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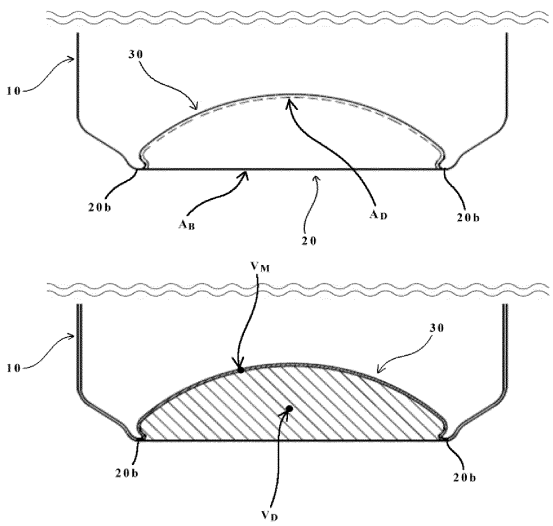
(54) **SEAMLESS CAN BODY AND METHOD FOR PRODUCING SEAMLESS CAN BODY**

(57) Provided are a seamless can body having excellent pressure resistance and a method for producing the seamless can body. The seamless can body according to the present invention includes a tubular body section (10), a peripheral ground section (20b) continuing from a lower end of the tubular body section, and a raised bottom section (30) continuing from the peripheral ground section toward a center-axis side. When an outer surface area of the raised bottom section is denoted by A_D and an area of a virtual plane an outline of which is formed by the peripheral ground section is denoted by A_B, a relation of $1.55 \geq (A_D/A_B) \geq 1.40$ is satisfied.

FIG. 3



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Description

[Technical Field]

[0001] The present invention relates to a seamless can body and a method for producing a seamless can body.

[Background Art]

[0002] Hitherto, there is known what is generally called a seamless can body in which a can body section and the like are formed by drawing and ironing. Since the seamless can body has the can body section thinned by ironing after shallow drawing, it is excellent in weight reduction. Meanwhile, there have been made various proposals for maintaining or enhancing pressure resistance of such a seamless can body even when its can bottom section is thinned.

[0003] For example, PTL 1 and PTL 2 disclose what is generally called bottom reforming conducted for the purpose of preventing a phenomenon (buckling) in which a dome section of the can bottom is inverted and which would occur when an internal pressure of the can exceeds its pressure resistance strength. Specifically, there is disclosed bottom reforming in which an inner peripheral wall, located on the inner side in a radial direction orthogonal to an axis of the can, of a ground section of the can bottom is pressed to form a recess.

[Citation List]

[Patent Literature]

[0004]

[PTL 1]
Japanese Patent Laid-open No. 2018-103227
[PTL 2]
Japanese Patent Laid-open No. 2016-47541

[Summary]

[Technical Problem]

[0005] In other words, in the bottom reforming step described above, it is typical to form a recess by pressing the inner peripheral wall of the can bottom by use of a forming roller or the like.

[0006] In addition, recently, in order to achieve weight reduction of a seamless can body, it is demanded to further reduce the plate thickness of a blank sheet (blank) yet to be subjected to drawing and ironing. However, in the case of the bottom reforming described above, a metallic blank material at a pressed part contacted by the forming roller or the like is extended to be thinned through the bottom reforming, and therefore, there has been a limit on reduction of the plate thickness of the blank sheet (blank).

[0007] The present inventor has repeated extensive and intensive investigations in consideration of the above-exemplified problems, and as a result, has made it possible to provide a seamless can body having excellent pressure resistance and a method for producing the same, thereby reaching the present invention.

[Solution to Problem]

[0008] A seamless can body according to one embodiment of the present invention (1) includes a tubular body section, a peripheral ground section continuing from a lower end of the tubular body section, and a raised bottom section continuing from the peripheral ground section toward a center-axis side. When an outer surface area of the raised bottom section is denoted by A_D and an area of a virtual plane an outline of which is formed by the peripheral ground section is denoted by A_B, a relation of $1.55 \geq (A_D/A_B) \geq 1.40$ is satisfied.

[0009] In addition, in the seamless can body described in (1) above, (2) it is preferable that, when a volume of a space surrounded by the virtual plane and the raised bottom section is denoted by V_D and a volume of a metallic member forming the raised bottom section is denoted by V_M, a relation of $26.0 \geq (V_D/V_M) \geq 22.0$ be satisfied.

[0010] Besides, to solve the above-mentioned problem, a method for producing a seamless can body according to one embodiment of the present invention (3) includes a first forming step of forming a metallic blank material into a cup body having a tubular body section, a peripheral bottom section continuing from a lower end of the tubular body section, and a bulging section bulging from the peripheral bottom section toward an opening section by a first height, and a

second forming step of pressing down the bulging section in such a manner that the bulging section has a second height smaller than the first height, to thereby form a peripheral ground section continuing from the lower end of the tubular body section and a raised bottom section continuing from the peripheral ground section toward a center-axis side. When an outer surface area of the raised bottom section is denoted by A_D and an area of a virtual plane an outline of which is formed by the peripheral ground section is denoted by A_B, a relation of $1.55 \geq (A_D/A_B) \geq 1.40$ is satisfied.

[Advantageous Effect of Invention]

[0011] According to the present invention, a seamless can body which prevents buckling by adopting a raised bottom section having excellent pressure resistance can be obtained with a reduced amount of material.

[Brief Description of Drawings]

[0012]

[FIG. 1]
FIG. 1 is a schematic view depicting an overall longitudinal cross section of a seamless can body in an embodiment.
[FIG. 2]
FIG. 2 is an enlarged view depicting a can bottom of the seamless can body in the embodiment.
[FIG. 3]
FIG. 3 is a schematic view for explaining an outer surface area A_D of a raised bottom section, an area A_B of a virtual plane an outline of which is formed by a peripheral ground section, a volume V_D of a space surrounded by the virtual plane and the raised bottom section, and a volume V_M of a metallic member forming the raised bottom section.
[FIG. 4]
FIG. 4 is a flow chart depicting a method for producing a seamless can body in the embodiment.
[FIG. 5]
FIG. 5 is a diagram depicting a first forming step of the method for producing the seamless can body of the embodiment.
[FIG. 6]
FIG. 6 is a diagram depicting a second forming step of the method for producing the seamless can body of the embodiment.
[FIG. 7]
FIG. 7 is a schematic view depicting compressive stresses applied to a rising-up section in the embodiment.
[FIG. 8]
FIG. 8 is a schematic view for explaining state transition from a provisional peripheral ground section after the first forming step to the peripheral ground section after the second forming step in the seamless can body of the embodiment.
[FIG. 9]
FIG. 9 is a schematic view depicting an example of application of an organic coating film to the can bottom of the seamless can body.
[FIG. 10]
FIG. 10 is a schematic view depicting a can bottom section and the vicinity thereof in an experimental example.

[Description of Embodiment]

[0013] A seamless can body and a method for producing the same of the present invention will be described specifically below with reference to the drawings as required. Note that the following embodiment presents examples of the present invention and describes the contents thereof, and do not intentionally limit the present invention.

[First Embodiment]

<Seamless Can Body 1>

[0014] As illustrated in FIG. 1, a seamless can body 1 of the present embodiment is a seamless can body having a tubular body section 10, and a can bottom section 20 including at least a peripheral bottom section 20a continuing from a lower end of the tubular body section 10. Note that, in the illustration, a part above the tubular body section 10 is drawn as an example to be a neck-flange shape, but a structure of a known seamless can body having an opening section 10a can be applied to the part above the tubular body section 10.

[0015] The tubular body section 10 is a part constituting a side surface of the seamless can body 1 and is formed by drawing and ironing a known metallic sheet made of aluminum, steel, or the like described later. Though there are variations depending on the use, the tubular body section 10 is configured to have a thickness of, for example, on the order of 0.07 to 0.40 mm.

[0016] The tubular body section 10 in the present embodiment is defined to have a lower end 10e, which will be described later, as its lower end part and to have as its upper end part a boundary between the tubular body section 10 and a neck shoulder part (part reduced in diameter in going upward along an axial direction) as depicted in FIG. 1.

[0017] The can bottom section 20 is configured to include at least the peripheral bottom section 20a continuing from the lower end 10e of the tubular body section 10 described above in the manner of decreasing in diameter toward an inner side as depicted in FIG. 1, and a raised bottom section 30 bulging from the inner side of the peripheral bottom section 20a toward the opening section 10a.

[0018] Note that, as is clear from FIG. 1, the peripheral bottom section 20a and the raised bottom section 30 in the present embodiment are partitioned by a peripheral ground section 20b that comes into contact with on a flat surface such as a table when the seamless can body 1 is placed on the flat surface. In other words, the peripheral ground section 20b can be said to be a part continuing from the lower end 10e of the tubular body section 10, and the peripheral bottom section 20a can be said to be a part located between the tubular body section 10 and the peripheral ground section 20b.

[0019] In this manner, the seamless can body 1 has the raised bottom section 30 formed to protrude upward from the peripheral ground section 20b. As is clear from the illustration, the raised bottom section 30 of the present embodiment is formed to be continuous from the peripheral ground section 20b toward a center-axis side. Note that the raised bottom section 30 in the present embodiment rises from the peripheral ground section 20b and is then gently dome-shaped (protruding toward the tip), but this shape is not limitative, and at least a part of a top section may be flat plate shaped.

