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(54) HIGH STRENGTH BOTTLE

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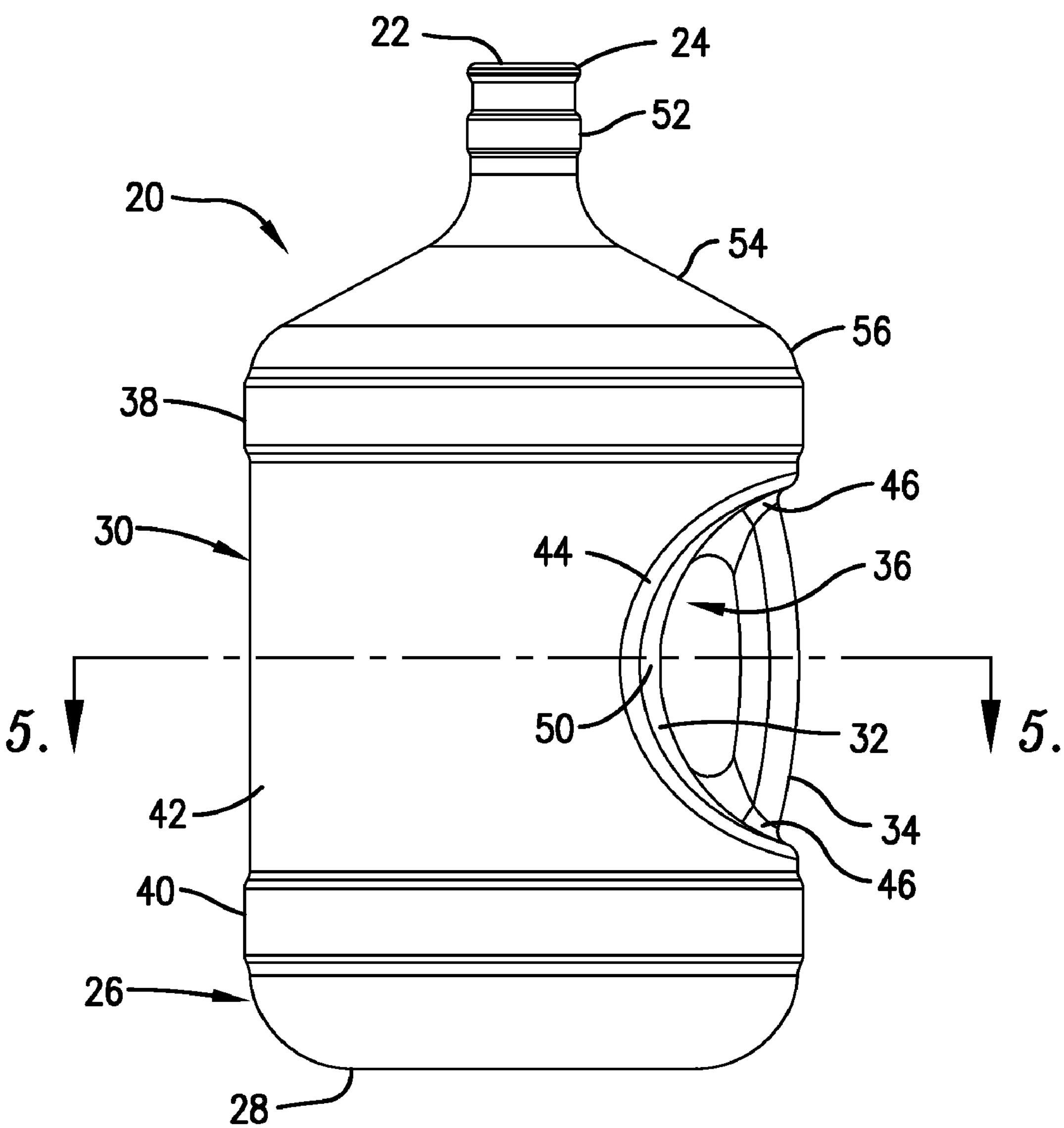
(57) ABSTRACT

A bottle with improved strength is provided. The bottle can have a liquid holding capacity of at least 2.5 gallons and can exhibit a drop impact resistance of at least 3 feet as measured by ASTMD 2463-95. The bottle can be formed from a substantially BPA-free material. The bottle can be used in liquid dispensers, such as water coolers.



