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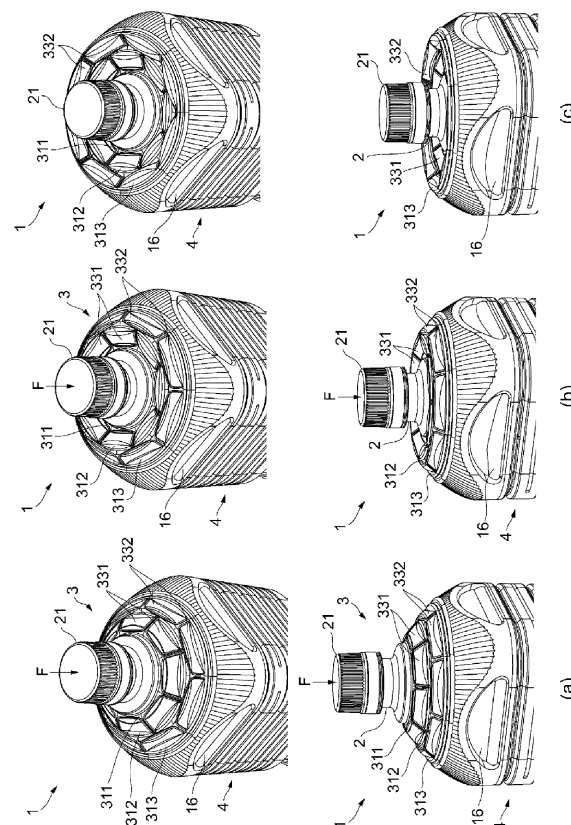
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(54) **PLASTIC BOTTLE**

(57) Provided is a plastic bottle that can be depressed and restored without damaging the bottle shoulder portion even with thin plastic bottles and that can effectively handle top loads. A shoulder portion (3) has, in order from the top, a first circumferential rib (311), a second circumferential rib (312), and a third circumferential rib (313), each being annular, on the same axis as an opening (2) and is configured so that a plastic bottle (1) transitions to a depressed state in which the bottle is depressed down by deformation that starts at the first circumferential rib (311), the second circumferential rib (312), and the third circumferential rib (313) when a top load (F) is acting on the bottle and so that the depressed state can be maintained even after the top load (F) is removed.

[Fig. 5]



Description

Technical Field

[0001] The present invention relates to a plastic bottle.

Prior Art

[0002] Plastic bottles (also referred to below simply as "bottles") are widely used as bottles for beverages and must be lightweight. The wall thickness of bottles is generally reduced as a method for reducing the weight thereof, but a reduction in wall thickness leads to a reduction in strength of the bottle at the same time. When a bottle is designed, it is therefore necessary to achieve a balance between conflicting elements, namely reducing weight and maintaining strength.

[0003] In particular, bottles filled with contents such as a beverage must be able to withstand a large top load (longitudinal compressive load). That is to say, when bottles are transported and stored, they are held in cardboard boxes in units of several bottles to several tens of bottles while filled with contents, and are bundled using a shrink pack or binding bands or the like and stacked on pallets, so the bottles at the lower levels must be able to withstand a large top load.

[0004] Efforts are therefore being made to achieve a balance between reducing weight and maintaining strength through the design of the bottle shape. Specifically, investigations are progressing in an attempt to maintain a normal bottle shape even when a top load is applied, by forming annular recessed ribs on a bottle body portion in order to enhance the strength thereof (see Patent Document 1).

Prior Art Document

Patent Document

[0005] Patent Document 1: JP 2011-116427 A

Summary of the Invention

Problem to be Solved by the Invention

[0006] There has recently been increased awareness of saving resources, among other things, and this has led to a further need for thinner walls of plastic bottles. Methods for enhancing strength through the design of the bottle shape and for resisting top load while maintaining the normal bottle shape, as in the prior art, have encountered difficulties in responding to the need for thinner walls.

[0007] The inventor of this application therefore attempted to solve this problem through an entirely different approach from that of the prior art. That is to say, rather than maintaining a normal bottle shape, the inventor of this application considered attempting to resist top load

by crushing a bottle filled with contents by a predetermined amount in the longitudinal direction in advance.

[0008] To be more specific, a relatively small top load is first of all applied to the bottle before storage in a cardboard box, for example, and a bottle shoulder portion is deformed in such a way as to collapse inside a bottle body portion. While in this collapsed state, the bottle is stored inside a cardboard box to be transported or stored. The bottle stored in this way in the cardboard box is removed from the cardboard box at the destination retail outlet or the like, after which the bottle shoulder portion which had been collapsed until that point is pulled out from inside the bottle body portion whereby the normal bottle shape can be restored. That is to say, the bottle is deformed (collapsed) in advance for transportation and storage in such a way as to be able to withstand the top load when cardboard boxes are stacked, and after transportation the normal bottle shape is restored so that the bottle can be placed in a storefront in the conventional manner and supplied as a beverage.

[0009] However, the inventor of this application discovered a new problem in this case. That is to say, when a top load is applied to a bottle before storage in a cardboard box, a large amount of localized collapse is produced at the bottle shoulder portion and a phenomenon was observed whereby uniform collapse does not occur over the whole of the bottle shoulder portion. As a result, the bottle mouth portion above the bottle shoulder portion is inclined and becomes unable to withstand the top load when cardboard boxes are stacked, with stress being concentrated on part of the bottle shoulder portion and leading to damage, among other things, which is a problem in that the commercial value is considerably impaired.

[0010] The present invention has been devised against this background and the aim thereof lies in providing a plastic bottle which can be collapsed and restored without causing damage to the bottle shoulder portion, even if the plastic bottle has thin walls, while also being able to effectively deal with a top load.

Means for Solving the Problem

[0011] In order to achieve the abovementioned aim, a plastic bottle according to the present invention comprises a bottle mouth portion forming a contents pouring opening, a bottle body portion, and a bottle shoulder portion expanding downward in such a way as to join the bottle mouth portion and the bottle body portion, wherein the bottle shoulder portion comprises a first circumferential rib, a second circumferential rib and a third circumferential rib, which are all annular, in succession from an upper side and coaxial with the bottle mouth portion, and when a top load acts on the plastic bottle, deformation is produced starting from the first circumferential rib, the second circumferential rib and the third circumferential rib, transitioning to a state of downward collapse, and after the top load has been released, the collapsed state

can be maintained.

[0012] According to the present invention, a top load is made to act on the plastic bottle before it is stored in a cardboard box, for example, and as a result a compressive load is made act on the bottle shoulder portion to enable deformation of the bottle shoulder portion starting from the first circumferential rib, second circumferential rib and third circumferential rib, transitioning to a state of collapse. In this case, the first circumferential rib, second circumferential rib and third circumferential rib are all annular and coaxial with the bottle mouth portion so the bottle shoulder portion deforms in such a way as to collapse uniformly about the bottle mouth portion. It is therefore possible for the bottle shoulder portion to buckle and transition to a state of collapse under a compressive load without inclination of the bottle mouth portion, and stress produced in the bottle shoulder portion during this transition is diffused across the first circumferential rib, second circumferential rib and third circumferential rib so it is possible to limit localized stress concentration and damage caused thereby.

[0013] Furthermore, when a further top load is exerted on the plastic bottle that has transitioned to a collapsed state, a reversal occurs in that a tensile load acts on the bottle shoulder portion that has collapsed inside the bottle body portion. The plastic bottle can therefore maintain a stable shape while still withstanding a large top load when cardboard boxes are stacked, for example.

[0014] According to a preferred embodiment of the present invention, at least one of the first circumferential rib, the second circumferential rib and the third circumferential rib should exhibit an annular shape as a result of a plurality of linear ridge lines being placed in series.

[0015] By virtue of this configuration, the bottle shoulder portion, when subjected to a top load before being stored in a cardboard box, for example, is able to deform in such a way as to fold along the linear ridge lines. It is therefore possible to more reliably prevent inclination of the bottle mouth portion in comparison with when the ridge lines are curved, thus enabling a transition to a collapsed state able to withstand a top load when the cardboard boxes are stacked, for example.

[0016] Preferably, the bottle shoulder portion should comprise a first radial rib between the first circumferential rib and the second circumferential rib, said first radial rib extending radially from the bottle mouth portion side toward the bottle body portion side, and should comprise a second radial rib between the second circumferential rib and the third circumferential rib, said second radial rib extending radially from the bottle mouth portion side toward the bottle body portion side.

[0017] By virtue of this configuration, the bottle shoulder portion is able to deform in such a way as to fold along the first radial rib and the second radial rib, and it is possible to more reliably prevent inclination of the bottle mouth portion, thus enabling the plastic bottle to transition to a collapsed state.

[0018] Preferably, the first radial rib and the second

radial rib should be disposed with an offset in the circumferential direction about the bottle mouth portion, as seen from the upper surface.

[0019] By virtue of this configuration, when the plastic bottle transitions to the collapsed state, transmission of stress produced in the first radial rib and the second radial rib is limited so it is possible to more reliably limit stress concentration and damage to the bottle shoulder portion.

[0020] Preferably, the bottle body portion should comprise a compression absorbing surface which deforms in such a way as to expand as the bottle shoulder portion transitions to the collapsed state.

[0021] By virtue of this configuration, when deformation occurs as the plastic bottle transitions to the collapsed state, a pressure increase inside the plastic bottle can be absorbed by expansion of the compression absorbing surface. This means that when a top load is exerted before the plastic bottle is stored in a cardboard box, for example, a reaction force produced by the increased internal pressure (a force acting on the bottle mouth portion from inside the plastic bottle) can be lessened, inclination of the bottle mouth portion can be prevented as the bottle shoulder portion collapses stably, and a transition to the collapsed state able to withstand a top load when cardboard boxes are stacked is possible.

