A (TOYOTA IND CORP) 16 May 2013 (2013-05-16) figures 3, 4	8,25

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 December 2023	05/02/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Scheid, Michael

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2023/073518

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:
1-11, 18-21, 24-27

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-11, 18-21, 24-27

   Secondary cylindrical cell defined by the attachment surface (3s)

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2. claims: 12-14

   Detail of the cell concerning the conductive sheet

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3. claims: 15-17, 22

   Detail of the cell concerning the cell other than the welding surface

   ---

4. claim: 23

   Detail of the cell concerning the terminals

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2023/073518

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2022102789 A1	31-03-2022	CN 113228384 A	06-08-2021
		CN 116169408 A	26-05-2023
		JP WO2020138492 A1	11-11-2021
		US 2022102789 A1	31-03-2022
		WO 2020138492 A1	02-07-2020
WO 2022113716 A1	02-06-2022	JP WO2022113716 A1	02-06-2022
		US 2023307713 A1	28-09-2023
		WO 2022113716 A1	02-06-2022
JP 2013093208 A	16-05-2013	JP 5691998 B2	01-04-2015
		JP 2013093208 A	16-05-2013