[0020] Note that, in the present embodiment, the kind of the metallic blank material to be used for the seamless can body 1 is not particularly limited. That is, known metallic sheets ordinarily used for seamless can bodies, for example, an aluminum alloy sheet or a steel sheet (for example, tin plate), can be used. In addition, the metallic sheet may be subjected to surface coating on at least one surface as required, such as one laminated with a known film, one coated with an organic resin, or one subjected to chemical conversion treatment.

[0021] In addition, the seamless can body 1 of the present embodiment is subjected to, for example, known flange processing, necking processing, screw processing, or the like, and after beer, carbonated drink, coffee, juice, liquid food, or the like is accommodated in the seamless can body 1 as contents, a lid, a cap, or the like is attached to the opening section 10a by a known method.

<Structural Characteristics of Raised Bottom Section 30>

[0022] Next, with reference to FIG. 1, FIG. 3, and other drawings, the structure of the raised bottom section 30 in the present embodiment will be described in detail below.

[0023] As is clear from these drawings, the raised bottom section 30 of the seamless can body 1 in the present embodiment satisfies a relation of the following formula (1), where an outer surface area of the raised bottom section 30 is denoted by A_D and an area of a virtual plane VP an outline of which is formed by the peripheral ground section 20b is denoted by A_B.

$$1.55 \geq (A_D/A_B) \geq 1.40 \quad \ldots \quad (1)$$

[0024] As described above, recent years have seen increasing kinds of beverages brought to beverage market, as carbonated drinks for which the internal pressure of the can is relatively high such as what is generally called strong carbonated drinks have been provided. Attendant on the increase in the range of needs, it is assumed that seamless can bodies in which carbonated beverages such as strong carbonated drinks and beer and non-carbonated beverages such as fruit juice drinks are stored are also required to have high pressure resistance. To enhance the pressure resistance of seamless can bodies, it is possible to simply increase the plate thickness of the seamless can bodies, but this is not practical since it leads to a weight increase of the cans themselves and an increase in cost.

[0025] As a result of the present inventor's extensive and intensive investigations, it has been found out that the raised bottom section 30 disclosed in the present embodiment can exhibit excellent pressure resistance when the above-mentioned relational formula (1) is satisfied. In other words, the above-mentioned (A_D/A_B) is a concept in which the degree of the upward bulging of the raised bottom section 30 in the present embodiment is expressed in the form of parameter (numerical value), and when the bulging degree of (A_D/A_B) exceeds 1.40, the balance between the plate thickness and the pressure resistance which is ordinarily acceptable on the product market can be secured.

[0026] Note that, while the outer surface area A_D of the raised bottom section 30 and the area A_B of the virtual plane VP can be calculated based on a known calculation formula, they can easily and accurately be determined by, for

example, a commercial shape measuring instrument. In the present embodiment, as such a shape measuring instrument, CONTOURECORD (model 1600DH) made by TOKYO SEIMITSU CO., LTD. was used for measurement. More specifically, shape data generated by upward and downward movements of a probe moving on a plane passing through a center axis of a cup was put into computer-aided design (CAD) to obtain a cross-sectional shape, and based on the cross-sectional shape, the surface area as a body of revolution and the volume (obtained through multiplication by the plate thickness data measured separately) were measured with sufficient accuracy.

[0027] On the other hand, when the bulging degree of (A_D/A_B) is less than 1.40, rigidity of the raised bottom section cannot be secured, and for example, the plate thickness has to be increased. Thus, such problems as an increase in cost and wasting of resources can occur, and it becomes difficult to secure the balance between the plate thickness and the pressure resistance.

[0028] Note that the upper limit for the bulging degree of (A_D/A_B) can be set in various manners according to the specifications of the can body required by the market, and a value equal to or less than 1.55 is preferable, for example. This is because, when (A_D/A_B) > 1.55, such a problem that the material area becomes excessive, which leads to a rise in cost and wasting of resources, can occur.

[0029] Further, in consideration of transportation cost and the like, the seamless can body 1 of the present embodiment is desirably reduced in weight while being excellent in pressure resistance. The present inventor has made investigations based on such a viewpoint, and it has been found out that the raised bottom section 30 disclosed in the present embodiment can realize weight reduction in addition to the excellent pressure resistance described above when the above relational formula (2) is satisfied.

[0030] That is, where a volume of a space surrounded by the above-described virtual plane VP and the raised bottom section 30 is denoted by V_D and a volume of the metallic member forming the raised bottom section 30 is denoted by V_M, it is desirable that the relation represented by the following formula (2) be satisfied.

$$26.0 \geq (V_D/V_M) \geq 22.0 \quad \ldots \quad (2)$$

[0031] Note that, as in the above description, while the volume V_D of the raised bottom section 30 and the volume V_M of the metallic member can be calculated by a known calculation formula, the volumes can easily and accurately be determined by a commercial shape measuring instrument. In the present embodiment, the volume V_D and the volume V_M were also measured by use of the above-mentioned shape measuring instrument (product name: CONTOURECORD, model 1600DH, made by TOKYO SEIMITSU CO., LTD.).

[0032] Note that (V_D/V_M) described above in the present embodiment functions as an index of balance between pressure resistance, weight reduction, and the internal capacity of the container, and the upper limit for (V_D/V_M) is preferably equal to or less than 26. This is because, when (V_D/V_M) > 26, such disadvantages as a rise in cost and lowering in internal capacity can be generated rather than enhancement of pressure resistance.

<Method for Producing Seamless Can Body 1>

[0033] Next, the method for producing the seamless can body 1 in the present embodiment will be described with reference to FIGS. 4 to 8 as required.

[0034] The method for producing the seamless can body 1 in the present embodiment is a method for producing a seamless can body having the tubular body section 10 and the can bottom section 20 as depicted in FIG. 1, which, as depicted in FIG. 4, includes at least a first forming step as STEP 1 and a second forming step as the subsequent STEP.

[First Forming Step]

[0035] According to the method for producing the seamless can body 1 in the present embodiment, in the first forming step, a metallic blank material (precursor 3) is formed into a cup body 2 (see FIG. 5) that includes the tubular body section 10, the peripheral bottom section 20a continuing from the lower end 10e of the tubular body section 10, and a bulging section 4 bulging from the peripheral bottom section 20a toward the opening section by a first height Ho. In this instance, at a lower end on the inner side than the tubular body section 10, which is at a boundary with the bulging section 4, a provisional peripheral ground section 20a' is located. The cup body 2 can be formed by a known forming method including drawing and redrawing forming, drawing and ironing forming, or the like.

[0036] In other words, in the first forming step, the metallic blank material (precursor 3) is formed into the cup body 2 that includes the tubular body section 10, the provisional peripheral ground section 20a' located at the lower end on the inner side than the tubular body section 10, and the bulging section 4 that has the first height Ho and is located on the inner side than the provisional peripheral ground section 20a'.

[0037] Note that, as illustrated in the drawing, the bulging section 4 of the cup body 2 in the present embodiment

includes a slant section S extending from the peripheral bottom section 20a toward an inner upper side, and a cup dome section D on the inner side of an end part Se of the slant section S. In addition, in the method for producing the seamless can body of the present embodiment, as the method for forming the tubular body section 10, a known method such as one described in the Japanese Patent Laid-open No. Hei 9-285832 can be adopted, for example.

[0038] More specifically, steps exemplified in (a) to (c) of FIG. 5 will be described.

[0039] First, by use of the above-described metallic blank material (blank), the can body section is formed by a known method, to prepare the precursor 3 having the shape of a cup.

[0040] Then, the metallic blank material (precursor 3) is formed into the cup body 2 that has the tubular body section 10, a cup peripheral bottom section A continuing from the lower end 10e of the tubular body section 10 in the manner of decreasing in diameter, and the bulging section 4 bulging from the cup peripheral bottom section A toward the inner upper side by the first height Ho. Here, the end part Se of the slant section S can be said to be a point of connection with the cup dome section D.

[0041] The first forming step depicted in FIG. 5 can be applied to the precursor 3 formed with the tubular body section 10 by a known press step or the like, by use of an upper die and a lower die as a separate step, or can be performed at a stroke final stage subsequent to a step of ironing.

[0042] In a specific example, as depicted in FIG. 5, the first forming step is carried out by a tubular punch 401 located inside the precursor 3 having a cup shape to support the precursor 3, a hold-down ring 501 that supports the peripheral bottom section of the precursor 3 in cooperation with the punch 401, and a doming die 502.

[0043] First, the peripheral bottom section of the precursor 3 is held by a tapered section 402 of the punch 401 and a tapered support section 503 of the hold-down ring 501, and the punch 401 and the doming die 502 are driven to be brought close to each other in such a manner as to mesh with each other, so that the cup body 2 having the cup dome section D of the first height Ho at the bottom can be obtained.

[0044] Here, the shape of the cup body 2 obtained by the first forming step will be described. That is, the slant section S in the cup body 2 extends toward the inner upper side from the cup peripheral bottom section A.

[0045] More specifically, the slant section S of the cup body 2 refers to a curved line part and a straight line part interposed between the lowest part of the cup body 2 in a Z-axis direction and a boundary (end part Se) with the cup dome section D, as depicted in FIG. 5.

[0046] Note that the shape of the cup dome section D is an example, and a top of the dome may be formed into, for example, a horizontal surface shape instead of a curved surface shape.