Brief Description of the Drawings

[0022]

[Fig. 1] is an oblique view of a plastic bottle according to a first mode of embodiment;

[Fig. 2] is a front surface view of the plastic bottle in fig. 1;

[Fig. 3] is an upper surface view of the plastic bottle in fig. 1;

[Fig. 4] fig. 4(a) is an enlargement around the shoulder portion of the plastic bottle in fig. 1, and fig. 4(b) is a half end surface view cut along the line X-X in fig. 4(a);

[Fig. 5] fig. 5(a) is an enlarged oblique view seen from the upper surface side and the front surface side, respectively, in a state before deformation of the plastic bottle in fig. 1, fig. 5(b) is an enlarged oblique view seen from the upper surface side and the front surface side, respectively, in a state during deformation of the plastic bottle in fig. 1, and fig. 5(c) is an enlarged oblique view seen from the upper surface side and the front surface side, respectively, in a state after deformation of the plastic bottle in fig. 1;

[Fig. 6] fig. 6(a) is an enlarged oblique view of the state of initial deformation of the plastic bottle in fig. 1, fig. 6(b) is an enlarged oblique view of a state in which deformation of the plastic bottle in fig. 1 has further progressed, and fig. 6(c) is an enlarged oblique view of a state after deformation of the plastic bottle in fig. 1;

[Fig. 7] is an enlarged oblique view around the shoulder

der portion of a plastic bottle according to a second mode of embodiment;

[Fig. 8] is an upper surface view of the plastic bottle in fig. 7;

[Fig. 9] fig. 9(a) is an enlargement around the shoulder portion of the plastic bottle in fig. 7, and fig. 9(b) is a half end surface view cut along the line Y-Y in fig. 9(a);

[Fig. 10] is an enlarged oblique view around the shoulder portion of a plastic bottle according to a third mode of embodiment;

[Fig. 11] is an upper surface view of the plastic bottle in fig. 10;

[Fig. 12] fig. 12(a) is an enlargement around the shoulder portion of the plastic bottle in fig. 10, and fig. 12(b) is a half end surface view cut along the line Z-Z in fig. 12(a);

[Fig. 13] fig. 13(a) is an oblique view of a plastic bottle according to a fourth mode of embodiment, and fig. 13(b) is an enlarged oblique view around the shoulder portion of the plastic bottle in fig. 13(a); and

[Fig. 14] fig. 14(a) is an oblique view of a plastic bottle according to a fifth mode of embodiment, and fig. 14(b) is an enlarged oblique view around the shoulder portion of the plastic bottle in fig. 14(a).

Mode of Embodiment of the Invention

[0023] Plastic bottles according to preferred modes of embodiment of the present invention will be described with reference to the appended drawings.

[0024] In the following description, the side where the mouth portion of the bottle is present refers to the upper side, and the side where the bottom portion of the bottle is present refers to the lower side. The transverse sectional shape means the cross-sectional shape on a plane intersecting the center axis of the bottle.

(First Mode of Embodiment)

[0025] As shown in fig. 1-4, a plastic bottle 1 (referred to below as "the bottle 1") comprises, in succession from the upper side, a mouth portion 2, a shoulder portion 3, a body portion 4 and a bottom portion 5. These sections (2, 3, 4 and 5) are formed as a single piece and form a bottle wall shaped like a bottomed cylinder for internally holding a beverage. Beverages suitable for storage include uncarbonated beverages such as water, green tea, brown tea, blended tea, sports drinks and fruit juices. Furthermore, the bottle 1 is suitable for use as a large-sized bottle having a capacity in excess of 1 liter; here a 2-liter bottle is being used as an example, but the present invention is not limited thereby and may equally be applied to a bottle having a capacity of less than 1 liter.

[0026] The bottle 1 is molded by means of a stretch molding process such as biaxial stretch-blow molding, using a thermoplastic resin such as polyethylene, polypropylene or polyethylene terephthalate as a main ma-

terial, for example.

[0027] An example of the process for producing bottle 1 will be described. The thermoplastic resin is first of all injected into a die in order to injection-mold a preform.

5 The preform comprises a mouth portion having the same shape as the mouth portion 2, and a cylindrical portion with a base joined to the lower side thereof. After the injection molding, the preform is set in a blow-molding apparatus in order to heat the cylindrical portion of the preform. The cylindrical portion is then stretched in the longitudinal direction by means of a stretching rod, while compressed air is blown in so as to stretch the cylindrical portion in the transverse direction. Part of the stretched cylindrical portion is pressed against the inner surface of the die and then hardened. As a result, the shoulder portion 3, body portion 4 and bottom portion 5 are formed and the series of processes for molding the bottle 1 is completed.

[0028] As shown in fig. 4, the mouth portion 2 has an open upper end that functions as a beverage pouring opening. The opening of the mouth portion 2 is opened and closed by attachment/detachment of a cap 21. The shoulder portion 3 gradually increases in size in the downward transverse section thereof. That is to say, the shoulder portion 3 increases in size downwardly in such a way that the minimum-diameter mouth portion 2 of the bottle 1 is joined to an upper end of the body portion 4 forming the maximum width of said bottle 1. Furthermore, a ridge line joining the shoulder portion 3 and the upper end of the body portion 4 is curved substantially in the shape of sine wave extending in a repeated circumferential alternation of a crest portion 12 and a trough portion 14. Specifically, the tip of the crest portion 12 is located directly in the center of one side of a square shape while the tip of the trough portion 14 is located at corners of the square shape, correspondingly with the transverse sectional shape of the square of the body portion 4.

[0029] The body portion 4 is a rectangular cylindrical portion having a basically square transverse sectional shape. Specifically, as shown in fig. 3, the transverse sectional shape of the square of the body portion 4 comprises four corner portions 31 of the square shape and has linear portions 33 between adjacent corner portions 31, 31. Furthermore, as shown in fig. 1 and fig. 2, the body portion 4 comprises, midway along in the vertical direction, a constricted portion 40 and an indented portion 80 for finger insertion. As shown in fig. 2, if the body portion 4 is divided into three vertical areas then said body portion comprises the constricted portion 40, an upper-side body portion 42 above the constricted portion 40, and a lower-side body portion 44 below the constricted portion 40. The upper-side body portion 42 and lower-side body portion 44 are portions having a constant square transverse sectional shape in the vertical direction. A plurality of continuous grooves 50 and a plurality of intermittent grooves 52 are alternately formed on the upper-side body portion 42 and the lower-side body portion 44 in the vertical direction in such a way as to extend

in the circumferential direction. Furthermore, as shown in fig. 4, a compression absorbing surface 16 provided as an inward recess into the bottle 1 is formed on an upper side surface of the upper-side body portion 42. There is no particular limitation as to the shapes of the mouth portion 2, body portion 4 or bottom portion 5, and said shapes may be set as appropriate.

[0030] The shoulder portion 3 comprises a plurality of first blocks 331 disposed in an annular form around the mouth portion 2, and a plurality of second blocks 332 disposed in an annular form at the outer circumference of said plurality of first blocks 331. The first blocks 331 and the second blocks 332 are formed as protrusions of the preform that protrude from inside the bottle 1 toward the outside thereof, exhibiting a substantially quadrilateral shape as seen from the upper surface thereof. The first blocks 331 and second blocks 332 are thus disposed in an annular form, whereby a first circumferential rib 311 which is an annular groove surrounding the periphery of the mouth portion 2 is formed between the mouth portion 2 and the first blocks 331, and a second circumferential rib 312 which is an annular groove surrounding the first circumferential rib 311 is also formed between the first blocks 331 and the second blocks 332. A third circumferential rib 313 which is an annular groove surrounding the outer circumference of the second circumferential rib 312 is further formed on the outer circumferential side of the second blocks 332. It should be noted that the first circumferential rib 311, second circumferential rib 312 and third circumferential rib 313 may also be apparent as stepped portions or curved portions formed on the shoulder portion 3 exhibiting a substantially circular truncated-cone shape.

[0031] The first blocks 331 comprise end portions 331a-331c which are substantially linear. Furthermore, the second blocks 332 also comprise end portions 332a-332c which are substantially linear. The first circumferential rib 311, second circumferential rib 312 and third circumferential rib 313 formed at the end portions of the first blocks 331 and second blocks 332 therefore exhibit an annular shape as a result of a plurality of grooves comprising linear ridge lines tangential to a circle centered on the mouth portion 2, as seen from the upper surface, being placed in series.

[0032] Furthermore, the plurality of first blocks 331 are disposed in an annular form at predetermined intervals, so first radial ribs 321 are formed between end portions 331b, 331b of adjacent first blocks 331, 331. Second radial ribs 322 are likewise formed between end portions 332b, 332b of adjacent second blocks 332. The first radial ribs 321 and the second radial ribs 322 both form grooves extending radially from the mouth portion 2 side toward the body portion 4 side. Furthermore, as shown in fig. 3, the first radial ribs 321 and the second radial ribs 322 are disposed in such a way as to be offset by an angle θ in the circumferential direction about the mouth portion 2, as seen from the upper surface.

[0033] Deformation (collapse) of the bottle 1 according

to the abovementioned mode of embodiment will be described.

[0034] As shown in fig. 5, when a top load (longitudinal compressive load) is exerted in the direction shown by the arrow F (vertically downward direction) on the upper surface of the cap 21 attached to the mouth portion 2, the force thereof is transmitted to the shoulder portion 3 via the mouth portion 2. As indicated above, the first circumferential rib 311, second circumferential rib 312 and third circumferential rib 313 are formed on the shoulder portion 3 coaxially with the mouth portion 2, so stress concentration is produced at the location thereof where the cross-sectional shape of the bottle 1 changes.

[0035] As a result of this stress concentration, a compressive load is exerted on the plurality of first blocks 331 formed between the first circumferential rib 311 and the second circumferential rib 312, and on the plurality of second blocks 332 formed between the second circumferential rib 312 and the third circumferential rib 313. Bending is produced in the first blocks 331 and the second blocks 332 because of this compressive load, and the shape thereof becomes unstable. As a result, when buckling occurs first of all in the first blocks 331, as shown in fig. 5(b), deformation is produced starting from the first circumferential rib 311 and the second circumferential rib 312, and the plurality of first blocks 331 fold downward along the second circumferential rib 312 and collapse downward. The adjacent first blocks 331, 331 which have folded downward are also folded to the mouth portion 2 side starting from the first radial ribs 321 formed therebetween, in such a way as to move closer together.

[0036] The pressure inside the bottle 1 increases as a result of the shoulder portion 3 collapsing into the bottle. This pressure increase causes the compression absorbing surface 16 to expand outward. The increase in internal pressure of the bottle 1 is absorbed as a result.

[0037] When a top load still continues to be exerted after the deformation as shown in fig. 5(b), a tensile load acts on the plurality of first blocks 331 which have folded downward, between the first circumferential rib 311 and the second circumferential rib 312. Meanwhile, a compressive load then acts on the plurality of second blocks 332, between the second circumferential rib 312 and the third circumferential rib 313. When bending is produced in the second blocks 332 as a result of this compressive load, thereby leading to buckling thereof, deformation is produced starting from the second circumferential rib 312 and the third circumferential rib 313, as shown in fig. 5(c), and the plurality of second blocks 332 fold downward along the third circumferential rib 313 and collapse downward. The adjacent second blocks 332, 332 which have folded downward are also folded to the mouth portion 2 side starting from the second radial ribs 322 formed therebetween, in such a way as to move closer together.