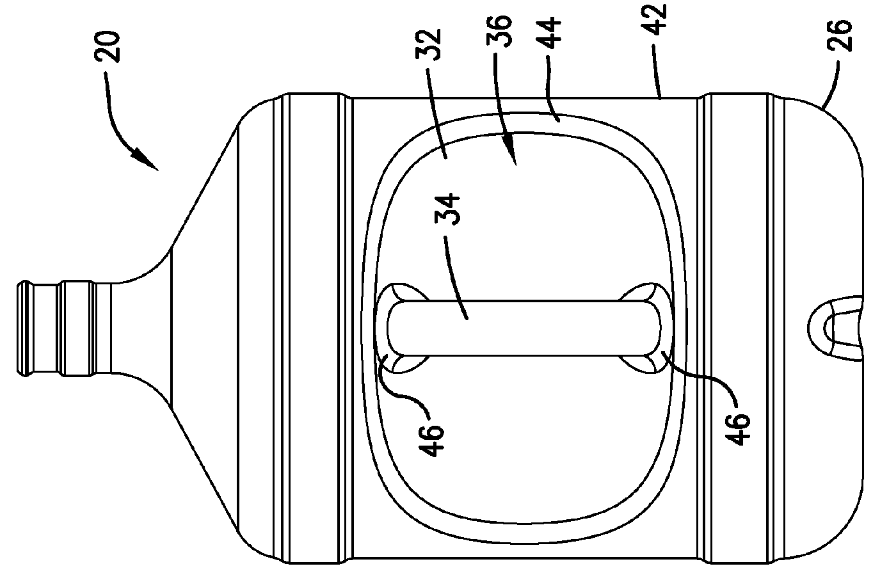

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Fig. 2.

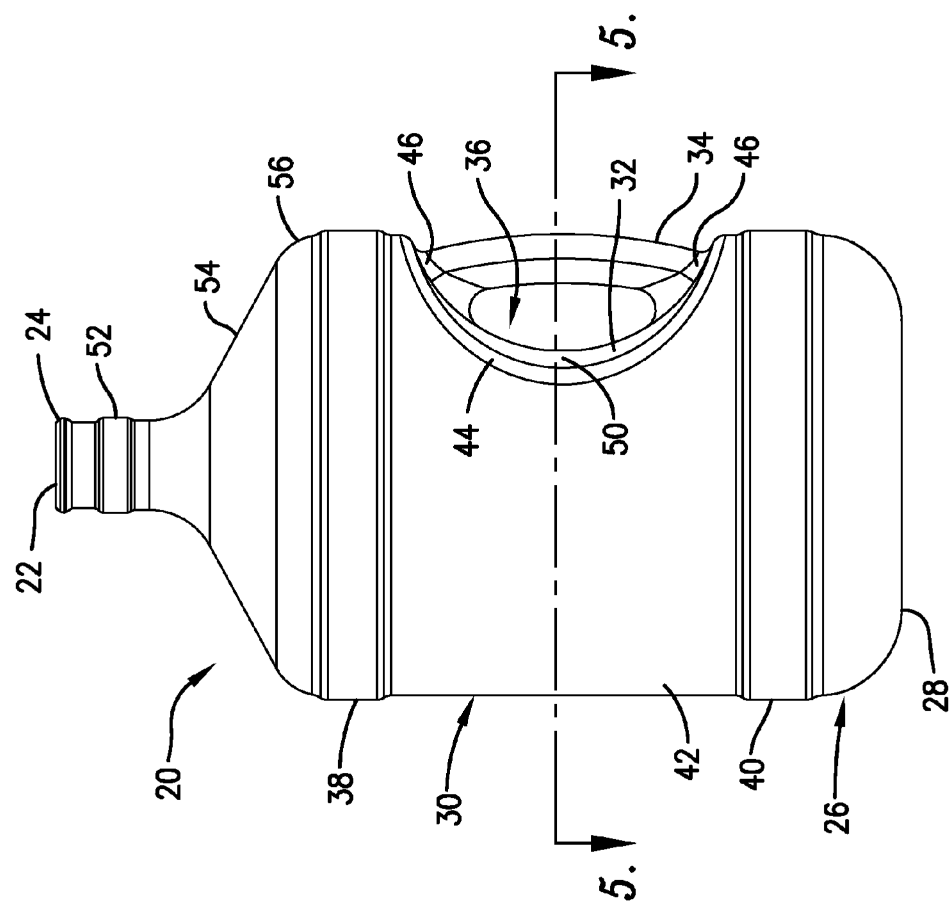
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Fig. 1.