[0047] While the slant section S may be vertical as depicted in (c) of FIG. 5, but it is preferably inclined at a predetermined angle θ_1. Specifically, the angle θ_1 formed between the slant section S and the Z axis is preferably 5° to 30°, and is more preferably 10° to 30° since spray coating is easy to conduct in the case of forming a coating film on an inner surface by a spray coating method after the first forming step is carried out.

[0048] In addition, a radius of curvature R (see (c) of FIG. 5) in an angle θ_2 formed from the cup peripheral bottom section A to the slant section S may be a single radius of curvature, or may be a curved line in which a plurality of different radii of curvature are connected. For example, in the case of a single radius of curvature R, when the plate thickness of the blank sheet (blank) is t0, it is more preferable that R = 5 $\times$ t0 to 15 $\times$ t0, since spray coating is easy to conduct in the case of forming a coating film on the inner surface by the spray coating method after the first forming step is carried out.

[0049] Further, the first height Ho of the cup dome section D in the cup body 2 is preferably greater than a height Hp of the raised bottom section 30 in the seamless can body 1 to be obtained by the second forming step which will be described later. The reason is to apply a compressive stress to the slant section S while the cup dome section D of the cup body 2 is pressed down in the second forming step described later. In other words, the reason is to eventually obtain the preferable height Hp of the raised bottom section 30 in the seamless can body 1 by preliminarily setting large the first height Ho of the cup dome section D in the cup body 2.

[Second Forming Step]

[0050] Next, with reference to FIG. 6, the second forming step of the method for producing the seamless can body 1 in the present embodiment will be described.

[0051] After the cup body 2 having the provisional peripheral ground section 20a' and the slant section S is formed by the above-described first forming step, the second forming step described in detail below is carried out.

[0052] Specifically, in the second forming step of the method for producing the seamless can body 1 according to the present embodiment, the bulging section 4 described above is pressed down in such a manner that the bulging section 4 has the second height Hp smaller than the first height Ho, to thereby form the peripheral ground section 20b continuing from the lower end 10e of the tubular body section 10 and the raised bottom section 30 continuing from the peripheral ground section 20b toward the center-axis side.

[0053] In other words, in the second forming step, it can be said that, by pressing down the bulging section 4 relative to the cup body 2, the peripheral ground section 20b located at a position different from that of the provisional peripheral

ground section 20a' and the raised bottom section 30 having the height Hp smaller than the first height Ho are formed.

[0054] As described above, the shape of the raised bottom section 30 at this time satisfies the above-mentioned formula (1) defined by the outer surface area A_D and the area A_B of the virtual plane VP. In addition, the shape of the raised bottom section 30 at this time desirably satisfies the above-mentioned formula (2) defined by the volume V_D of the space surrounded by the virtual plane VP and the raised bottom section 30 and the volume V_M of the metallic member forming the raised bottom section.

[0055] More specifically, in the second forming step, processing is carried out on the cup body 2 by use of a die different from the molding die used in the first forming step, to form the seamless can body 1. In other words, while the cup body 2 is kept in contact with a lower molding die member, a pressure is applied to the cup dome section D of the cup body 2 in a can outside direction (-Z axis direction) by use of an upper molding die member.

[0056] Alternatively, while the cup body 2 is kept in contact with the lower molding die member and the upper molding die member, a pressure may be applied in the +Z axis direction by use of the lower molding die member.

[0057] In more detail, as illustrated in FIG. 6, the cup peripheral bottom section A of the cup body 2 is placed on a cup peripheral side holder 60. A dome pressing-down tool 70 is relatively moved downward, and a support section 701 of the dome pressing-down tool 70 makes contact with the cup dome section D. Here, the cup peripheral side holder 60 has a tapered surface 601 and a groove 602, and after the cup peripheral bottom section A of the cup body 2 makes contact with the tapered surface 601, the dome pressing-down tool 70 is further pressed down, so that the metal of the slant section S of the cup body 2 is guided into the groove 602 while receiving a compressive stress and is pressed into the groove 602.

[0058] Then, the cup dome section D is pressed down in such a manner as to reach the second height Hp smaller than the first height Ho. Simultaneously, by use of the upper molding die member (dome pressing-down tool 70) and the lower molding die member (cup peripheral side holder 60), a compressive stress σ_ϕ in a meridian direction and a compressive stress σ_θ in a peripheral direction are made to act on the slant section S.

[0059] Note that FIG. 7 is a schematic view depicting the compressive stresses applied when the slant section S is formed into a rising-up section 20d in the present embodiment. Specifically, when the slant section S is pressed into the groove 602 of the lower molding die member, the compressive stress σ_ϕ in the meridian direction caused by the pressing force of the dome pressing-down tool 70 and the compressive stress σ_θ in the peripheral direction caused by movement toward a radially inner side in order to be along the lower molding die member simultaneously act on the slant section S, so that the thickness of the metallic blank material of the slant section S is increased (directions indicated by arrows σ_ψ in FIG. 7).

[0060] In this way, the seamless can body 1 is obtained after the second forming step is carried out.

[0061] When the forming is finished, it is only required to relatively raise the dome pressing-down tool and take the seamless can body 1 out of the cup peripheral side holder 60.

[0062] Here, the seamless can body 1 obtained after the second forming step is carried out is preferably the seamless can body 1 in the present embodiment described above.

[0063] In other words, the seamless can body 1 obtained after the second forming step is carried out is the one having the peripheral bottom section 20a and the peripheral ground section 20b, as depicted in FIG. 1.

[0064] Note that it is further preferable that the second forming step have the following characteristics.

[0065] Specifically, in the second forming step, the above-described cup body 2 is pressed into the lower molding die member (cup peripheral side holder 60) of the second forming step, to thereby form the slant section S into the peripheral ground section 20b located on the inner side than the peripheral bottom section 20a, an inner end section 20c located on the inner side than the peripheral ground section 20b, and the rising-up section 20d rising upward from the inner end section 20c.

[0066] Further, in the second forming step, a ring groove of which an outermost end 20e is protuberant toward the outside with respect to the can body axis is formed in such a manner that an inside diameter at a point of connection (outermost end 20e) between the rising-up section 20d and a dome section 20f of the seamless can body 1 is greater than an inside diameter of the inner end section 20c. In other words, as depicted in the drawing, in the vicinity of the outermost end 20e, a substantial "⊂" shape or "⊃" shape is formed in a cross-sectional view.

[0067] Conventionally, there has been a reforming method (bottom reforming) for forming such a ring groove as described above by use of a rotating roll or a split-cavity mold. However, with the conventional method, the processed part is liable to be thin, and it is difficult to form a sufficiently deep groove.

[0068] By contrast, with the method according to the present embodiment, the plate thickness of the ring groove section does not become thinner but becomes thicker, and a deep groove can rationally be formed.

[0069] In the method for producing the seamless can body of the present embodiment, between the first forming step and the second forming step, the shape and length of an upper part of the cup peripheral bottom section A of the cup body 2 are not changed.

[0070] Specifically, of a surface where the cup peripheral bottom section A of the cup body 2 and the tapered surface 601 of the cup peripheral side holder 60 make contact with each other when the cup body 2 is placed on the cup peripheral

side holder 60, the lowest point in the Z-axis direction is regarded as a point T. The point T does not change in position, attendant on a downward movement of the dome pressing-down tool 70 and pressing down of the cup dome section D (see FIG. 6).

[0071] On the other hand, by the second forming step, the part which has been the slant section S of the cup body 2 is formed into a part of the peripheral bottom section 20a, the peripheral ground section 20b, the inner end section 20c, and the rising-up section 20d of the seamless can body 1 (see also FIG. 2 and the like as required). In other words, most of the slant section S of the cup body 2 eventually enters the groove 602 of the cup peripheral side holder 60.

[0072] Note that, in the second forming step, the contact between the cup body 2 and the upper and lower dies is free of conspicuous sliding. Therefore, the metallic surface of the cup body 2 is not damaged, and to begin with, it is unnecessary to use a lubricant.

[0073] In addition, as the plate thickness t0 of the blank sheet (blank), any plate thickness available when ordinary seamless can bodies are produced may be adopted, and a metallic sheet of a thickness on the order of t0 = 0.15 to 0.4 mm can be die-cut and used as a blank sheet (blank), according to the use, but this thickness is not limitative.

[Surface Coating Treatment Step]

[0074] In a case where a metallic sheet not provided with organic coating on a surface thereof is used as a blank sheet, as depicted in FIG. 4, it is preferable that the method for producing the seamless can body of the present embodiment further include an inner surface treatment step (STEP 2) for subjecting at least an inner surface of the cup body 2 to a surface coating treatment, between the first forming step and the second forming step described above. Such a surface coating treatment can include such coating as known coating used on the inner surface side of the seamless can body 1.

[0075] In addition, further on an outer surface side, organic coating films 40a and 40b (see FIG. 8) can be applied to a part ranging from the cup peripheral bottom section A to the slant section S, with the lowermost curvature part of the cup body 2 as a center, for the purpose of securing transportability and corrosion resistance after the first forming step is carried out.

[0076] In other words, in the present embodiment, since two or more forming steps including at least the first forming step and the second forming step are conducted, it is assumed that the bottom section of the seamless can body is rubbed between these forming steps and during the subsequent transportation. In view of this, for example, the organic coating film 40 described above is applied between the first forming step and the second forming step, so that the organic coating films 40a and 40b are formed on the provisional peripheral ground section 20a' and the peripheral ground section 20b, respectively (see FIG. 8).

