



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
20.01.2010 Bulletin 2010/03

(51) Int Cl.:
B65D 1/02 (2006.01)

(21) Application number: **09075042.3**

(22) Date of filing: **23.01.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA RS

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(30) Priority: **16.07.2008 US 173910**

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(54) **Plastic bottle with superior top load strength**

(57) A plastic bottle (10) has a champagne base (12) that includes a planar standing ring (30) located between a lower margin of a convex heel (24) of the base and a lowermost portion (36) of a central concavity (32) within the standing ring. By making the inside vertical radius of

the convex heel lower margin and central concavity lowermost portion sufficiently small, the bottle is shown to exhibit increased top load strength without any increase in plastic. The bottle also has a larger standing ring diameter leading to a more stable bottle.

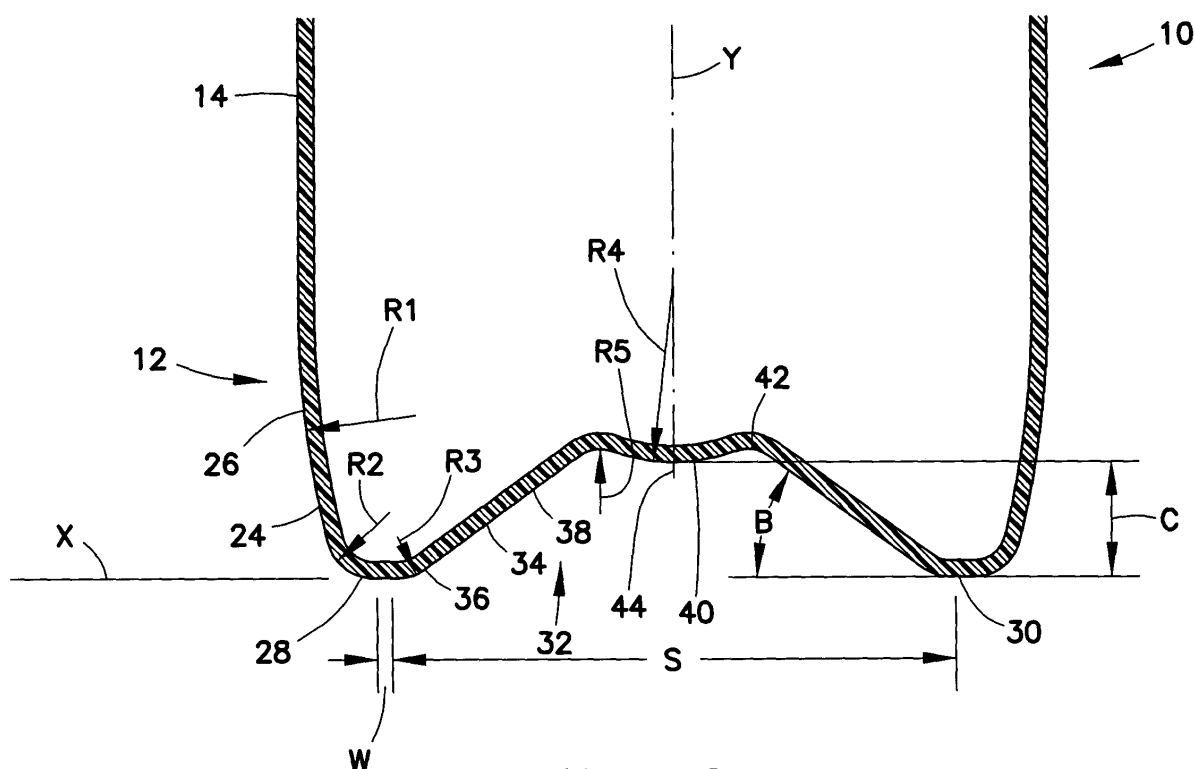


FIG. 2

Description**BACKGROUND OF THE INVENTION**

1. Field of the Invention

[0001] The present invention is directed to plastic bottles having a champagne style bottom structure closing the bottle lower end. The phrase champagne style is in reference to a base having an outside surface rotationally symmetric about a longitudinal axis of the bottle including a convex heel having an upper margin integrally formed with the lower end portion of the bottle sidewall, and a central concavity separated from the convex heel by a continuous standing ring that supports the bottle on any underlying surface.