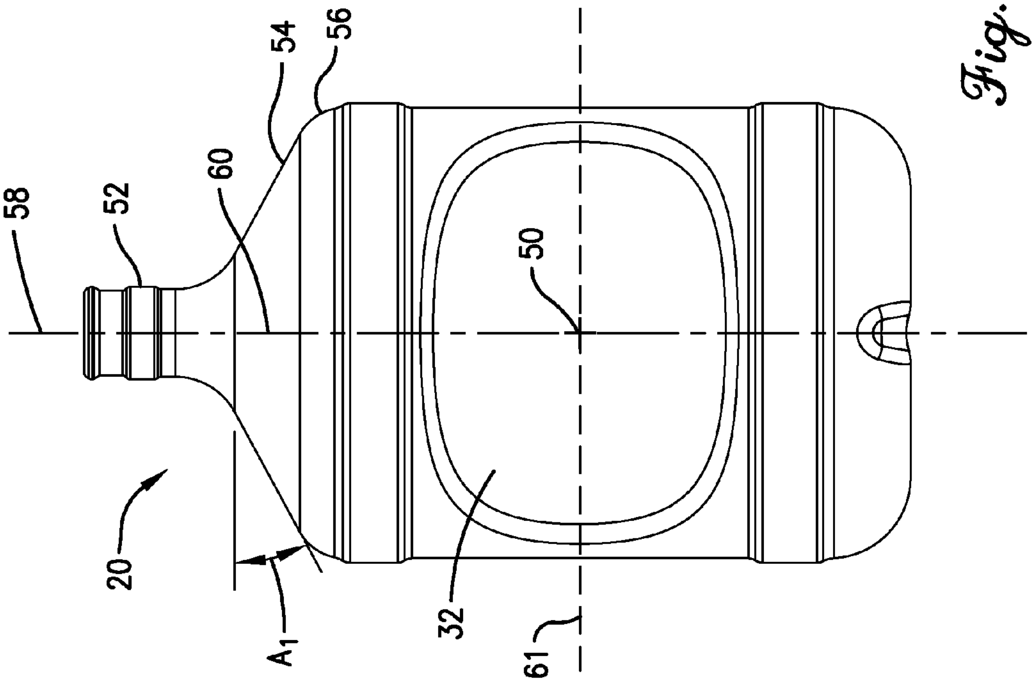

Fig. 4.