[0077] FIG. 9 depicts one example of a coating device by which the part ranging from the cup peripheral bottom section A to the slant section S can be coated with the organic coating film 40. As depicted in the drawing, when the cup body 2 is horizontally moved by a transporting mechanism TM, coating liquid LQ (liquid to be the organic coating film 40) stored in a storage container SC can be applied to the bottom section of the cup body 2 by use of coating rollers R1 and R2. Since a rubber material having appropriate elasticity is used at a surface of the roller R2, the part ranging from the cup peripheral bottom section A to the slant section S can be securely coated with the coating liquid LQ.

[0078] Note that the above-described coating device is merely an example, and a known technique such as spray coating of the coating liquid LQ to the bottom section of the cup body 2 by use of a known robot handler or the like, for example, may be applied.

[0079] Note that, other than the surface coating treatment step described above as STEP 2, between the first forming step and the second forming step, the cup body 2 may be subjected as required to a known cleaning step, a printing step, processing for shaping into a tubular body section, or neck-in (squeezing) processing in such a range as not to make a trouble in the second forming step.

[0080] With the seamless can body 1 and the method for producing the same according to the present embodiment described above, a seamless can body having excellent pressure resistance can be realized, and requirements for both weight reduction and pressure resistance strength of the can bottom can be satisfied at a high level. Experimental Examples

[0081] Experimental Examples carried out based on the above-described technique will be described below with reference also to FIG. 10. However, the present invention is not to be limited by the following Experimental Examples in any way.

[0082] First, aluminum alloy sheets (JIS H 4000 A3104-H19 materials) having plate thicknesses of 0.200 mm, 0.205 mm, 0.215 mm, 0.225 mm, 0.240 mm, 0.245 mm, and 0.250 mm were prepared as metallic blank materials (precursors 3), and were subjected to the first forming step, the surface treatment step, and the second forming step described above, to produce drawn and ironed cans (DI cans), or seamless can bodies 1, of which the specifications of the can bottom were different as Experimental Examples 1 to 19 described later and which had an internal volume of 350 mL and a can diameter of 211D (outside diameter of ϕ66.0 mm).

[0083] The thus obtained various seamless can bodies 1 and two kinds of commercial products were subjected to measurement of outline on the outer surface side passing through the center line of the can body by use of the above-mentioned shape measuring instrument (product name: CONTOURECORD, model 1600DH, made by TOKYO SEIMITSU CO., LTD.), the shape data thus obtained was put into CAD, and various parameters such as the outer surface area A_D, the area A_B of the virtual plane the outline of which is formed by the peripheral ground section 20b, the volume V_D of the space surrounded by the virtual plane VP and the raised bottom section 30, and the volume V_M of the metallic member (in this example, aluminum alloy) forming the raised bottom section 30 were calculated.

[0084] In addition, the thus obtained seamless can bodies 1 were subjected to a pressure resistance test. The pressure resistance strength was measured by hermetically sealing the opening section of the can with a holed cap, and feeding pressurized water into the can through a pipe passed through the hole. The evaluation of pressure resistance (buckling pressure) was conducted by evaluating the seamless can body having a pressure resistance in excess of 0.686 MPa applicable to carbonated beverage as "∘" (Good) and evaluating the seamless can body having a pressure resistance of equal to or less than 0.686 MPa as "×" (Bad).

[0085] With the intention to reduce the material required for can production, attention was paid to the metal volume V_M of the raised bottom section as the amount of material used for the can bottom section. The seamless can body having the metal volume V_M of less than 615 mm^3 was evaluated as "∘," while the seamless can body having the metal volume V_M of equal to or more than 615 mm^3 was evaluated as "×."

[0086] To evaluate a disadvantage of reduction in the capacity of the container due to the volume V_D of the raised bottom section 30 becoming excessive, attention was paid to the volume V_D of the raised bottom section 30. The seamless can body having the volume V_D of less than 17,000 mm^3 (17 ml) was evaluated as "∘," while the seamless can body having the volume V_D of equal to or more than 17,000 mm^3 was evaluated as "×." Note that the capacity of the seamless can bodies 1 in Experimental Examples is assumed to be 350 ml as an example, and 17 ml corresponds to approximately 5% thereof.

[0087] A seamless can body with all the evaluation results of "pressure resistance," "material use amount," and "capacity reduction" being "o" was given a comprehensive evaluation of "∘," and a seamless can body with at least one of the evaluation results being "×" was given a comprehensive evaluation of "×."

[0088] The specifications (measured values and calculated values) of the seamless can bodies 1 of Experimental Examples 1 to 19 and the two kinds of commercial products as well as their evaluation results are together set forth in Table 1.

[0089] Experimental Example 1 is adopted as a basic specification by the forming method of the present invention. As compared to a commercial product with a can diameter of 211D (approximately 66 mm) commercialized at present, the ground diameter is substantially the same, and the blank sheet thickness is as extremely small as 0.225 mm, but the comprehensive evaluation was "∘." This indicates that Experimental Example 1 is extremely excellent in both can bottom performance and cost performance.

[0090] Experimental Examples 2 to 5 are modifications in which the height H_p of the raised bottom section 30 was increased as compared to Experimental Example 1. For these examples, the seamless can bodies were formed by preliminarily increasing also the respective first heights Ho (see (c) of FIG. 5) as required, in such a manner that an inside diameter ϕd_R of the outermost end 20e and an innermost diameter ϕd_e of the inner end section 20c depicted in FIG. 10 are not changed.

[0091] Experimental Examples 6 to 8 are modifications in which the blank sheet thickness was reduced as compared to Experimental Example 1.

[0092] Experimental Examples 9 to 11 are modifications in which the blank sheet thickness was increased as compared to Experimental Example 1.

[0093] Experimental Examples 12 to 15 are modifications in which the inside diameter ϕd_R of the outermost end 20e was reduced as compared to Experimental Example 1. For these examples, the seamless can bodies were formed by preliminarily reducing also the respective first heights Ho as required, in such a manner that the height H_p of the raised bottom section 30 and the innermost diameter ϕd_e of the inner end section 20c are not changed.

[0094] Experimental Example 16 is a modification in which the inside diameter ϕd_R of the outermost end 20e was increased as compared to Experimental Example 1. For this example, the seamless can body was formed by preliminarily increasing also the first height Ho as required, in such a manner that the height H_p of the raised bottom section 30 and the innermost diameter ϕd_e of the inner end section 20c are not changed.

[0095] Experimental Examples 17 and 18 are modifications in which a dome spherical surface radius r_P (see FIG. 10) was increased to 40 mm, which is somewhat larger, for the purpose of further increasing the inside diameter ϕd_R of the outermost end 20e as compared to Experimental Example 16. For these examples, the seamless can bodies were formed by preliminarily modifying also the respective first heights Ho as required, in such a manner that the height H_p of the raised bottom section 30 and the innermost diameter ϕd_e of the inner end section 20c are not changed.

[0096] Experimental Example 19 is a modification in which the blank sheet thickness was reduced to 0.215 mm from that in Experimental Example 4.

[0097] The two kinds of commercial products are selected from those circulated on the market at present. In the selected products, the contents include carbonic acid gas, the bottom section has undergone what is generally called reforming by a roll, and the material thickness and the weight are thought to be relatively small. The products thus selected were measured and evaluated.

[0098] In the evaluation results of the Experimental Examples and the commercial products as above, those which are given a comprehensive evaluation of "∘" had the value of (A_D/A_B) and the value of (V_D/V_M) within the respective ranges of numerical values defined in the claims of the present invention. On the other hand, those which are given a comprehensive evaluation of "×" had the value of (A_D/A_B) and the value of (V_D/V_M) outside the respective ranges of numerical values defined in the claims of the present invention.

[0099] In Experimental Examples and the like described above, the can diameter was all 66 mm, but the value of (A_D/A_B) and the value of (V_D/V_M) are both dimensionless numbers, and in regard of the evaluation of pressure resistance and cost performance, a similarity rule is established irrespective of the size of the cans. In other words, the present invention is not limited to seamless can bodies with a can diameter of 66 mm. The numerical value ranges defined by the present invention can be realized with various can diameters, and in such cases, too, effects similar to the effects described above are produced.