2. Description of the Prior Art

[0002] Bottle bases having a standard champagne dome have long been employed with glass bottles. Consumers have become accustomed to such base configurations, particularly when the bottles contain wine, whether a sparkling wine or a non-sparkling wine. In glass bottles, the champagne dome distributes forces exerted thereon by any internal pressure of the bottle. The standard champagne base also provides for a stable presentation of the bottle on a continuous standing ring. In glass bottles, the champagne base provides an adequate support during capping operations as well as during shipment. While the use of a champagne base is desirable from a consumer point of view, the application of such a base to plastic bottles has provided difficulties to the plastic bottle industry.

[0003] Global trade in wine has increased rapidly in recent years and is currently estimated to exceed ten billion US dollars annually. Reports of health benefits and rising global incomes have spurred this increasing demand for wine. Together, the United States and the European Union accounted for over 60% of global imports of wine. The wine industry is considering the adoption of plastic bottles to lower both packaging and transportation costs. However the consumer still requires that the bottles have the base configuration to which they are accustomed. For reasons of efficiency and cost, the plastic bottle industry has embraced the conventional technique of blow molding plastic bottles from plastic preforms. The preforms are desirably made with the least amount of plastic that will still permit the finished bottle to satisfactorily perform in the intended manner. The industry often uses polyethylene terephthalate ("PET") or polypropylene ("PP") to construct plastic bottles due, in part, to the ability to reclaim and recycle such bottles. A barrier layer can be included to inhibit the migration of gases such as oxygen as well as moisture into or out of, the bottle. The barrier layer can be an intermediate extruded or injection formed layer made, for example, from ethylene vinyl alcohol ("EVOH"), or an interior layer such as a barely perceptible layer of glass, applied by plasma after the bottle is formed. In order to provide a plastic bottle constructed of PET or PP with desirable clarity characteristics, it is generally desirable to impart bi-axial stretching to the plastic material forming the bottle.

[0004] A standard practice used to blow mold plastic bottles having a champagne base is to slightly increase the thickness of a majority of the base relative to the thickness of the remainder of the bottle. Preforms used to construct a bottle having such a base are known and do not require complex configurations. However, other attempts to blow mold an acceptable plastic bottle have placed material concentrations in specific predetermined areas of the base to increase the amount of stress that can be withstood without failing. One such prior art base configuration uses a stepped base to increase the thickness of the dome to a thickness that is substantially thicker than the dome of a standard base. Another prior art plastic bottle having a champagne base designed for enhanced pressure within the bottle includes a reinforced hoop to deter the champagne dome from inverting due to the enhanced internal pressure of the bottle. However, an intricate preform is required to direct material concentrations to the necessary areas of the base to form the reinforced hoop. This configuration increases material consumption and increases the difficulty of constructing the preforms. Because plastic bottles are desirably produced in extremely high volume, economies of scale make these configurations prohibitive.

[0005] There is therefore an unsatisfied need for a low-cost plastic bottle for containing wine having an acceptable appearance from the consumer point of view, which is stable on planar supporting surfaces and withstands the top load requirements experienced during the bottling and capping operation as well as during transport of the filled bottles.

SUMMARY OF THE INVENTION

[0006] In one aspect, a plastic bottle has a sidewall and a bottom structure closing the bottle at a lower end portion of the sidewall, the bottom structure providing superior resistance to failure when the bottle is subjected to a vertical load. The bottom structure has an outside surface that is rotationally symmetric about a longitudinal axis of the bottle. The bottom outside surface can include a convex heel having an upper margin of diameter D integrally formed with the lower end portion of the sidewall. A lower margin of the convex heel can lead to a continuous planar standing ring lying

in a plane perpendicular to the longitudinal axis of the bottle that can support the bottle on any underlying surface. A central concavity is provided inside the standing ring. The central concavity can include a first surface defined by a circular cone inclined with respect to the plane of the standing ring, with the first surface having a lower most portion smoothly joining the standing ring. The inside vertical radius of curvature of the lower margin of the convex heel and the lower most portion of the first surface can be suitably dimensioned in relation to the diameter D to achieve the desired enhanced top load failure resistance.