[0038] The bottle 1 in the collapsed state shown in fig. 5(c) maintains this collapsed state even after the top load exerted thereon has been released. When a further top load acts on the bottle 1 in this kind of collapsed state, a

tensile load is produced at both the plurality of first blocks 331 and second blocks 332, so the top load can be stably resisted without buckling being produced.

[0039] The bottle 1 is transitioned from the normal state shown in fig. 5(a) to the collapsed state shown in fig. 5 (c) as a result of a top load being exerted on the bottle 1 before it is stored in a cardboard box, for example, and said bottle 1 is transported and stored while received in the collapsed state in the cardboard box. As a result, even if cardboard boxes are stacked on a pallet, the bottles 1 inside the cardboard boxes at the lower levels are able to withstand a large top load due to the reaction force with respect to the tensile load and the reaction force based on internal pressure which increases as the bottle collapses.

[0040] The first circumferential rib 311, second circumferential rib 312 and third circumferential rib 313 are all annular grooves coaxial with the mouth portion 2, and therefore when the bottle transitions to the collapsed state, the shoulder portion 3 deforms in such a way as to collapse uniformly about the mouth portion 2. That is to say, the bottle transitions to the collapsed state without the mouth portion 2 becoming inclined and it is possible to achieve a state such that a top load when the cardboard boxes are stacked can be resisted.

[0041] Furthermore, it is possible for a consumer or staff at the destination sales outlet to restore the bottle to its normal shape by pulling out the shoulder portion 3, which was collapsed until that point, from inside the body portion 4. That is to say, during transportation and storage, the bottle is deformed (collapsed) in advance so that it is able to withstand the top load when the cardboard boxes are stacked, and the normal bottle shape is restored after transportation, so that the bottle can be placed in a storefront in the conventional manner and supplied as a beverage.

[0042] Furthermore, the first circumferential rib 311, second circumferential rib 312 and third circumferential rib 313 exhibit an annular shape as a result of a plurality of grooves comprising linear ridge lines tangential to a circle centered on the mouth portion 2, as seen from the upper surface, being placed in series. The shoulder portion 3, when subjected to a top load before being stored in a cardboard box, is therefore able to deform in such a way as to fold along the linear ridge lines of the grooves. It is therefore possible to more reliably prevent inclination of the mouth portion 2 in comparison with when the ridge lines of the annular grooves are curved, thus enabling a transition to a collapsed state able to withstand a top load when the cardboard boxes are stacked.

[0043] In addition, when a top load is exerted before the bottle is stored in a cardboard box, the reaction force produced by the increased internal pressure can be lessened by virtue of the fact that the increased internal pressure in the bottle 1 is absorbed by expansion of the compression absorbing surface 16. It is therefore possible for the shoulder portion 3 to collapse stably and prevent inclination of the mouth portion 2, thus enabling a tran-

sition to the collapsed state able to withstand the top load when the cardboard boxes are stacked.

[0044] The results of a numerical analysis relating to deformation (collapse) and stress when a top load is exerted on the bottle 1 will be described next with reference to fig. 6. Here, a numerical analysis model of the bottle 1 was produced using a general-purpose program, and a structural analysis was carried out employing the finite element method in order to evaluate stress and deformation produced in the bottle 1. Although small, localized variations in the wall thickness of the bottle 1 in the numerical analysis model were reproduced in the same way as with an actual plastic bottle produced by means of injection molding. A top load was exerted on the bottle 1 while it was placed on a tabletop in order to simulate the state of collapse of the shoulder portion 3, and boundary conditions were set in the numerical analysis model of the bottle 1 in such a way that a vertically downward load was exerted on the cap 21 while the bottom portion of the bottle was also held.

[0045] As shown in fig. 6(a) to fig. 6(c), it is clear from the numerical analysis model of the bottle 1 that even when a top load is applied, the shoulder portion 3 collapses essentially without any inclination of the mouth portion 2. This is believed to be due to the fact that the shoulder portion 3 of the bottle 1 deforms in such a way as to fold along the ridge lines of the grooves, while the first radial ribs 321 and the second radial ribs 322 are also disposed with an offset in the circumferential direction so that there is no stress transmission or stress concentration along the first radial ribs 321 and the second radial ribs 322. As a result, localized deformation of the shoulder portion 3 in the model of the bottle 1 is restricted and a uniform collapse takes place while symmetry is maintained.

(Second Mode of Embodiment)

[0046] A plastic bottle 1A according to a second mode of embodiment (referred to below as "the bottle 1A") will be described next with reference to fig. 7 to fig. 9. The bottle 1A differs from the bottle 1 in terms of the shape around the shoulder portion; elements which are the same bear the same reference symbols where appropriate and will not be described again.

[0047] A first circumferential rib 311A which is an annular groove surrounding the periphery of the mouth portion 2, and a second circumferential rib 312A which is an annular groove surrounding the first circumferential rib 311A are formed on a shoulder portion 3A of the bottle 1A. A third circumferential rib 313 which is an annular groove surrounding the outer periphery of the second circumferential rib 312 is also formed. That is to say, the shoulder portion 3A comprises the first circumferential rib 311A, the second circumferential rib 312A and the third circumferential rib 313 coaxially with the mouth portion 2. It should be noted that the first circumferential rib 311A, second circumferential rib 312A and third circum-

ferential rib 313A may also be apparent as stepped portions or curved portions formed on the shoulder portion 3 exhibiting a substantially circular truncated-cone shape.

[0048] Protrusions in the form of the first blocks 331 and second blocks 332 are not formed around the mouth portion 2 on the shoulder portion 3A of the bottle 1A, as was the case with the bottle 1 described above. The first circumferential rib 311A, second circumferential rib 312A and third circumferential rib 313A therefore do not comprise linear ridge lines, rather they are formed in an annular shape centered on the mouth portion 2, as seen from the upper surface and as shown in fig. 7.

[0049] When a top load is exerted on the bottle 1A configured in this manner, stress concentration is first of all produced along the first circumferential rib 311A, second circumferential rib 312A and third circumferential rib 313A. A compressive load is then exerted on the region of the shoulder portion 3A between the first circumferential rib 311A and the second circumferential rib 312A and the region between the second circumferential rib 312A and the third circumferential rib 313A, and localized buckling is produced. As a result, the bottle 1A can transition to a collapsed state in which the upper portion thereof collapses inside the bottle from the third circumferential rib 313A.

(Third Mode of Embodiment)

[0050] A plastic bottle 1B according to a third mode of embodiment (referred to below as "the bottle 1B") will be described next with reference to fig. 10 to fig. 12. The bottle 1B differs from the bottle 1 in terms of the shape around the shoulder portion; elements which are the same bear the same reference symbols where appropriate and will not be described again.

[0051] A shoulder portion 3B of the bottle 1B comprises a plurality of first blocks 331B disposed in an annular form around a mouth portion 2, and a plurality of second blocks 332B disposed in an annular form at the outer periphery of the plurality of first blocks 331B, in the same way as with the bottle 1. The first blocks 331B comprise end portions 331Ba-331Bc formed with a substantially linear shape. Furthermore, the second blocks 332B comprise end portions 332Ba-332Bc formed with a substantially linear shape. A first circumferential rib 311B, a second circumferential rib 312B and a third circumferential rib 313B therefore exhibit an annular shape as a result of a plurality of grooves comprising linear ridge lines tangential to a circle centered on the mouth portion 2, as seen from the upper surface, being placed in series.

[0052] Furthermore, the bottle 1B is the same as the bottle 1 in that the first circumferential rib 311B, second circumferential rib 312B and third circumferential rib 313B are formed in succession from the mouth portion 2 side as a result of the first blocks 331B and the second blocks 332B being formed. The bottle 1B is also the same as the bottle 1 in that first radial ribs 321B are formed

between the end portions 331Bb, 331Bb of adjacent first blocks 331B, 331B, and second radial ribs 322B are formed between end portions 332Bb, 332Bb of adjacent second blocks 332B, 332B.

[0053] The bottle 1B differs from the bottle 1 in terms of the arrangement of the first radial ribs 321B and the second radial ribs 322B. That is to say, as described above, the first radial ribs 321 and the second radial ribs 322 of the bottle 1 are disposed in such a way as to be offset by an angle θ in the circumferential direction about the mouth portion 2, as seen from the upper surface (see fig. 3), whereas the first radial ribs 321B and the second radial ribs 322B of the bottle 1B are disposed in a collinear arrangement (see fig. 11).

[0054] When a top load is exerted on the bottle 1B configured in this manner, the shoulder portion 3B is able to deform in such a way as to fold along the linear ridge lines of the grooves. The first radial ribs 321B and the second radial ribs 322B are disposed in a collinear arrangement, so stress is transmitted along said radial ribs during the transition to the collapsed state. In this case, it is possible to limit stress concentration and localized deformation by reducing variations in wall thickness etc., and a uniform collapse can be achieved while symmetry is maintained.

(Fourth Mode of Embodiment)

[0055] A plastic bottle 1C according to a fourth mode of embodiment (referred to below as "the bottle 1C") will be described next with reference to fig. 13. The bottle 1C differs from the bottle 1 in terms of the shape around the shoulder portion; elements which are the same bear the same reference symbols where appropriate and will not be described again. Furthermore, the area around the cap 21 is omitted from fig. 13(b).

[0056] A shoulder portion 3C of the bottle 1C comprises a plurality of first blocks 331C disposed in an annular form around the mouth portion 2, and a plurality of second blocks 332C disposed in an annular form at the outer periphery of the plurality of first blocks 331C, in the same way as with the bottle 1. The first blocks 331C comprise end portions 331Ca, 331Cb, 331Cc formed with a substantially linear shape. Furthermore, the second blocks 332C comprise end portions 332Ca, 332Cb, 332Cc formed with a substantially linear shape. A first circumferential rib 311C, a second circumferential rib 312C and a third circumferential rib 313C therefore exhibit an annular shape as a result of a plurality of grooves comprising linear ridge lines tangential to a circle centered on the mouth portion 2, as seen from the upper surface, being placed in series.

[0057] Furthermore, the bottle 1C is the same as the bottle 1 in that the first circumferential rib 311C, second circumferential rib 312C and third circumferential rib 313C are formed in succession from the mouth portion 2 side as a result of the first blocks 331C and the second blocks 332C being formed. The bottle 1C is also the same

as the bottle 1 in that first radial ribs 321C are formed between the end portions 331Cb, 331Cb of adjacent first blocks 331C, 331C, and second radial ribs 322C are formed between end portions 332Cb, 332Cb of adjacent second blocks 332C, 332C.