[Table 1]

Experimental Example	Can diameter (mm)	Blank sheet thickness t_0 (mm)	Ground diameter ϕd_B (mm)	Ground circle area A_B (mm^2)	Dome section surface area A_D (mm^2)	A_D/A_B	Raised bottom section volume V_D (mm^3)	Raised bottom section metal volume V_M (mm^3)	V_D/V_M	Inside diameter of outermost end 20e ϕd_R (mm)	Innermost diameter of inner end section 20c ϕd_e (mm)	Dome spherical surface radius r_D (mm)	First height H_0 (mm)	Raised bottom section height H_P (mm)	Evaluation			
															Pressure resistance	Material use amount	Capacity reductbn	Comprehensive evaluation
Experimental Example 1	66.00	0.225	48.00	1810	2594	1.43	13552	584	23.2	47.60	46.00	36.0	15.9	12.0	○	○	○	○
Experimental Example 2	66.00	0.225	48.00	1810	2725	1.51	15305	613	25.0	47.60	46.00	36.0	16.8	13.0	○	○	○	○
Experimental Example 3	66.00	0.225	48.00	1810	2791	1.54	16175	628	25.8	47.60	46.00	36.0	17.2	13.5	○	×	○	×
Experimental Example 4	66.00	0.225	48.00	1810	2857	1.58	17041	643	26.5	47.60	46.00	36.0	17.6	14.0	○	×	×	×
Experimental Example 5	66.00	0.225	48.00	1810	2923	1.62	17903	658	27.2	47.60	46.00	36.0	18.1	14.5	○	×	×	×
Experimental Example 6	66.00	0.215	48.00	1810	2594	1.43	13552	558	24.3	47.60	46.00	36.0	15.9	12.0	○	○	○	○
Experimental Example 7	66.00	0.205	48.00	1810	2594	1.43	13552	532	25.5	47.60	46.00	36.0	15.9	12.0	○	○	○	○
Experimental Example 8	66.00	0.200	48.00	1810	2594	1.43	13552	519	26.1	47.60	46.00	36.0	15.9	12.0	×	○	○	×

(continued)

Experimental Example	Can diameter (mm)	Blank sheet thickness t_0 (mm)	Ground diameter ϕd_B (mm)	Ground circle area A_B (mm^2)	Dome section surface area A_D (mm^2)	A_D/A_B	Raised bottom section volume V_D (mm^3)	Raised bottom section metal volume V_M (mm^3)	V_D/V_M	Inside diameter of outermost end 20e ϕd_R (mm)	Innermost diameter of inner end section 20c ϕd_e (mm)	Dome spherical surface radius r_D (mm)	First height H_0 (mm)	Raised bottom section height H_P (mm)	Evaluation			
															Pressure resistance	Material use amount	Capacity reductbn	Comprehensive evaluation
Experimental Example 9	66.00	0.240	48.00	1810	2594	1.43	13552	623	21.8	47.60	46.00	36.0	15.9	12.0	○	×	○	×
Experimental Example 10	66.00	0.245	48.00	1810	2594	1.43	13552	636	21.3	47.60	46.00	36.0	15.9	12.0	○	×	○	×
Experimental Example 11	66.00	0.250	48.00	1810	2594	1.43	13552	649	20.9	47.60	46.00	36.0	15.9	12.0	○	×	○	×
Experimental Example 12	66.00	0.225	48.00	1810	2542	1.40	13492	572	23.6	47.00	46.00	36.0	15.6	12.0	○	○	○	○
Experimental Example 13	66.00	0.225	48.00	1810	2534	1.40	13479	570	23.6	46.90	46.00	36.0	15.5	12.0	○	○	○	○
Experimental Example 14	66.00	0.225	48.00	1810	2526	1.40	13466	568	23.7	46.80	46.00	36.0	15.4	12.0	○	○	○	○
Experimental Example 15	66.00	0.225	48.00	1810	2518	1.39	13451	567	23.7	46.70	46.00	36.0	15.3	12.0	×	○	○	×
Experimental Example 16	66.00	0.225	48.00	1810	2633	1.46	13582	592	22.9	48.00	46.00	36.0	16.2	12.0	○	○	○	○

(continued)

Experimental Example	Can diameter (mm)	Blank sheetthickness t_0 (mm)	Ground diameter ϕd_B (mm)	Ground circle area A_B (mm^2)	Dome section surface area A_D (mm^2)	A_D/A_B	Raised bottom section volume V_D (mm^3)	Raised bottom section metal volume V_M (mm^3)	V_D/V_M	Inside diameter of outermost end 20e ϕd_R (mm)	Innermost diameter of inner end section 20c ϕd_e (mm)	Dome spherical surface radius r_D (mm)	First height H_0 (mm)	Raised bottom section height H_P (mm)	Evaluation			
															Pressure resistance	Material use amount	Capacity reductbn	Comprehensive evaluation
Experimental Example 17	66.00	0.225	48.00	1810	2716	1.50	14470	611	23.7	48.00	46.00	40.0	15.9	12.0	○	○	○	○
Experimental Example 18	66.00	0.225	48.00	1810	2823	1.56	14612	635	23.0	49.00	46.00	40.0	16.6	12.0	○	×	○	×
Experimental Example 19	66.00	0.215	48.00	1810	2857	1.58	17041	614	27.7	47.60	46.00	36.0	17.6	14.0	○	○	×	×
Commercial Product 1	66.00	0.245	48.40	1840	2533	1.38	12590	621	20.3	47.20	46.53	51.0	-	10.1	○	×	○	×
Commercial Product 2	66.00	0.260	48.23	1827	2475	1.35	12095	643	18.8	47.03	46.21	51.0	-	9.9	○	×	○	×

[0100] The embodiment described above is an example embodying the gist of the present invention and can be modified as required in such a range as not to depart from the gist of the present invention. Further, known structures may be added to the seamless can body depicted in the embodiment in such a range as not to depart from the gist of the present invention.

[Industrial Applicability]

[0101] The present invention is applicable to containers required to have excellent pressure resistance and can be used particularly for can bodies capable of storing liquid such as beverages or medicines.

[Reference Signs List]

[0102]

1: Seamless can body
2: Cup body
3: Precursor
4: Bulging section
10: Tubular body section
20: Can bottom section
60: Lower molding die member (cup peripheral side holder)
70: Upper molding die member (dome pressing-down tool)
D: Cup dome section
S: Slant section
Hp: Height of raised bottom section 30 (second height)
Ho: Height of bulging section 4 (first height)

Claims

1. A seamless can comprising:

a tubular body section;
a peripheral ground section continuing from a lower end of the tubular body section; and
a raised bottom section continuing from the peripheral ground section toward a center-axis side,
wherein, when an outer surface area of the raised bottom section is denoted by A_D and an area of a virtual plane an outline of which is formed by the peripheral ground section is denoted by A_B, a relation of

$$1.55 \geq (A_D/A_B) \geq 1.40$$

is satisfied.

2. The seamless can according to claim 1, wherein, when a volume of a space surrounded by the virtual plane and the raised bottom section is denoted by V_D and a volume of a metallic member forming the raised bottom section is denoted by V_M, a relation of

$$26.0 \geq (V_D/V_M) \geq 22.0$$

is satisfied.

3. A method for producing a seamless can body, the method comprising:

a first forming step of forming a metallic blank material into a cup body having a tubular body section, a peripheral bottom section continuing from a lower end of the tubular body section, and a bulging section bulging from the peripheral bottom section toward an opening section by a first height; and
a second forming step of pressing down the bulging section in such a manner that the bulging section has a

second height smaller than the first height, to thereby form a peripheral ground section continuing from the lower end of the tubular body section and a raised bottom section continuing from the peripheral ground section toward a center-axis side,

wherein, when an outer surface area of the raised bottom section is denoted by A_D and an area of a virtual plane an outline of which is formed by the peripheral ground section is denoted by A_B, a relation of

$$1.55 \geq (A_D/A_B) \geq 1.40$$

is satisfied.