[0007] In one aspect, the lower margin of the convex heel can have an inside vertical radius of less than 0.11 D. The lower margin of the convex heel leading to the planar standing ring can have an inside vertical radius of between 0.039D and 0.067D. A portion of the convex heel above the lower margin of the convex heel can have a vertical inside radius of curvature of between 1.26D and 1.42D.

[0008] In yet another aspect, the lower most portion of the first surface can have an inside vertical radius of less than 0.10D. The lowermost portion of the inside concavity first surface can have an inside vertical radius of between 0.055D and 0.084D. A portion of the inside concavity first surface above the lowermost portion of the first surface can be inclined at an angle of between 35° and 40° with respect to a plane formed by the standing ring.

[0009] In the various aspects of the present invention, the central concavity can also include a second surface joined to an upper margin of the first surface by a concave ring. The second surface can be a downwardly convex dome centered on the longitudinal axis of the bottle. The inside concavity second surface can have a radius of curvature of between 0.23D and 0.27D. The inside concavity second surface can have a lowermost nadir situated between 0.14D and 0.16D above the standing ring. The concave ring joining the inside concavity first surface to the inside concavity second surface can have an outside vertical radius of between 0.059D and 0.066D.

[0010] In the various aspects of the present invention the planar standing ring of the bottle can have a width of between 0.015D and 0.021 D. The planar standing ring should have a diameter as large as possible to enhance bottle stability. With the preferred configurations the standing ring can have an inner diameter of between 0.73D and 0.82D. The planar character of the standing ring helps assure the bottle will remain upright on any underlying supporting surface.

[0011] Each of these features contributes to a low gram weight bottle especially designed for containing wine having superior resistance to failure when subjected to a vertical force. For example, following these features one can form a one-liter bottle capable of withstanding a vertical force of 180 kg with only 54 grams of plastic. On the other hand a somewhat similar 750ml bottle made with the same amount of plastic and having features that differed in only small respects, detailed below in the comparative example, failed when subjected to a vertical force of less than 165 kg.

[0012] Further, by adopting smaller values for the vertical inside radius for both the lowermost portion of the inside concavity first surface and the lower margin of the convex heel, one can achieve satisfactory performance with a greater standing ring diameter which contributes to enhanced bottle stability.

[0013] Other features and advantages of the present invention will become apparent to those skilled in the art from the following disclosure of preferred embodiments of the present invention exemplifying the best mode of practicing the invention. The following disclosure references the accompanying drawings illustrating the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Figure 1 is a side elevation view of a bottle.

[0015] Figure 2 is a sectional outline of the exterior surface of the base of the bottle shown in Figure 1 taken through the axis of the bottle.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] A plastic bottle 10 is shown in Figure 1 to have a base 12, which will be detailed below. A sidewall 14 extends upward from the base 12. For the purpose of this disclosure, the diameter of the bottle 10 at the junction of the base 12 and sidewall 14 is given the dimension D. While the sidewall 14 is shown to have a right cylindrical configuration, other configurations for the sidewall 14 are also contemplated. A shoulder 16 unitarily joins the top of the sidewall 14 to a neck 18. A finish portion 20 is provided at the top of the neck 18 to which a suitable closure, not shown, can be applied to seal an opening 22 that is present at the top of the bottle 10. While the finish portion 20 is shown to include a threaded portion 24 and an optional tamper evident ring receiving portion 26, other configurations for the finish portion 20 are also contemplated. The bottle 10 has an overall height H, and is generally symmetric about a vertical axis Y extending from the center of the base 12 to the center of the opening 22.