[0058] The bottle 1C differs from the bottle 1 in terms of the arrangement of the second radial ribs 322C. That is to say, in the bottle 1, the number of second blocks 332 provided is the same as the number of first blocks 331, whereas in the bottle 1C, the number of second blocks 332C provided is twice the number of first blocks 331C. The number of second radial ribs 322C disposed on the shoulder portion 3C of the bottle 1C is therefore twice the number in the bottle 1. The bottle 1C also differs from the bottle 1 in that the first radial ribs 321C and the second radial ribs 322C of the bottle 1C are disposed in a collinear arrangement, and the bottle 1C is provided with a plurality of columnar ribs 16C1 extending in the vertical direction inside a compression absorbing surface 16C.

[0059] When a top load is exerted on the bottle 1C configured in this manner, the shoulder portion 3C is able to deform in such a way as to fold along the linear ridge lines of the grooves. The first radial ribs 321C and the second radial ribs 322C are disposed in a collinear arrangement, so stress is transmitted along said radial ribs during the transition to the collapsed state. In this case, it is possible to limit stress concentration and localized deformation by reducing variations in wall thickness etc., and a uniform collapse can be achieved while symmetry is maintained.

(Fifth Mode of Embodiment)

[0060] A plastic bottle 1D (referred to below as "the bottle 1D") will be described next with reference to fig. 14. The bottle 1D differs from the bottle 1 in terms of the shape around the shoulder portion; elements which are the same bear the same reference symbols where appropriate and will not be described again. Furthermore, the area around the cap 21 is omitted from fig. 14(b).

[0061] A shoulder portion 3D of the bottle 1D is formed in such a way that oblique surfaces 331D, 332D forming part of oblique surfaces of quadrangular pyramids of different sizes are placed one over another. As a result, a first circumferential rib 311D, a second circumferential rib 312D and a third circumferential rib 313D having linear ridge lines are formed in a stepped shape around the oblique surfaces 331D, 332D, in such a way as to surround the mouth portion 2. The first circumferential rib 311D, second circumferential rib 312D and third circumferential rib 313D are all formed in an annular fashion in the shape of a square with rounded corners.

[0062] When a top load is exerted on the bottle 1D configured in this manner, the shoulder portion 3D folds along the linear ridge lines of the steps and it is possible to limit stress concentration and localized deformation, and a uniform collapse can be achieved while symmetry

is maintained.

[0063] Modes of embodiment of the present invention were described above with reference to specific examples. However, the present invention is not limited to these specific examples. That is to say, appropriate design modifications may be added to these specific examples by a person skilled in the art, and any such modifications are included in the scope of the present invention, provided that said modifications comprise the features of the present invention. For example, the elements provided in the abovementioned specific examples and the arrangement, materials, conditions, shapes and sizes etc. thereof are not limited to what was illustrated and appropriate modifications may be made. For example, there may be three or more circumferential ribs (311, 312, 313). To give an example, the number of circumferential ribs may be increased to three or more when the head space can be made relatively large. Furthermore, the transverse sectional shape of the body portion 4 may be rectangular. In this case, at least one of the first circumferential rib 311, second circumferential rib 312 and third circumferential rib 313 may also be endowed with a flat annular shape, and various forms of circumferential ribs may also be combined, such as a combination of elliptical annular circumferential ribs and circular annular circumferential ribs. Furthermore, the elements provided in the abovementioned modes of embodiment may be combined within the bounds of technical possibility, and any such combinations are also included in the scope of the present invention provided that the features of the present invention are included.

Key to Symbols

[0064] 1: bottle (plastic bottle), 2: mouth portion (bottle mouth portion), 3: shoulder portion (bottle shoulder portion), 4: body portion (bottle body portion), 16: compression absorbing surface, 311: first circumferential rib, 312: second circumferential rib, 313: third circumferential rib, 321: first radial rib, 322: second radial rib

Claims

1. A plastic bottle comprising a bottle mouth portion forming a contents pouring opening, a bottle body portion, and a bottle shoulder portion expanding downward in such a way as to join the bottle mouth portion and the bottle body portion, wherein the bottle shoulder portion comprises a first circumferential rib, a second circumferential rib and a third circumferential rib, which are all annular, in succession from an upper side and coaxial with the bottle mouth portion, and when a top load acts on the plastic bottle, deformation is produced starting from the first circumferential rib, the second circumferential rib and the third circumferential rib, transitioning to a state of downward collapse, and after

the top load has been released, the collapsed state can be maintained.

2. The plastic bottle as claimed in claim 1, wherein at least one of the first circumferential rib, the second circumferential rib and the third circumferential rib exhibits an annular shape as a result of a plurality of linear ridge lines being placed in series. 5
3. The plastic bottle as claimed in claim 1 or 2, wherein the bottle shoulder portion comprises a first radial rib between the first circumferential rib and the second circumferential rib, said first radial rib extending radially from the bottle mouth portion side toward the bottle body portion side, and 10
comprises a second radial rib between the second circumferential rib and the third circumferential rib, said second radial rib extending radially from the bottle mouth portion side toward the bottle body portion side. 15 20
4. The plastic bottle as claimed in claim 3, wherein the first radial rib and the second radial rib are disposed with an offset in the circumferential direction about the bottle mouth portion, as seen from the upper surface. 25
5. The plastic bottle as claimed in claim 4, wherein the bottle body portion comprises a compression absorbing surface which deforms in such a way as to expand as the bottle shoulder portion transitions to the collapsed state. 30

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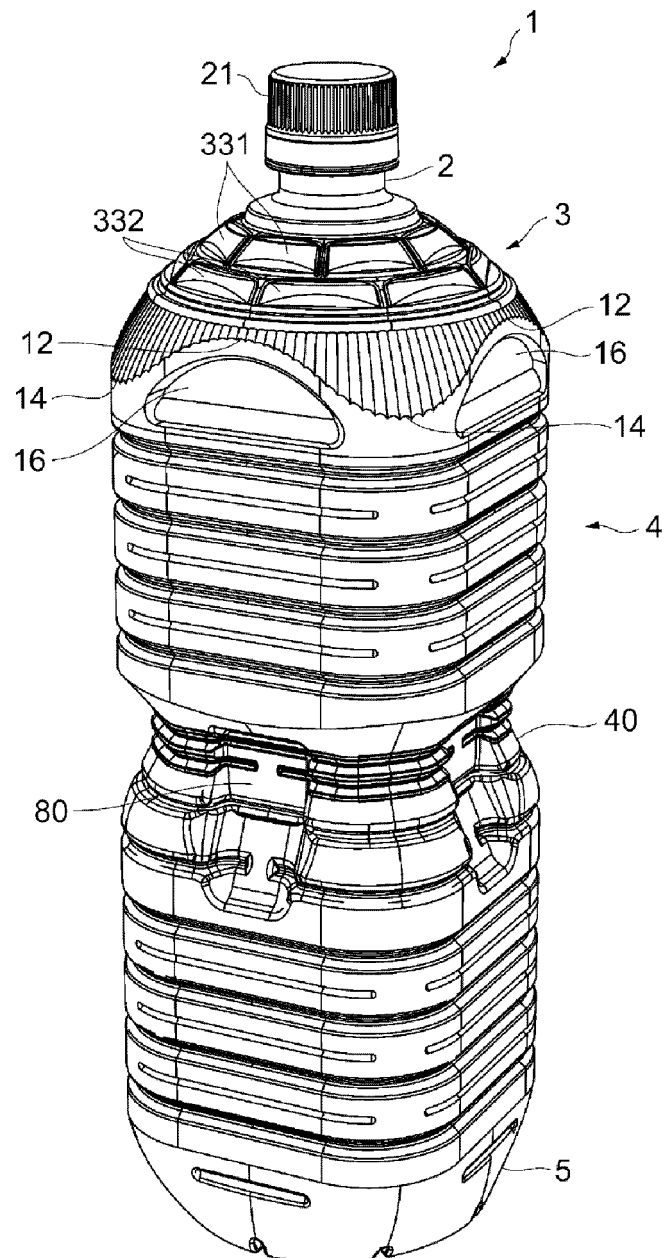
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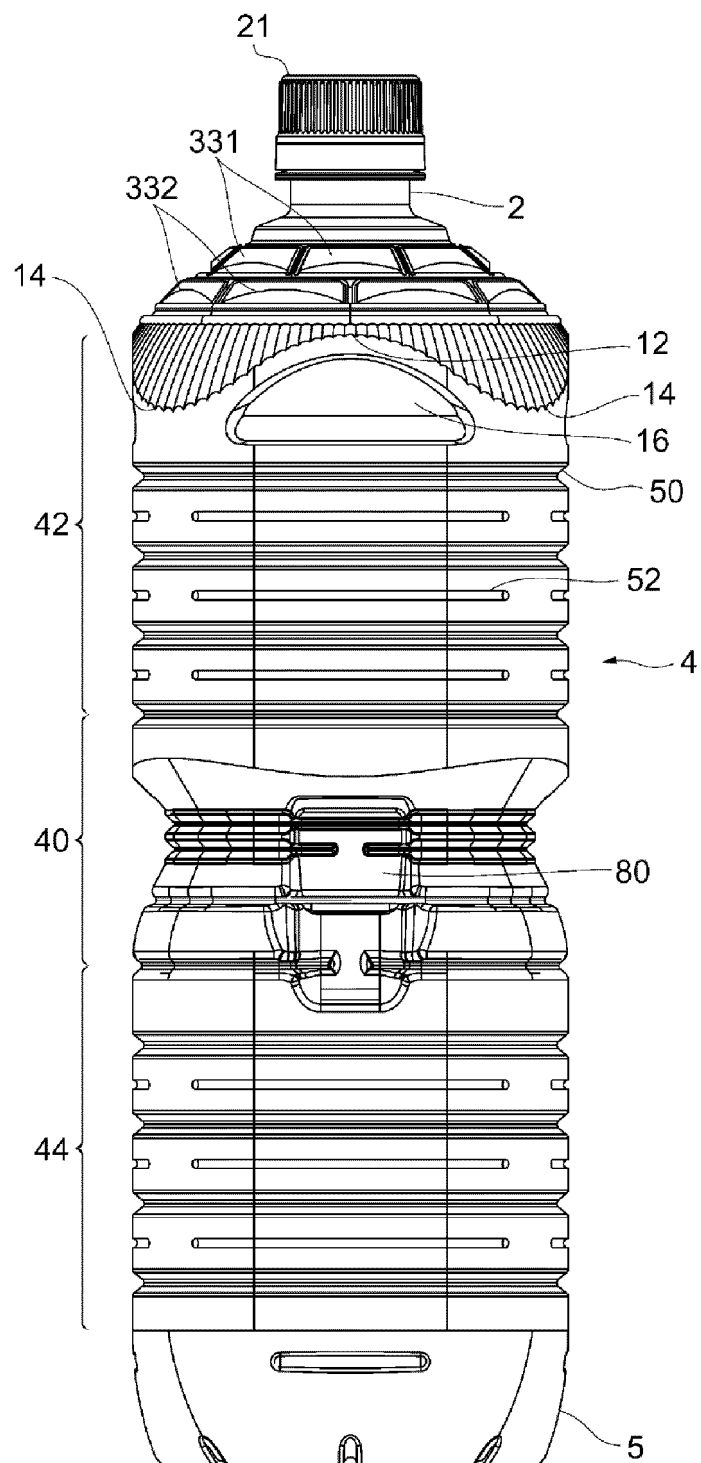
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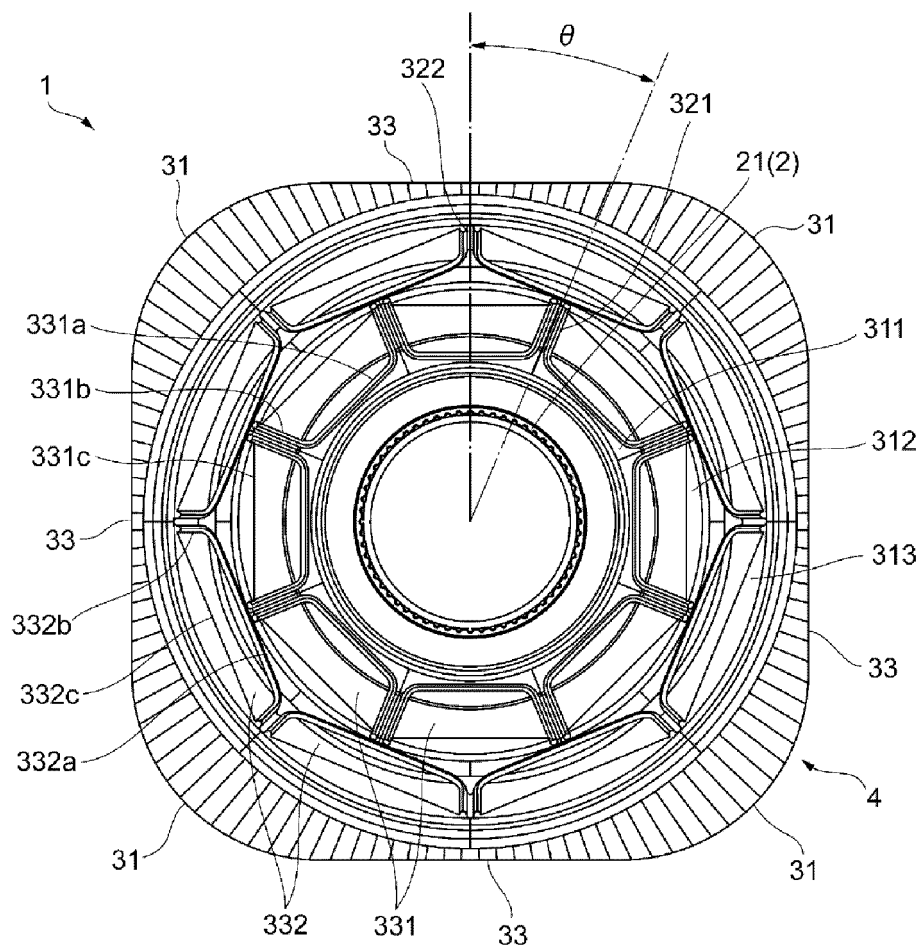
[Fig. 1]