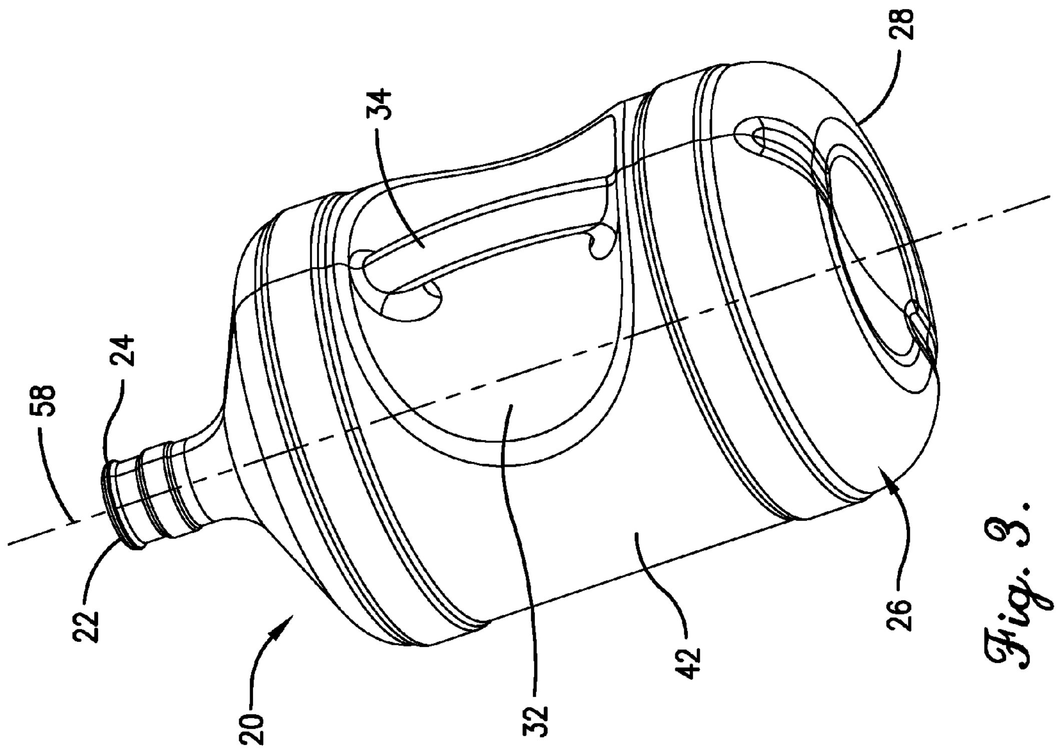

Fig. 3.