[0017] The base 12 of the bottle 10 is shown in detail in Figure 2 to include a convex heel 24 extending downward from the sidewall 14. An upper portion 26 of the heel 24 is defined by an inside vertical radius R1, while a lower portion 28 of the heel 24 is defined by a smaller inside vertical radius R2. A continuous planar standing ring 30 joins the heel lower portion 28 to a central concavity 32 situated within the standing ring 30. The standing ring 30 has a horizontal surface of width W and an inner diameter S. The standing ring 30 lies in a horizontal plane X that is generally perpendicular

to the longitudinal axis Y of the bottle 10. The central concavity 32 includes a first surface 34 having a lowermost portion 36. The first surface lowermost portion 36 is defined by a vertical inside radius R3 and smoothly joins the standing ring 30 to a portion 38, which can be conical. The conical portion 38 can extend upward from the lowermost portion 36 at an angle β with respect to the plane X. An upper margin of the conical portion 38 can be joined to a second surface 40 by a concave ring 42. The second surface 40 can be defined by a vertical inside radius R4 that can be centered on the vertical axis Y. The nadir 44 of the second surface 40 can be aligned with the vertical axis Y at a distance C above the plane X. The concave ring 42 can be defined by a vertical outside radius R5.

[0018] However, every bottle 10 having the general configuration shown in Figures 1 and 2 will not have the top load strength deemed minimally satisfactory. Table I provides the various dimensions for both a comparative example bottle 1A that failed to perform satisfactorily and some working examples of bottles that did perform satisfactorily. All of the bottles reported in Table I were made from preforms having approximately 55 grams of plastic, including bottle 3.1A, which is designed to contain 1 liter of liquid while the remaining bottles of Table I are designed to contain only 750ml. It will be noted that certain of the dimensions overlap for both satisfactory bottles and un-satisfactory bottles while other dimensions identify a clear separation between success and failure under the top load test.

[0019] For example, it will be noted that the inside vertical radius R1 of the upper portion of the heel 26 in the failing bottle 1A has the same dimension as in two bottles that were successful. It will be further noted that the radius R1 can have a range of values that are successful. The radius R1 for satisfactory bottles can have a range of values from 1.42D down to 1.26D. When radius R1 is increased much beyond 1.42D, the base has a tendency to fold under itself under below-standard top loads. When the radius R1 is reduced much below 1.26D, some difficulty is observed in the complete formation of the heel.

[0020] It will also be noted that the inside vertical radius R4 of the second surface 40 in successful bottles can be larger, smaller or the same size as the failing bottle 1A. The radius R4 can have a range of values from 0.23D to 0.27D. The radius R4 may be able to assume values even outside this range.

[0021] It will also be noted that the outside vertical radius R5 of the ring 42 joining the conical portion 38 to the second surface 40 in successful bottles can be larger, smaller or the same size as the failing bottle 1A. The radius R5 can have a range of values from 0.059D to 0.066D. The radius R5 may be able to assume values even outside this range.

[0022] It will be further noted that the width W of the standing ring 30 in the failing bottle 1A has the same dimension as in two bottles that were successful. It will be further noted that the width W can have a range of values that are successful. The width W for satisfactory bottles can have a range of values from 0.021 D down to 0.016D. The width W may be able to assume values even outside this range.

[0023] It will be further noted that the height C of the nadir 44 of the second surface portion 40 above the standing ring 30 for successful bottles can be larger, smaller or the same size as the failing bottle 1A. The height C for satisfactory bottles can have a range of values from 0.159D down to 0.143D. The height C may be able to assume values even outside this range.

[0024] One dimension that clearly separates successfully performing bottles from unsuccessful bottles is the vertical inside radius R2 of the lowermost portion 28 of heel 24. Distinctly smaller radius values for radius R2 perform satisfactorily while larger radius values appear to contribute to failure. The radius R2 should have a value of less than 0.11 D, and should preferably have a value between 0.039D and 0.067D.

[0025] Another dimension that separates successfully performing bottles from unsuccessful bottles is the vertical inside radius R3 of the lowermost portion 36 of the central concavity first surface 34. Distinctly smaller radius values for radius R3 perform satisfactorily while larger radius values also appear to contribute to failure. The radius R3 should have a value of less than 0.10D, and should preferably have a value between 0.055D and 0.084D.

[0026] Another dimension that separates successfully performing bottles from unsuccessful bottles is the diameter S of the standing ring 30. Greater values for the diameter S are preferred over smaller values as they contribute to enhanced stability for the bottle. The diameter S can have a value of greater than 0.74D, and should preferably have a value between 0.75D and 0.82D. This greater diameter S can only be achieved through the adoption of the smaller values for R2 and R3 as discussed above.