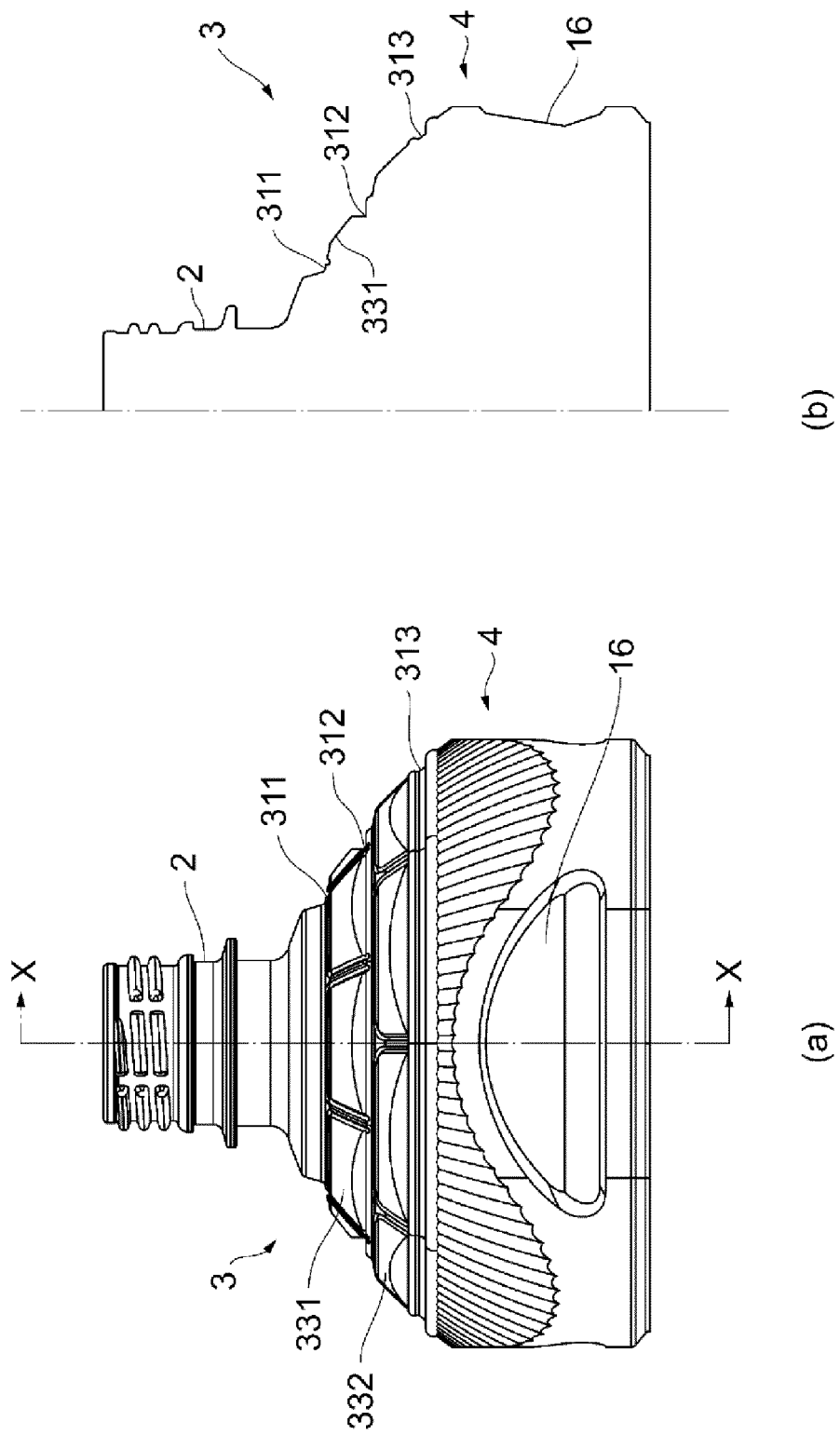
[Fig. 2]



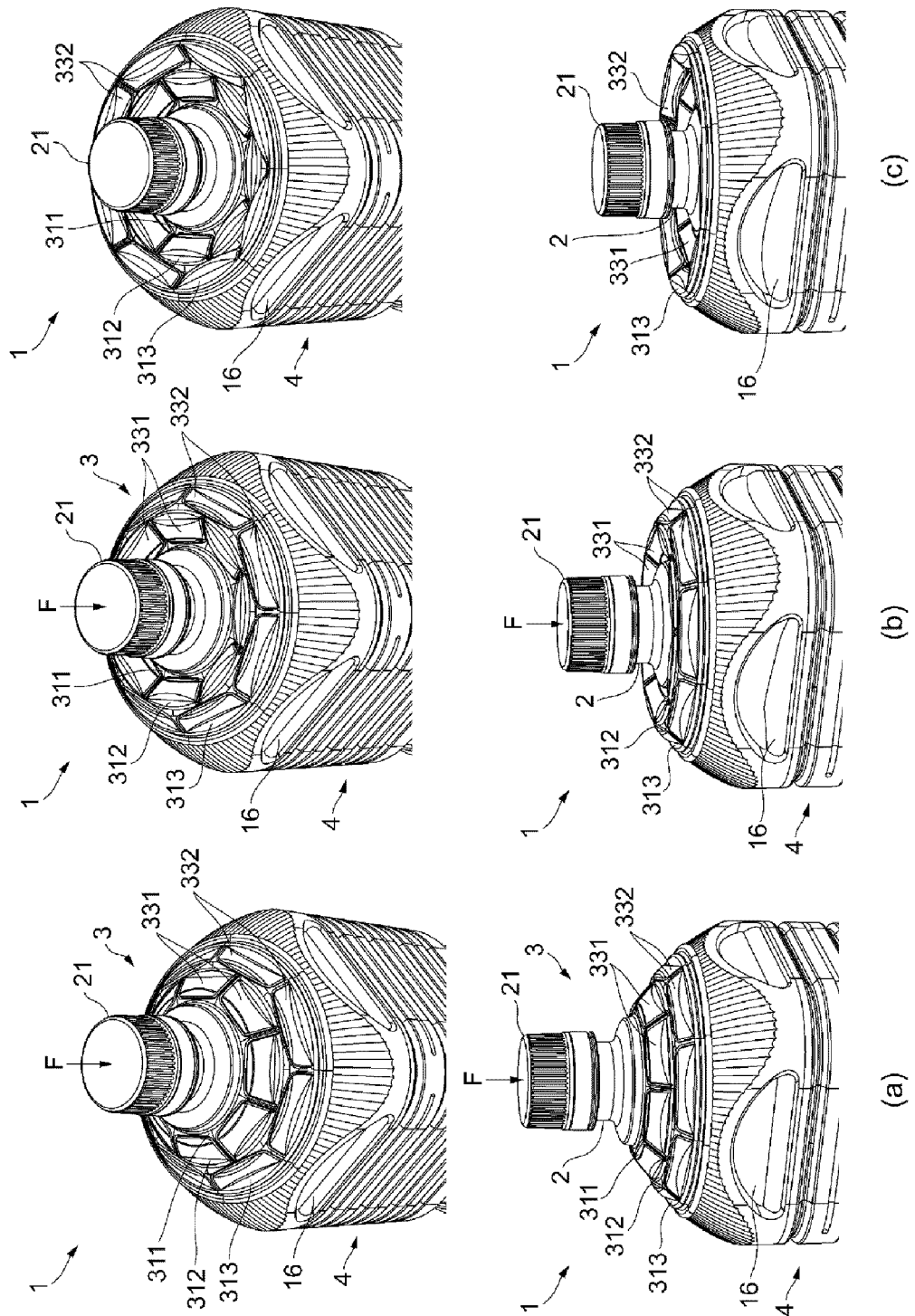
[Fig. 3]