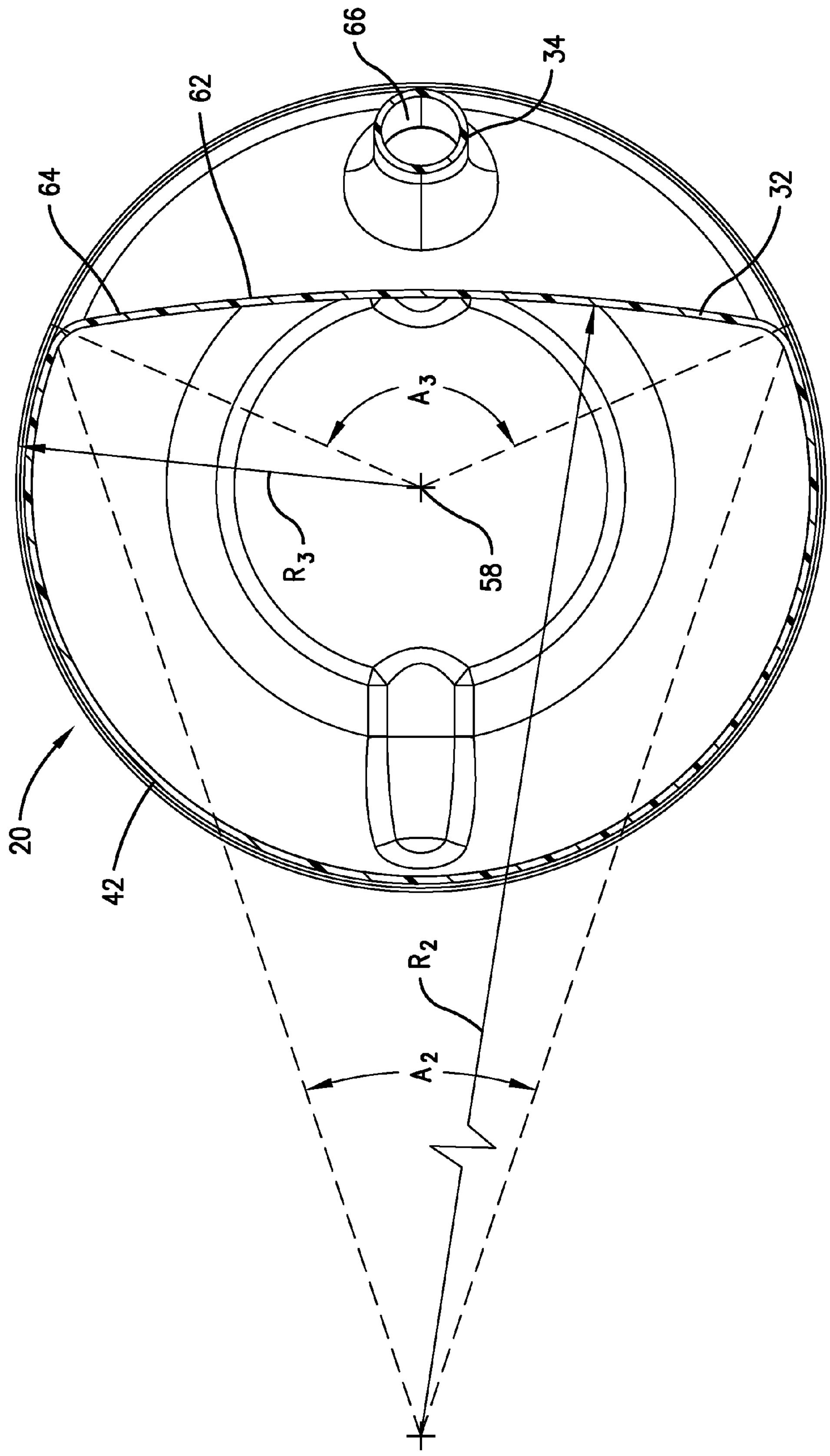

Fig. 5.

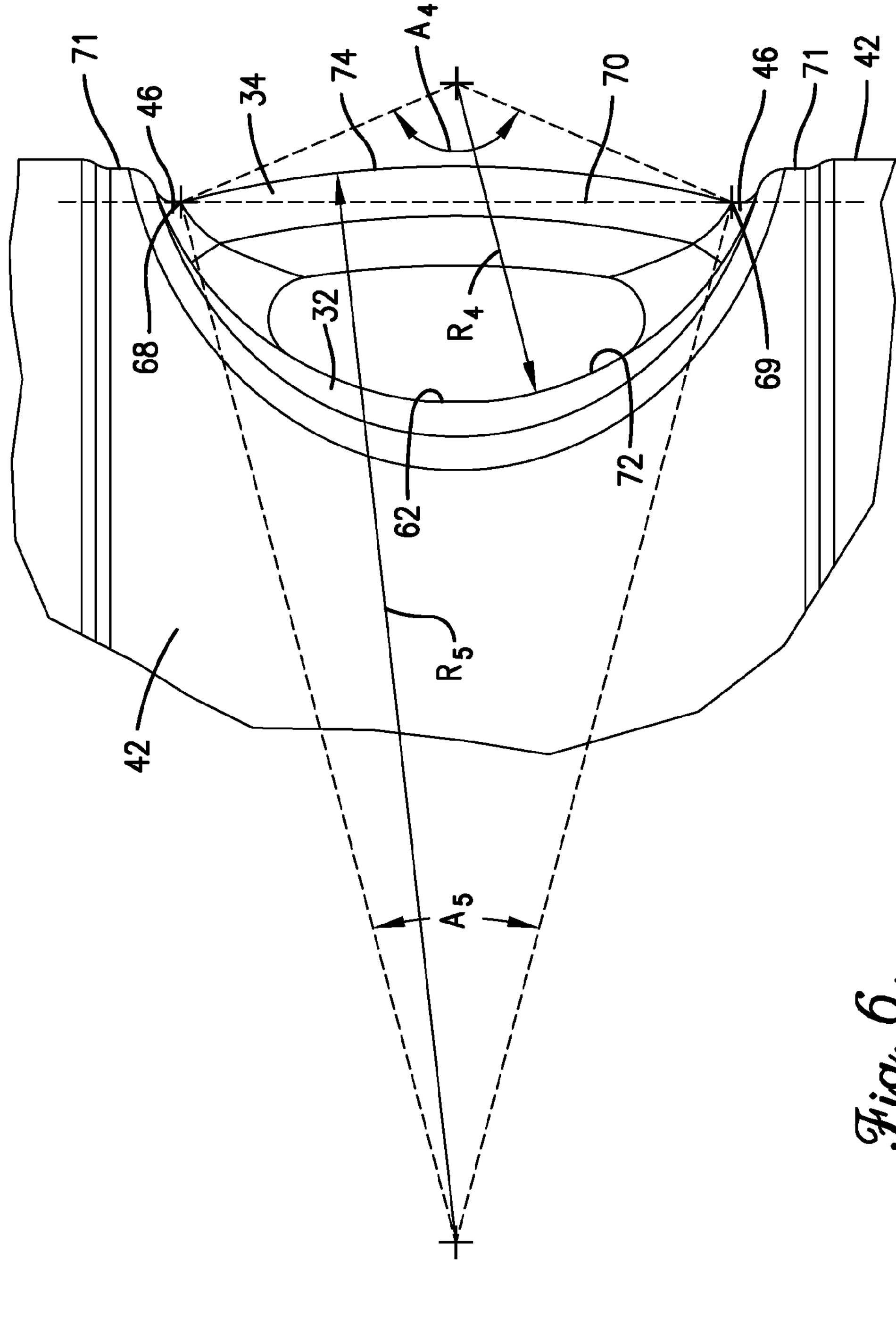

Fig. 6.