[0027] From the forgoing description of the structure and operation of a preferred embodiment of the present invention, it will be apparent to those skilled in the art that the present invention is susceptible to numerous modifications and embodiments within the ability of those skilled in the art and without exercise of the inventive facility. Accordingly, the scope of the present invention is defined as set forth of the following claims.

Table I

Examples	R1	R2	R3	R4	R5	W	S	C	β
1A (comp.)	1.42D	0.111D	0.104D	0.250D	0.063D	0.021D	0.733D	0.150D	40°
1AA	1.42D	0.067D	0.083D	0.250D	0.063D	0.021D	0.758D	0.150D	35°

(continued)

Examples	R1	R2	R3	R4	R5	W	S	C	β
2AA	1.42D	0.067D	0.083D	0.250D	0.063D	0.021D	0.758D	0.150D	35°
3.1A	1.27D	0.040D	0.056D	0.238D	0.060D	0.016D	0.818D	0.143D	35°
5A	1.37D	0.043D	0.060D	0.257D	0.064D	0.017D	0.803D	0.154D	35°
6A	1.41D	0.044D	0.062D	0.265D	0.066D	0.018D	0.797D	0.159D	35°

Claims

1. A plastic bottle having a sidewall and a bottom structure closing the bottle at a lower end portion of the sidewall and providing superior resistance to failure when the bottle is subjected to a vertical load, the bottom having an outside surface rotationally symmetric about a longitudinal axis of the bottle, the bottom outside surface including a convex heel having an upper margin of diameter D integrally formed with the lower end portion of the sidewall, a lower margin of the convex heel leading to a continuous planar standing ring lying in a plane perpendicular to the longitudinal axis of the bottle to support the bottle on any underlying surface, and a central concavity inside the standing ring, the central concavity including a first surface defined by a circular cone inclined with respect to the plane of the standing ring, the first surface having a lower most portion smoothly joining the standing ring, and **characterized by** the lower margin of the convex heel having an inside vertical radius of less than 0.11D, and the lowermost portion of the first surface having an inside vertical radius of less than 0.10D to achieve enhance failure resistance and stability.
2. The plastic bottle of claim 1, further **characterized by** a portion of the convex heel above the lower margin of the convex heel has a vertical inside radius of curvature of between 1.42D and 1.26D.
3. The plastic bottle of claim 1 or 2, further **characterized by** the planar standing ring having a width of between 0.015D and 0.02D.
4. The plastic bottle of any of claims 1 - 3, further **characterized by** the planar standing ring having an inner diameter of between 0.818D and 0.73D.
5. The plastic bottle of any of claims 1-4, further **characterized by** a portion of the inside concavity first surface above the lowermost portion of the first surface being inclined at an angle of between 35° and 40° with respect to a plane formed by the standing ring.
6. The plastic bottle of any of claims 1-5, further **characterized by** the lowermost portion of the inside concavity first surface having an inside vertical radius of between 0.055D and 0.084D.
7. The plastic bottle of any of claims 1-6, further **characterized by** the lower margin of the convex heel leading to a planar standing ring having an inside vertical radius of between 0.039D and 0.067D.
8. The plastic bottle of any of claims 1-7, further **characterized by** the central concavity having a second surface joined to an upper margin of the first surface by a concave ring, the second surface being a downwardly convex dome centered on the longitudinal axis of the bottle.
9. The plastic bottle of claim 8, further **characterized by** the inside concavity second surface having a radius of curvature of between 0.23D and 0.27D.
10. The plastic bottle of claim 8 or 9, further **characterized by** the inside concavity second surface having a lowermost nadir situated between 0.15D and 0.19D above the standing ring.
11. The plastic bottle of any of claims 8 -10, further **characterized by** the concave ring joining the inside concavity first surface to the inside concavity second surface having an outside vertical radius of between 0.059D and 0.066D.