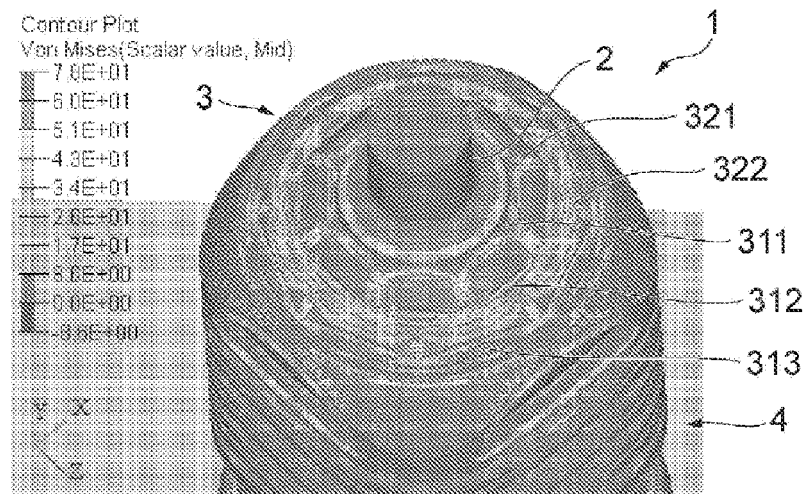
[Fig. 4]



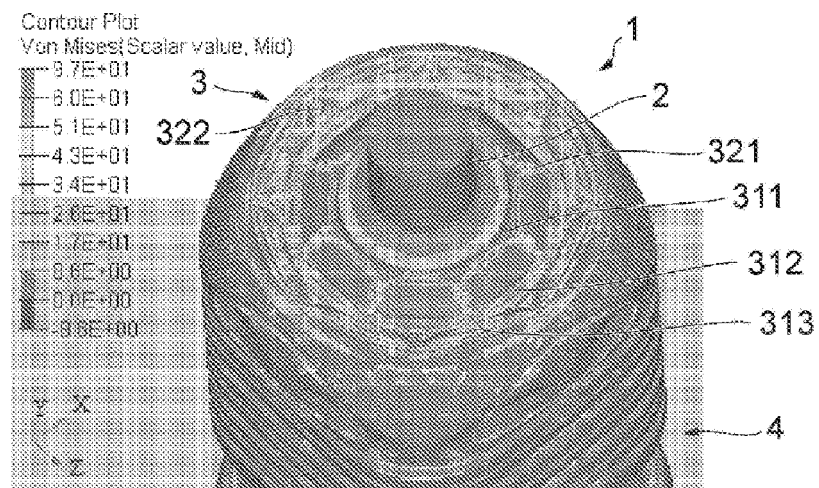
[Fig. 5]



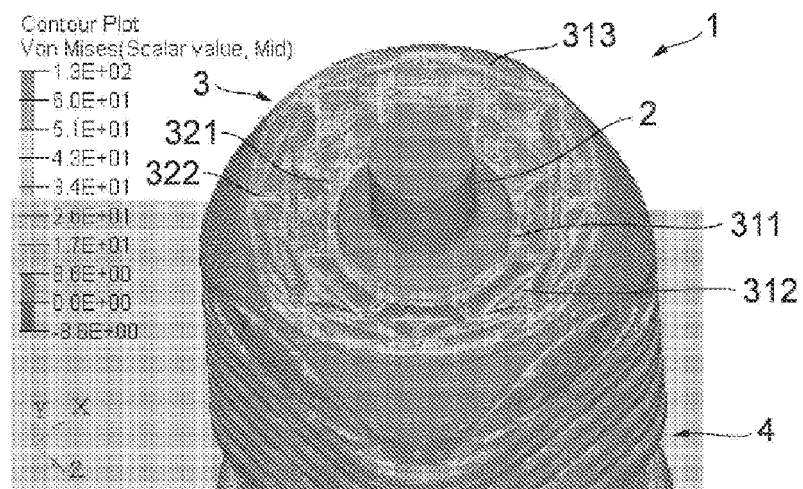
[Fig. 6]



(a)

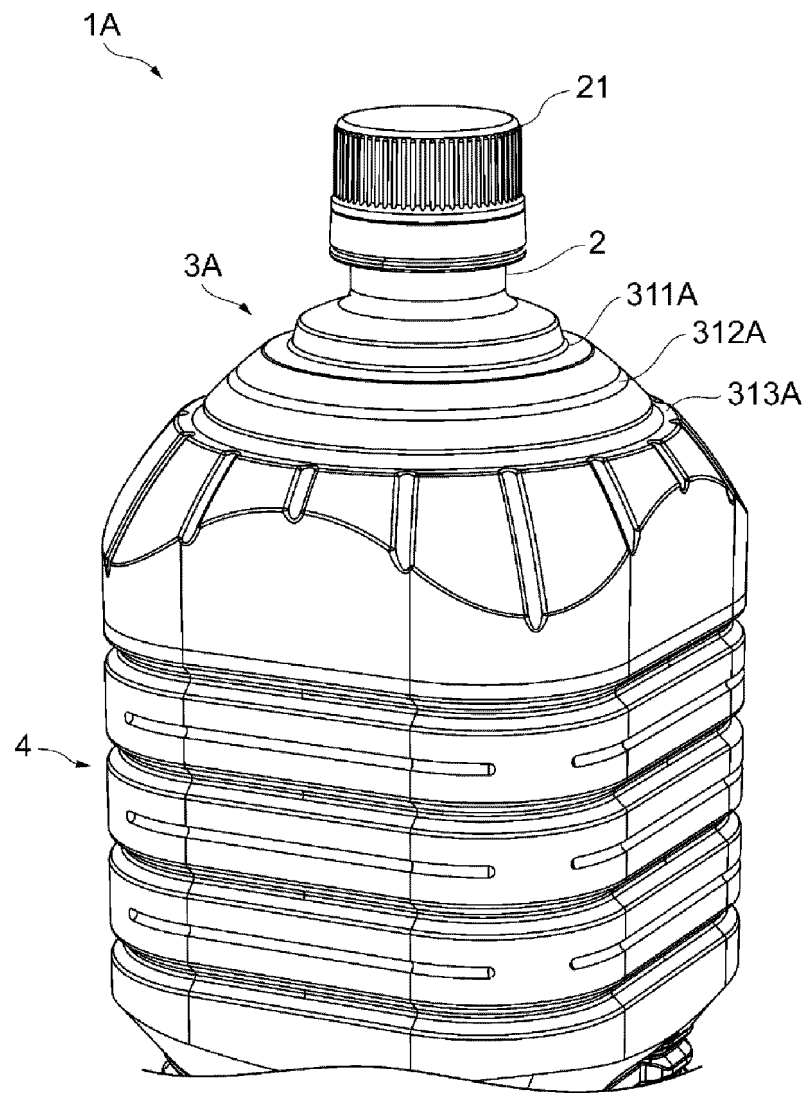


(b)

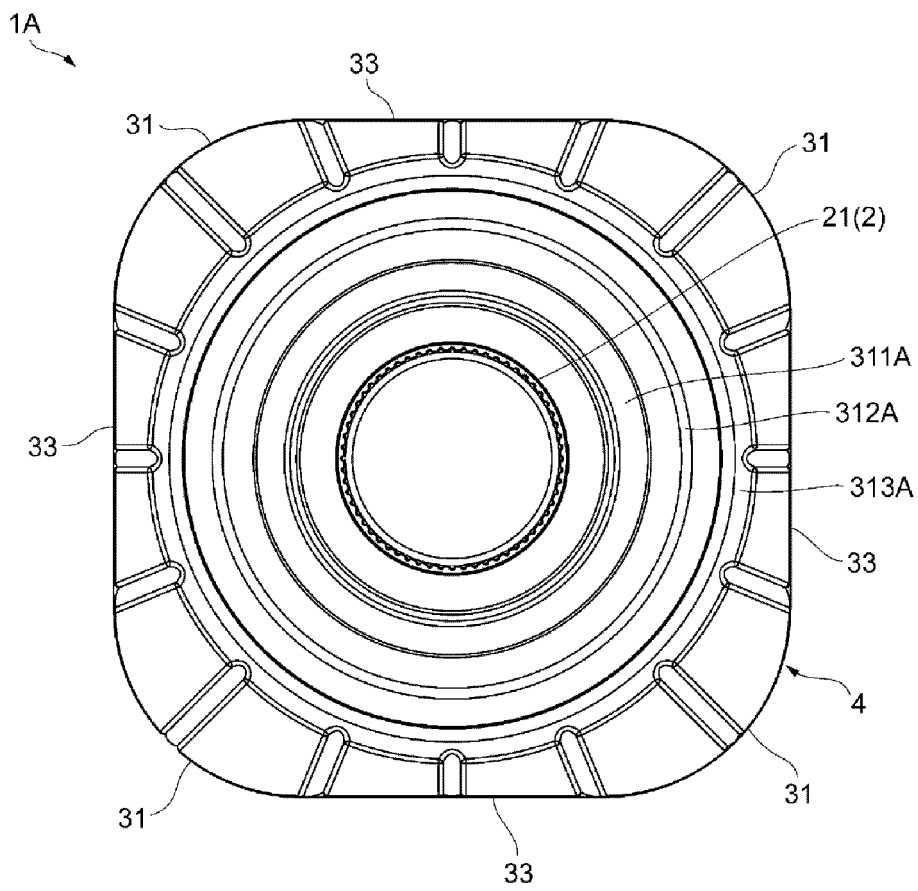


(c)