FIG. 1

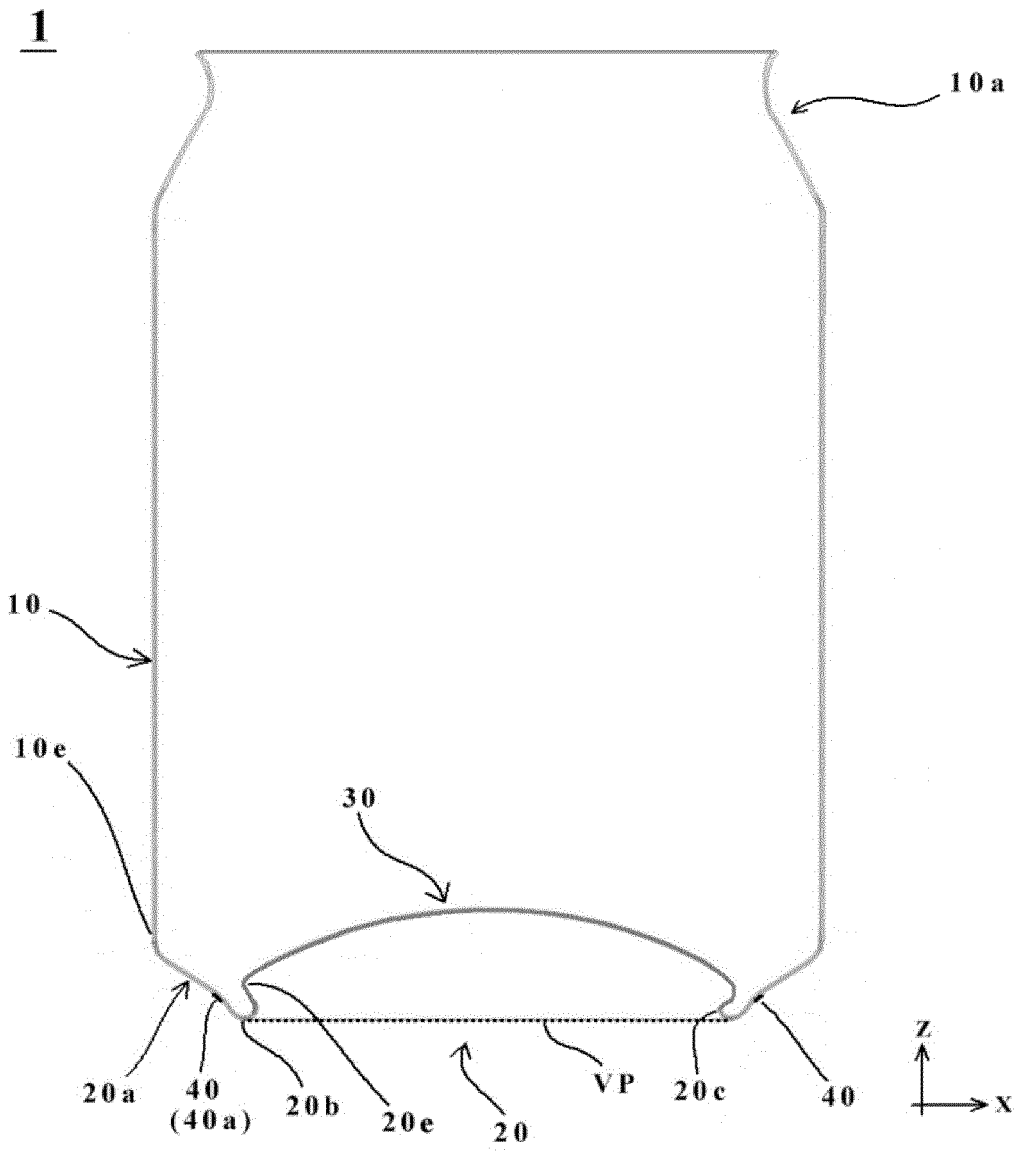


FIG. 2

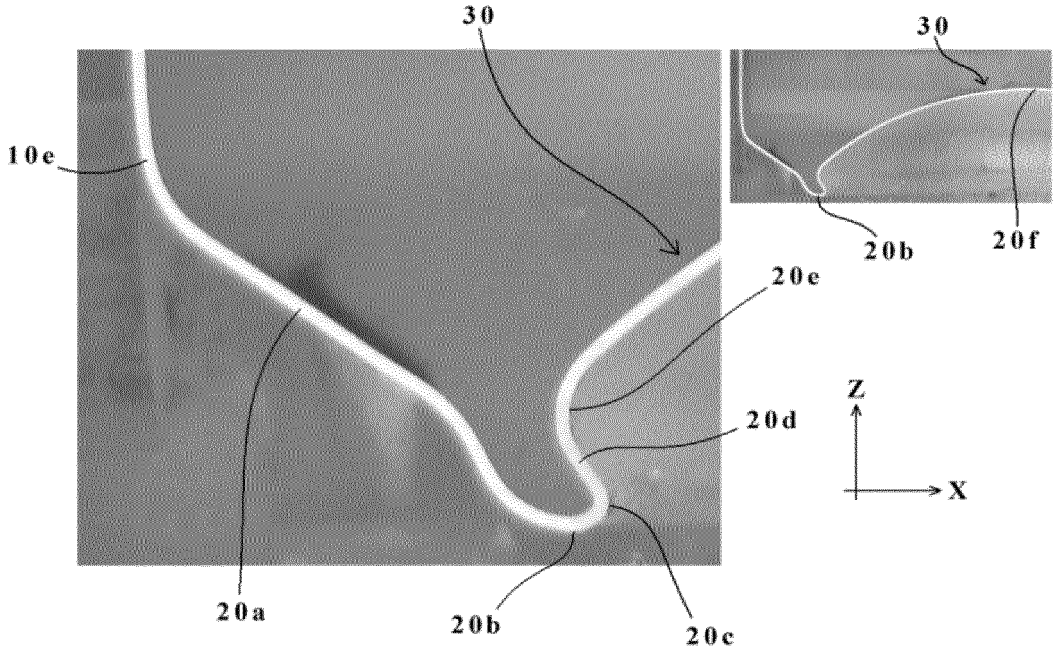


FIG. 3

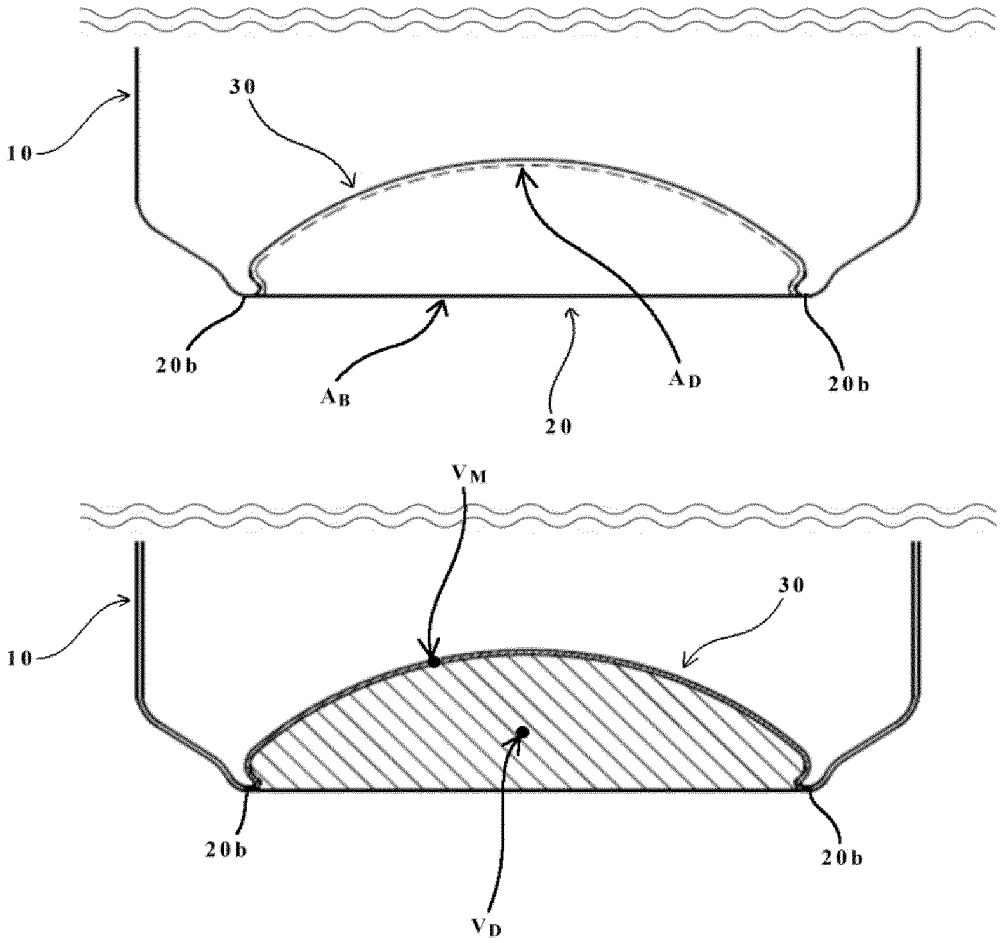
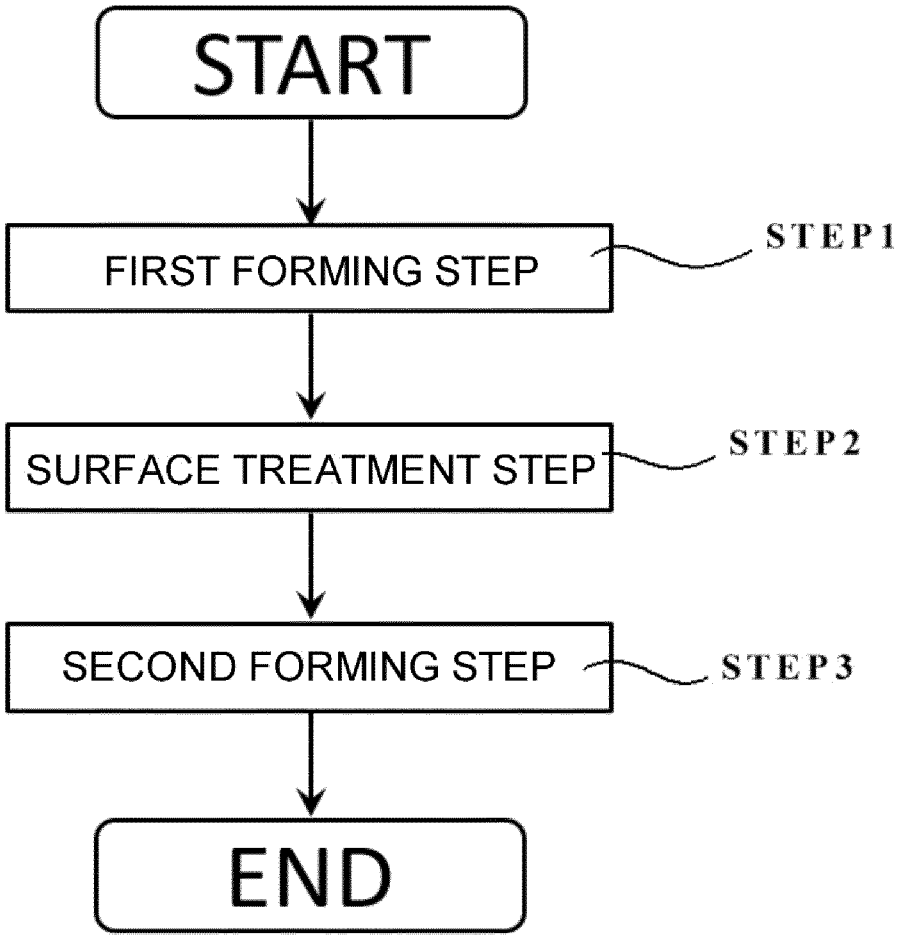