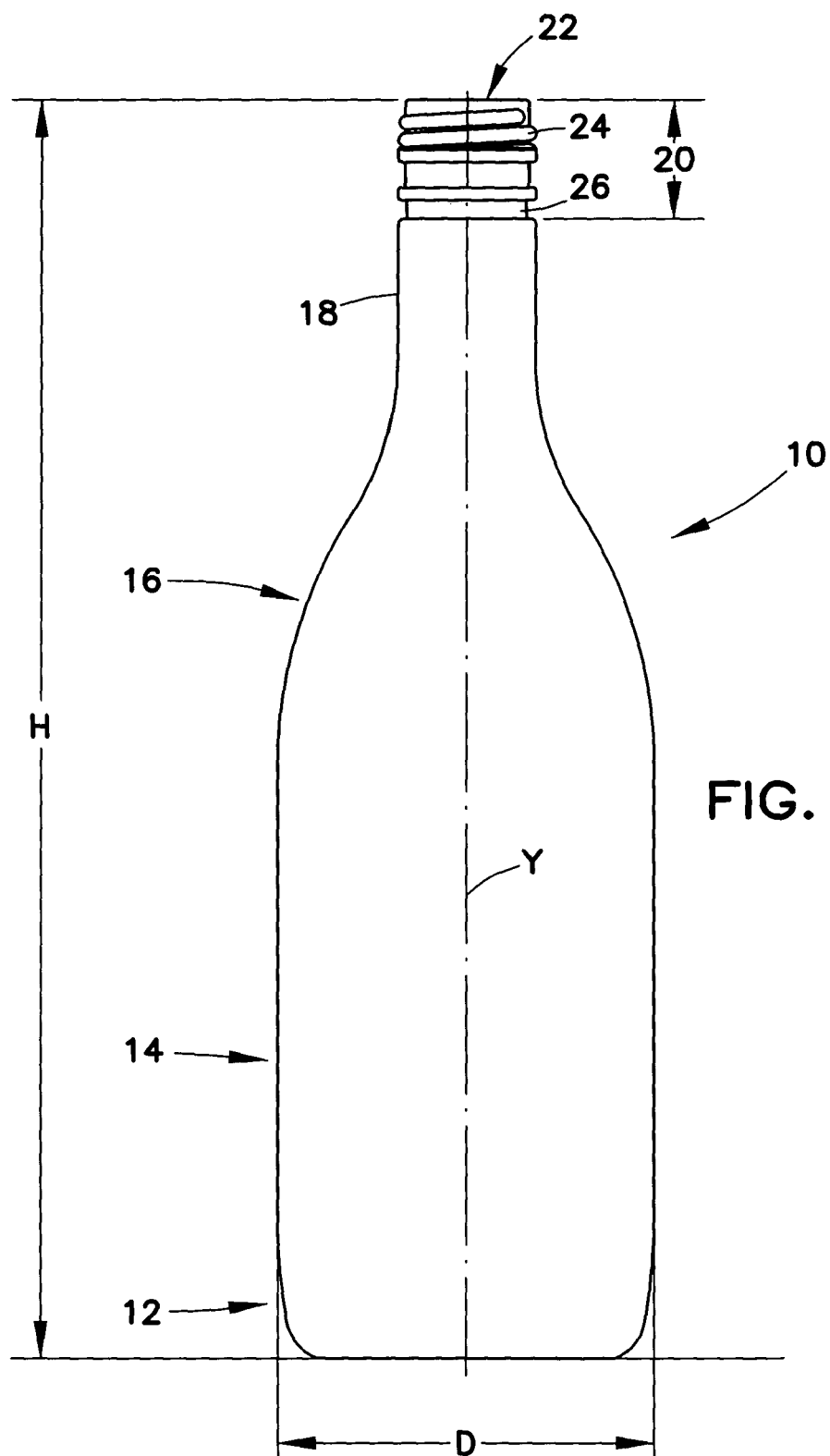


FIG. 1

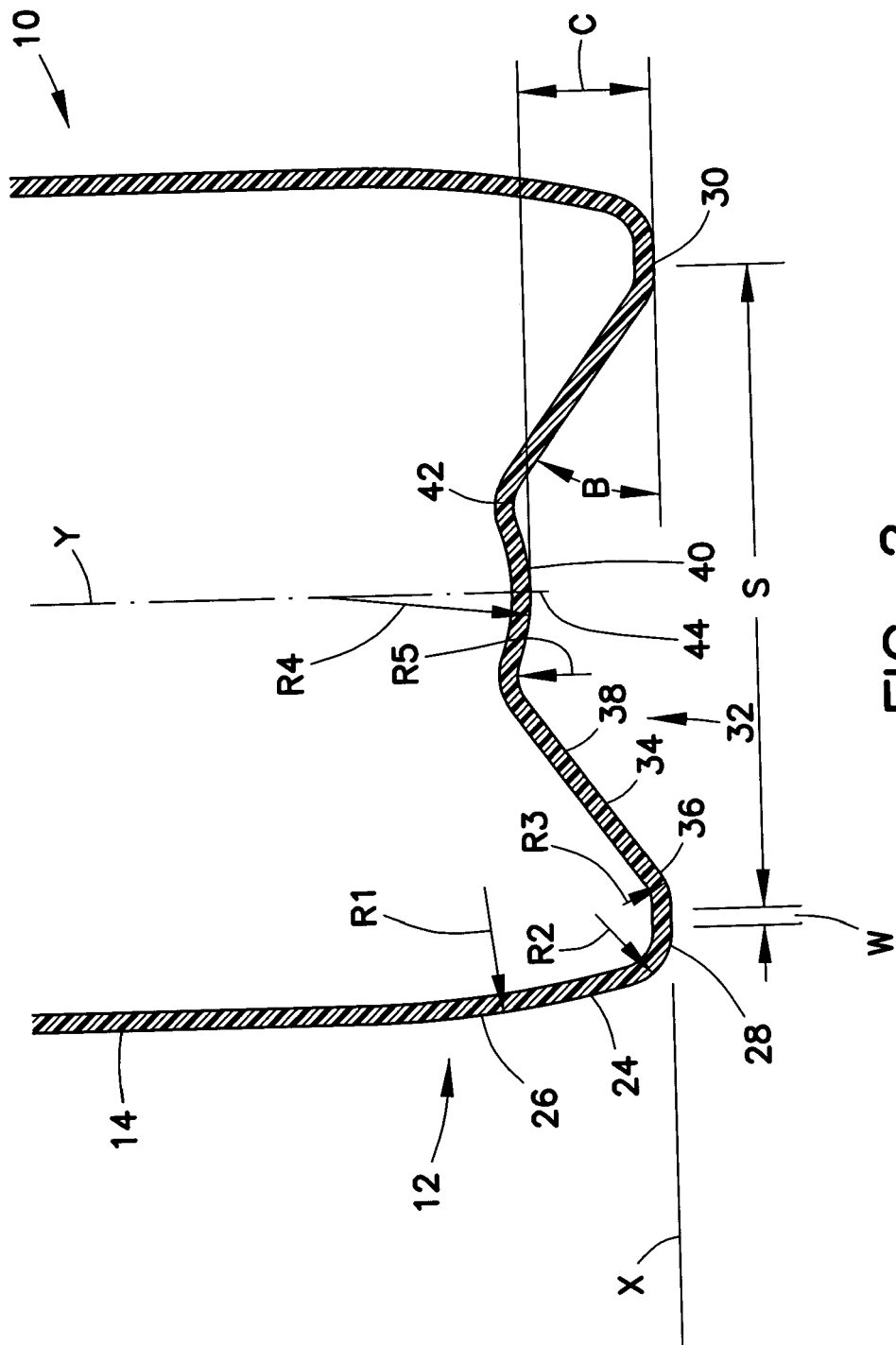


FIG. 2



EUROPEAN SEARCH REPORT

Application Number
EP 09 07 5042

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2003/116525 A1 (FUTRAL DANIEL M [US]; CORKER LESLEY S [US]) 26 June 2003 (2003-06-26)	1,4-5, 7-8,10	INV. B65D1/02
A	* paragraph [0021] - paragraph [0023]; figure 2 *	9	
A	----- US 4 231 483 A (DECHENNE ROGER; HUBERT GUY) 4 November 1980 (1980-11-04) * column 1, line 52 * * column 4, line 5 - line 20 * -----	1,4-5, 7-8	
			TECHNICAL FIELDS SEARCHED (IPC)
			B65D
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		29 September 2009	Bridault, Alain
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 09 07 5042

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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29-09-2009

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