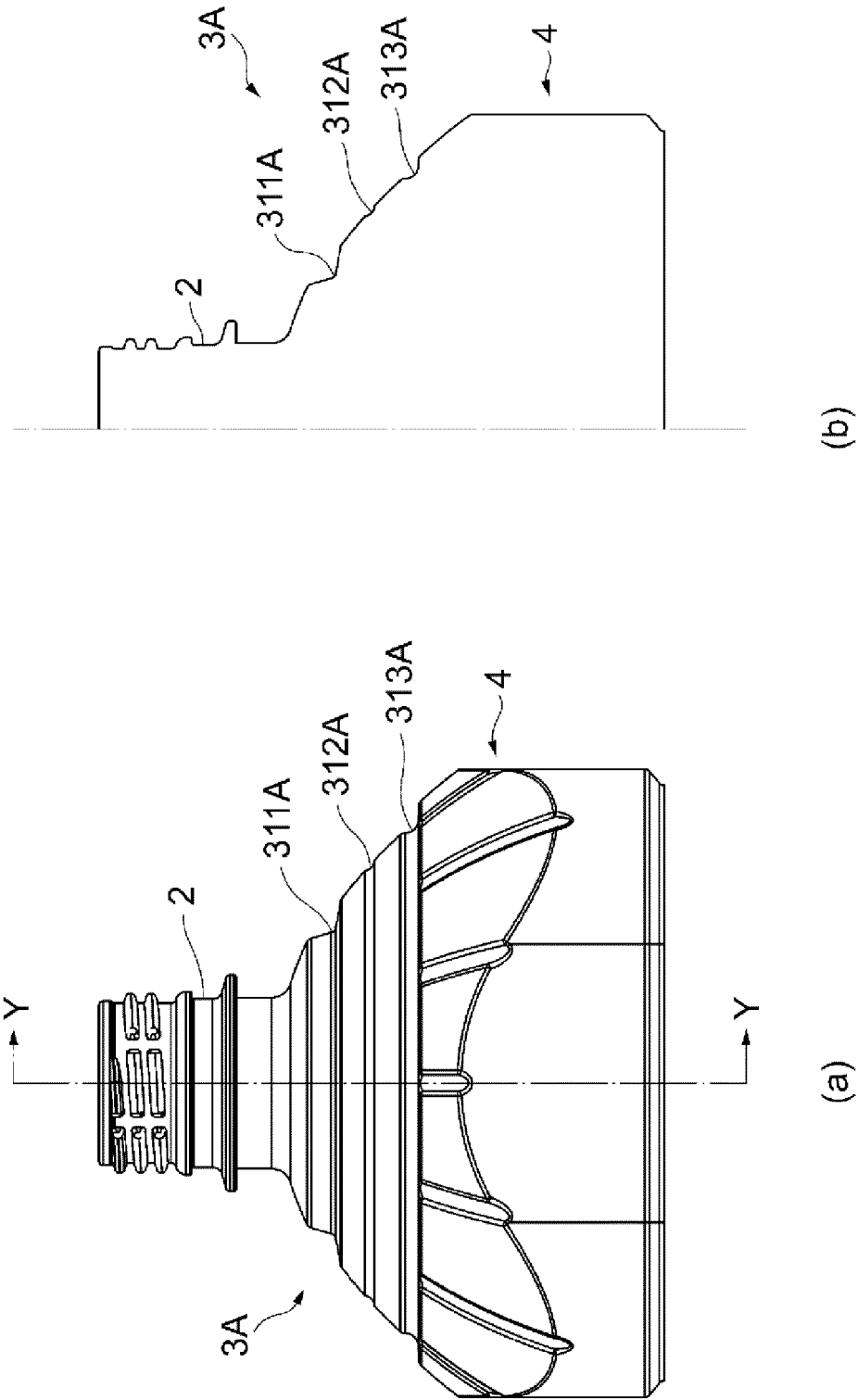
[Fig. 7]



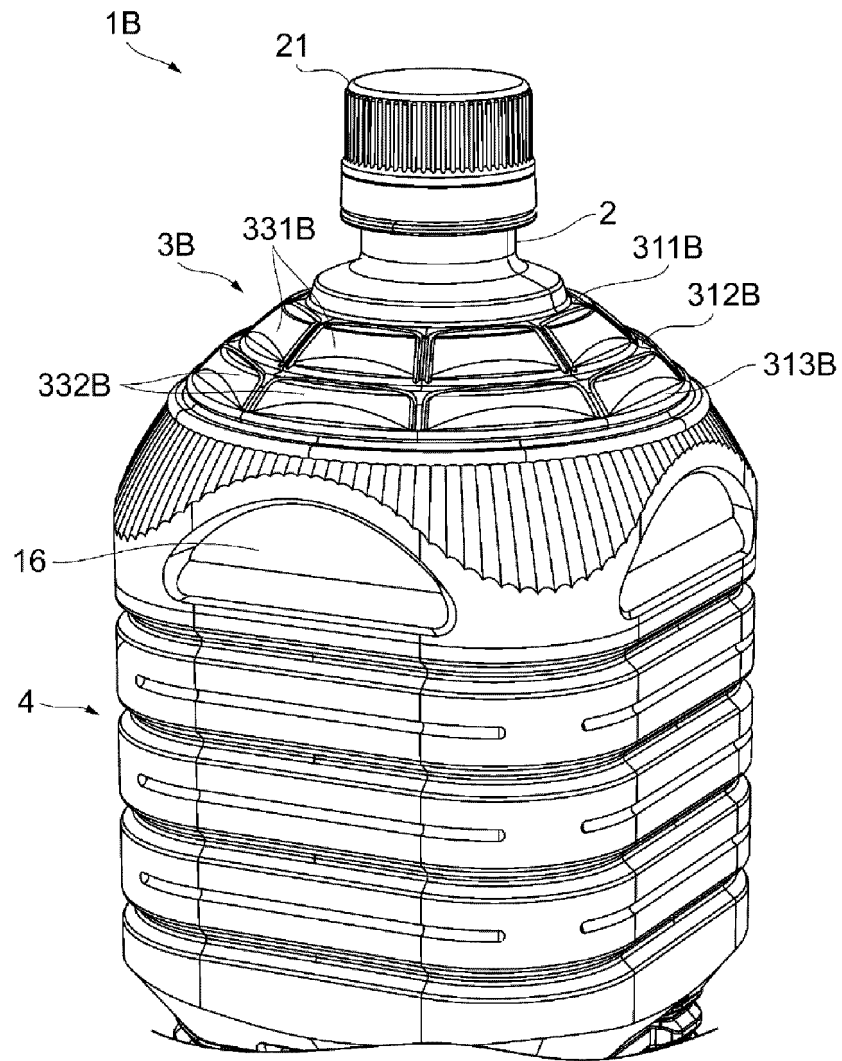
[Fig. 8]



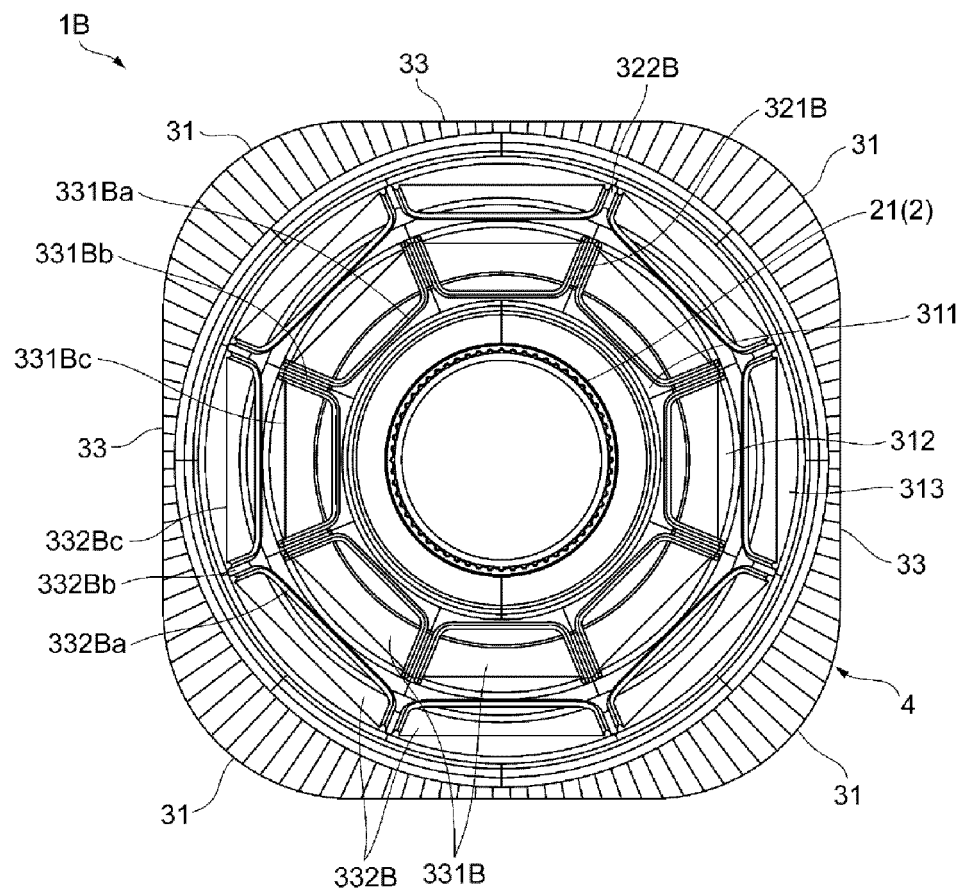
[Fig. 9]