FIG. 4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STEP1
SURFACE TREATMENT STEP
STEP2
SECOND FORMING STEP
STEP3
END

FIG. 5

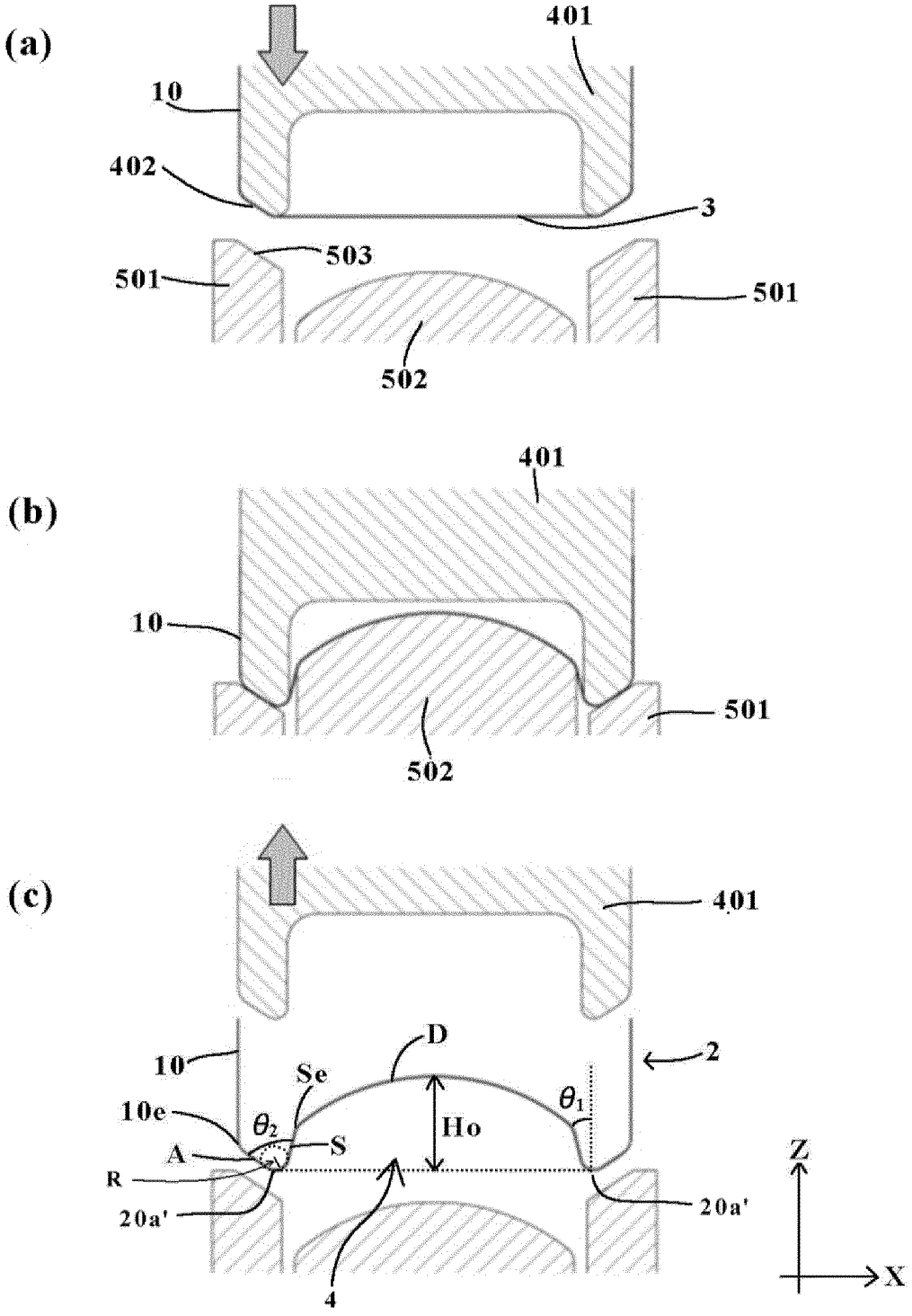
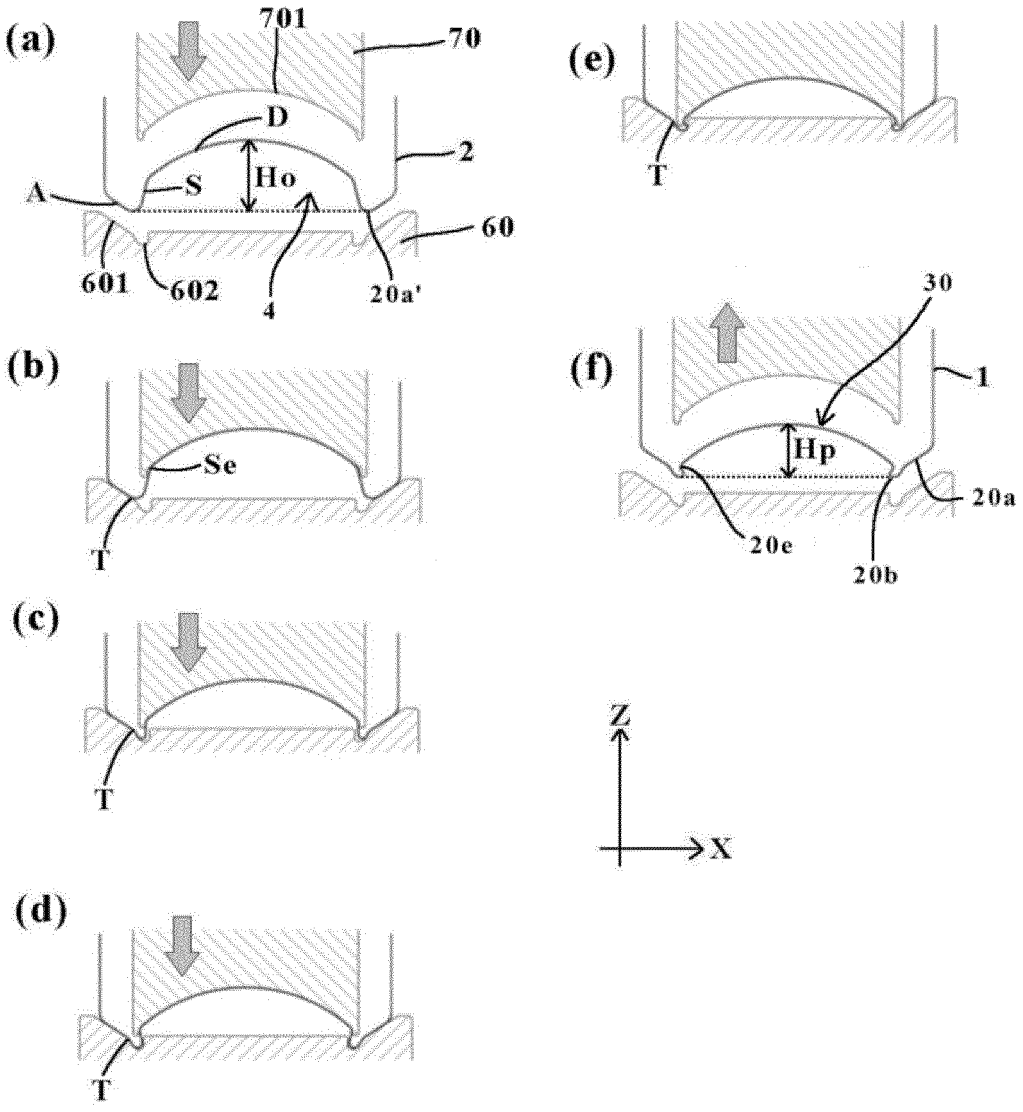

(a)
401
10
402
3
503
501
501
502
(b)
401
10
501
502
(c)
401
10
D
2
Se
10e
θ2
Ho
θ1
A
S
R
20a'
20a'
4
Z
X

FIG. 6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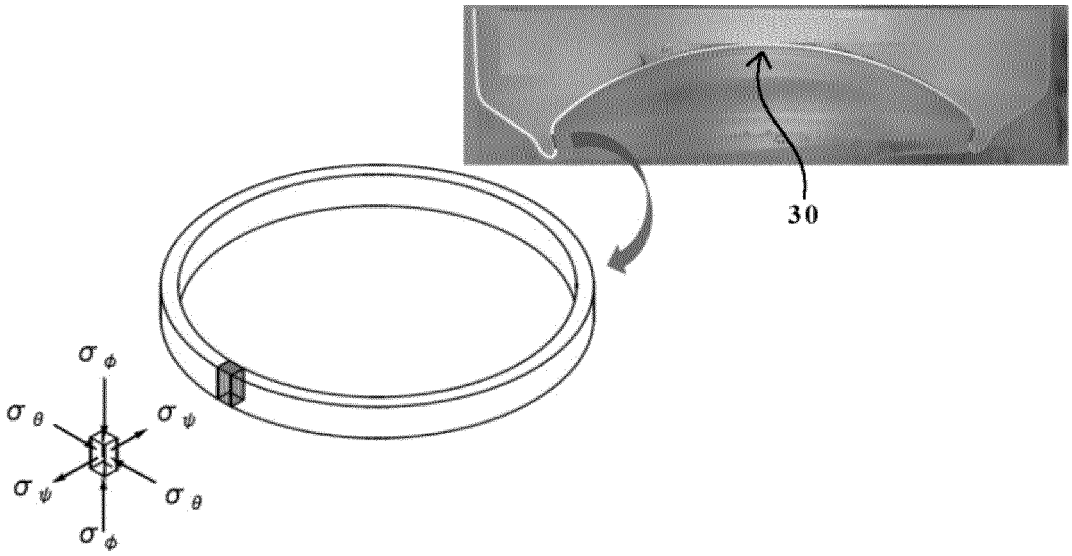
D
2
A
S
Ho
60
601
602
4
20a'
(b)
Se
T
(c)
T
(d)
T
(e)
T
(f)
30
1
Hp
20a
20e
20b
Z
X