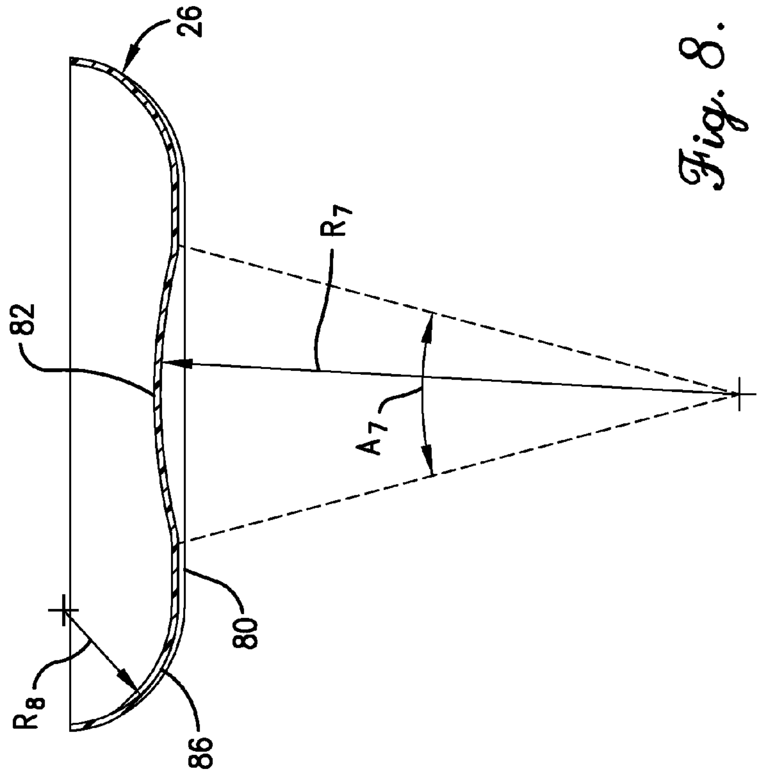

Fig. 8.

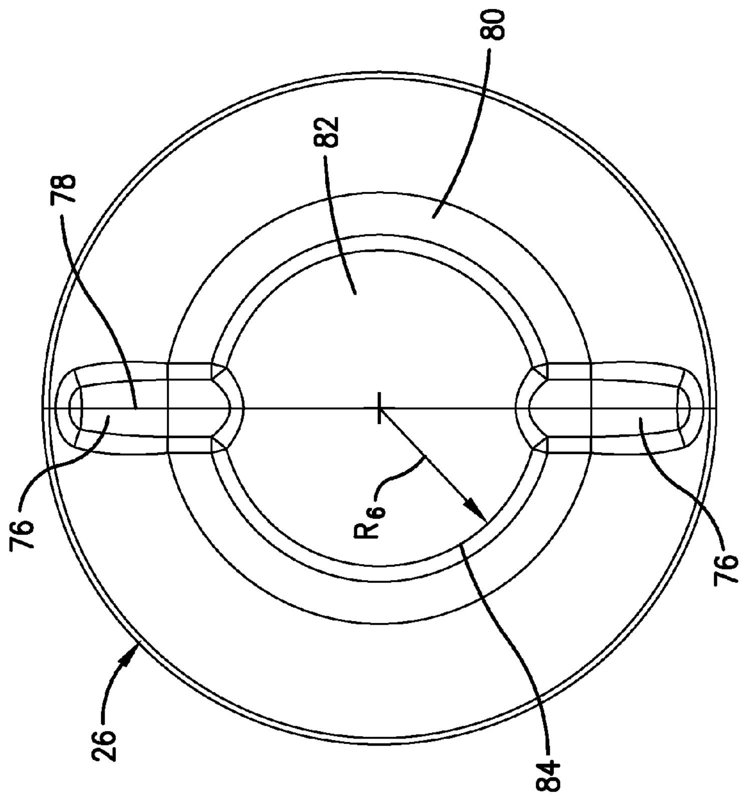

Fig. 7.