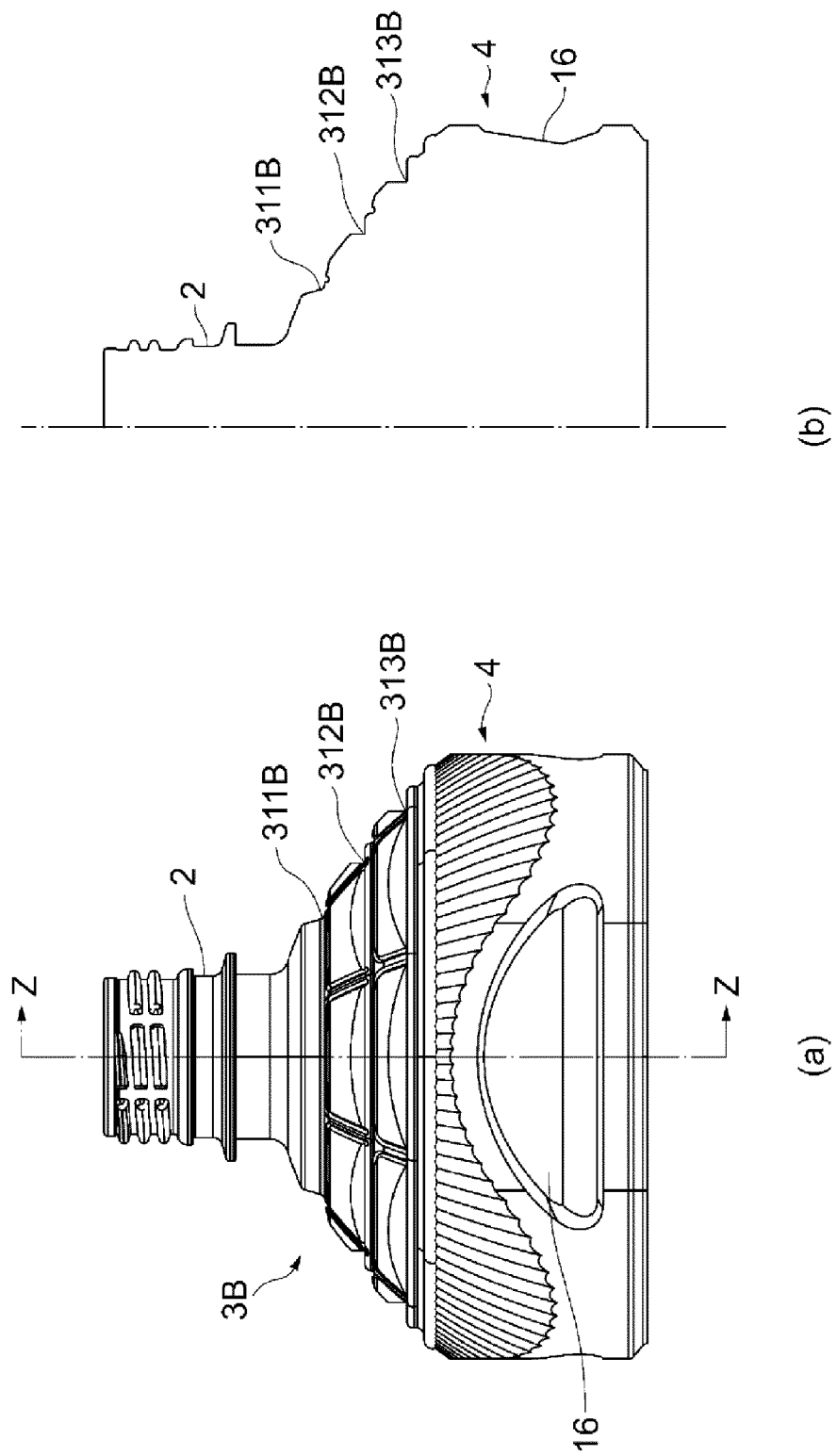
[Fig. 10]



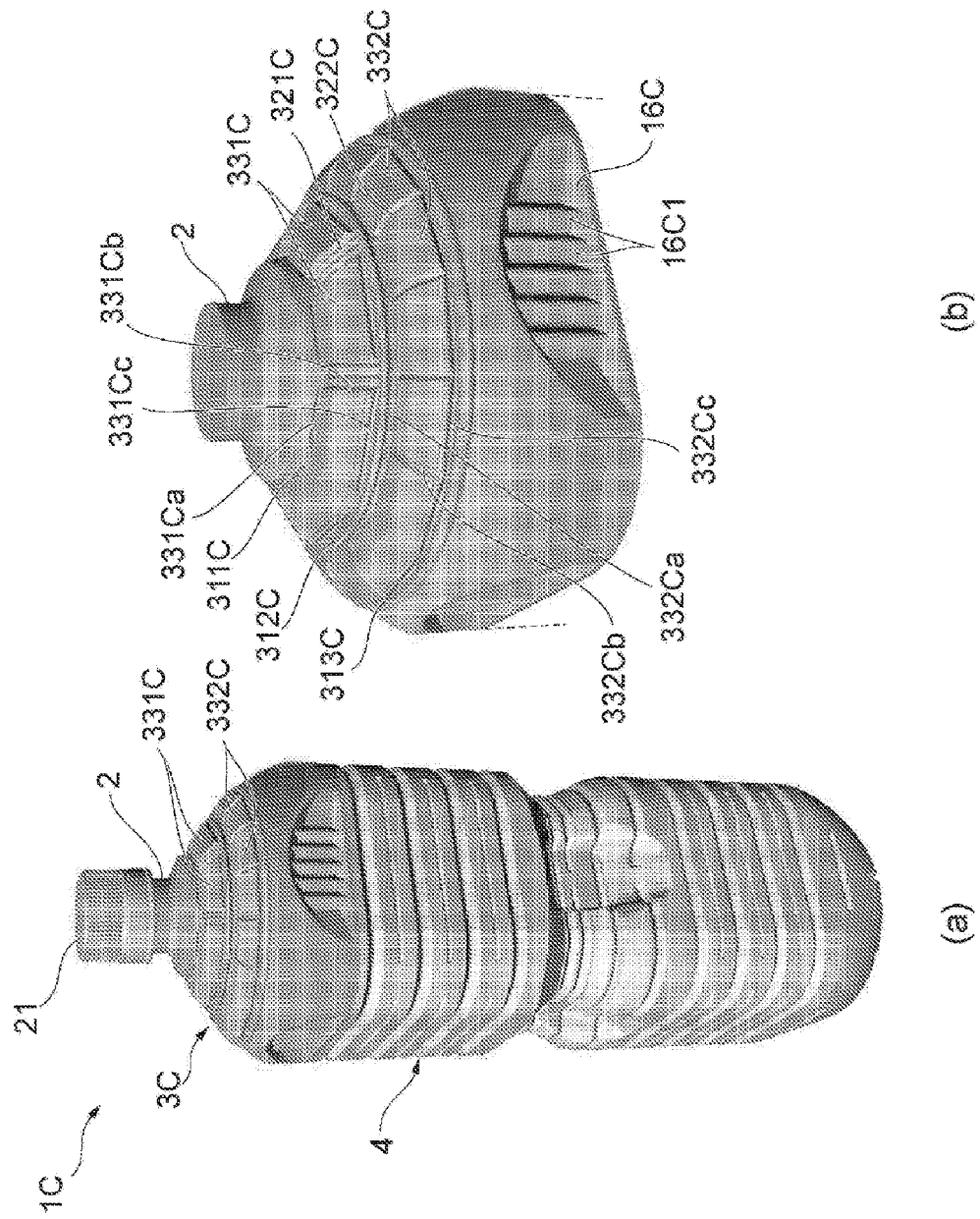
[Fig. 11]



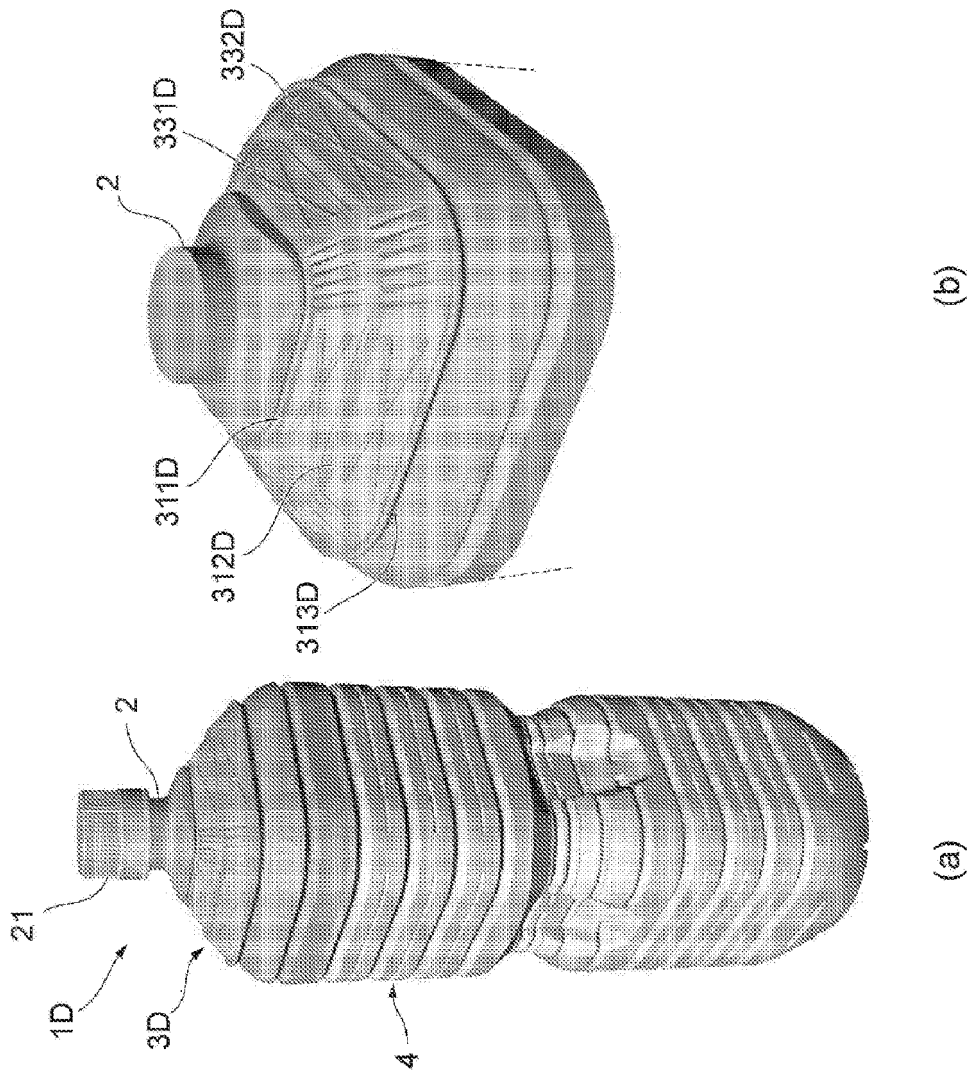
[Fig. 12]



[Fig. 13]



[Fig. 14]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/080870

A. CLASSIFICATION OF SUBJECT MATTER

B65D1/02(2006.01) i, B65D1/42(2006.01) i

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)

B65D1/02, B65D1/42

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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.
Y A	JP 2012-30837 A (Yoshino Kogyosho Co., Ltd.), 16 February 2012 (16.02.2012), claim 1; fig. 1 to 3 (Family: none)	1-2 3-5
Y A	JP 2010-260588 A (Yoshino Kogyosho Co., Ltd.), 18 November 2010 (18.11.2010), paragraphs [0018] to [0023]; fig. 2 (Family: none)	1-2 3-5

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

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Date of the actual completion of the international search
03 February 2015 (03.02.15)Date of mailing of the international search report
24 February 2015 (24.02.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

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Telephone No.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2011116427 A [0005]