FIG. 7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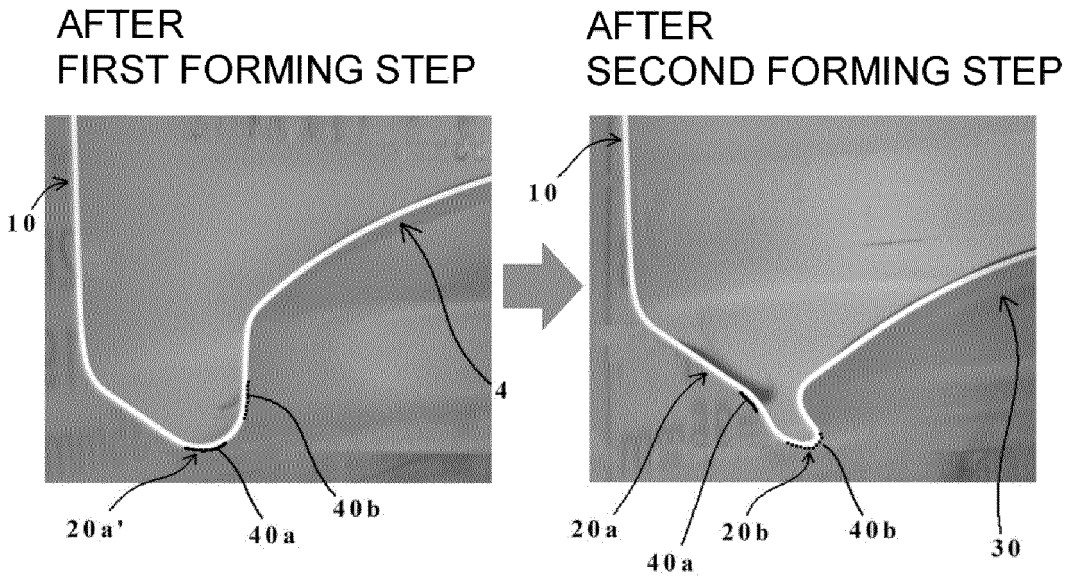
σ_ψ
σ_ψ
σ_θ
σ_ϕ

FIG. 8


AFTER
FIRST FORMING STEP
AFTER
SECOND FORMING STEP
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4
20a'
40a
40b
10
20a
40a
20b
40b
30

FIG. 9

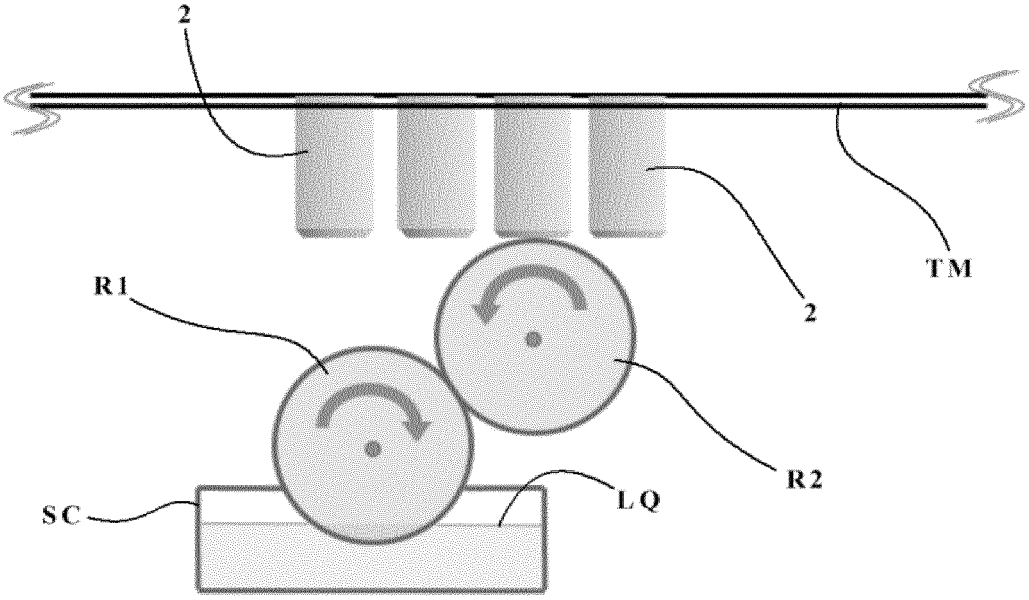
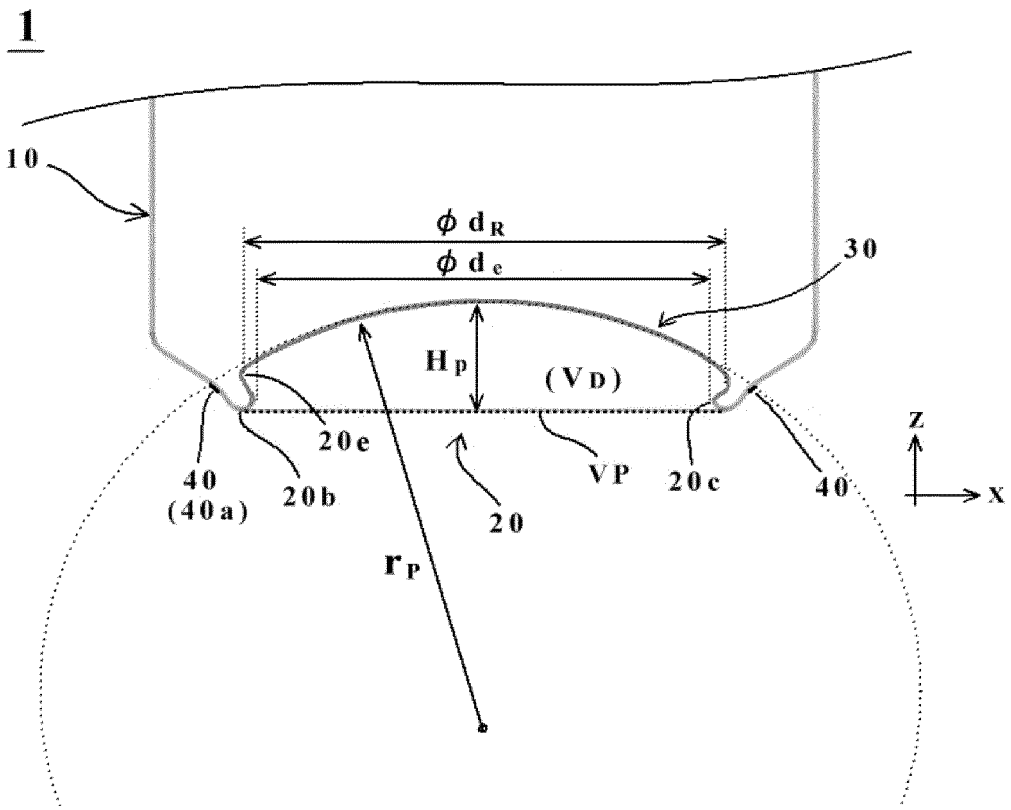


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/003842

A. CLASSIFICATION OF SUBJECT MATTER
B21D 51/26(2006.01)i; B21D 22/28(2006.01)i; B65D 1/16(2006.01)i
FI: B21D51/26 R; B21D51/26 X; B21D22/28 L; B65D1/16 111
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)
B21D51/26; B21D22/28; B65D1/16

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 9-285832 A (KISHIMOTO, Akira) 04 November 1997 (1997-11-04) paragraphs [0014]-[0112], fig. 1-18	1-3
X	JP 11-123481 A (KISHIMOTO, Akira) 11 May 1999 (1999-05-11) paragraphs [0083]-[0102], fig. 1-11	1
A	JP 2018-104095 A (UNIVERSAL CAN CORPORATION) 05 July 2018 (2018-07-05) entire text, all drawings	1-3
A	JP 2018-103227 A (UNIVERSAL CAN CORPORATION) 05 July 2018 (2018-07-05) entire text, all drawings	1-3
A	JP 2016-47541 A (UNIVERSAL CAN CORPORATION) 07 April 2016 (2016-04-07) entire text, all drawings	1-3

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 May 2021 (06.05.2021)	18 May 2021 (18.05.2021)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/003842

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 9-285832 A	04 Nov. 1997	(Family: none)	
JP 11-123481 A	11 May 1999	(Family: none)	
JP 2018-104095 A	05 Jul. 2018	(Family: none)	
JP 2018-103227 A	05 Jul. 2018	(Family: none)	
JP 2016-47541 A	07 Apr. 2016	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2018103227 A **[0004]**
- JP 2016047541 A **[0004]**
- JP HEI9285832 A **[0037]**