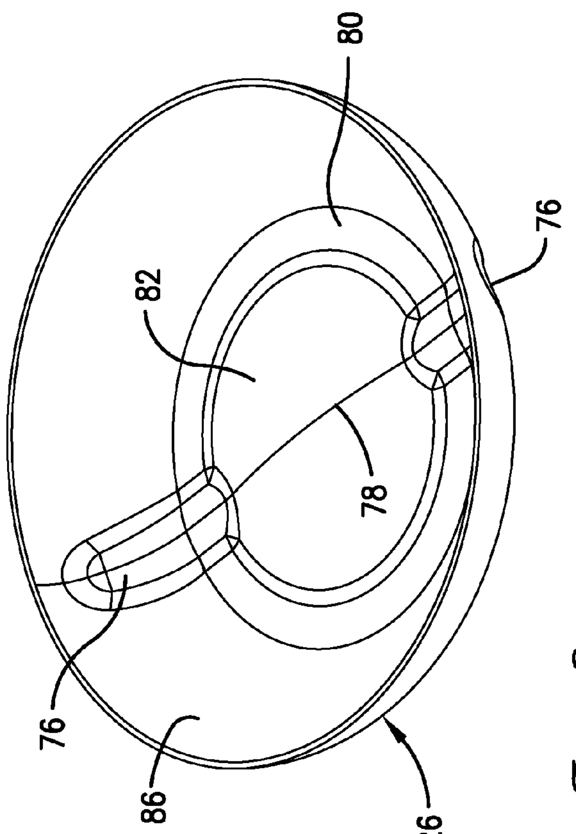

Fig. 9.

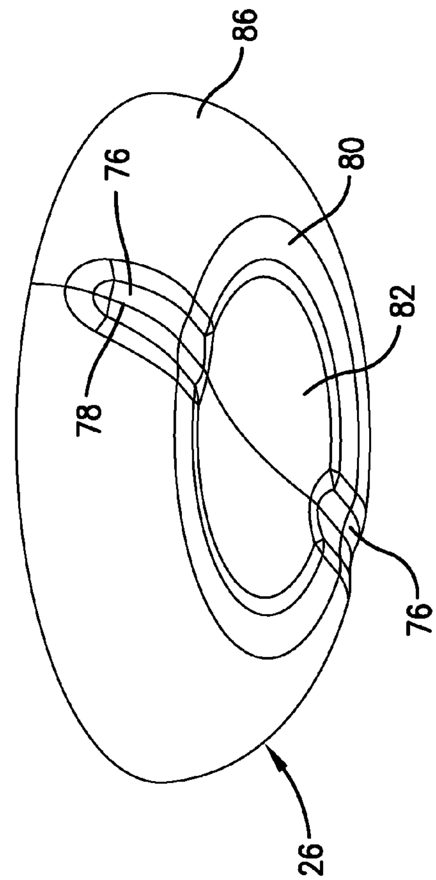

Fig. 10.

HIGH STRENGTH BOTTLE

BACKGROUND

[0001] 1. Field of the Invention

[0002] The present invention is directed to bottles having handles. More particularly, the present invention is directed to large capacity bottles having handles and being suitable for use in liquid dispensers, such as water coolers.

[0003] 2. Description of the Related Art

[0004] BPA-based polycarbonates have long been used to produce various types of food and beverage containers. However, due to some reports that BPA-based polycarbonates may have negative health effects, an emphasis has recently been placed on producing containers that are "BPA-free." In particular, the container industry has focused on the production of beverage bottles, where leaching of BPA into the beverage has been a concern due to the prolonged exposure of the beverage to the BPA-based polycarbonate. However, most of the bottle industry's BPA-free focus has been on smaller bottles with a capacity of less than one liter.

[0005] Despite the desire to produce beverage bottles that are BPA-free, many materials that could potentially replace BPA-based polycarbonates exhibit deficiencies in one or more important characteristics, such as strength, toughness, chemical resistance, clarity, heat resistance, and/or processability. Currently, there are no BPA-free bottles having a large capacity (e.g., at least 2.5 gallons) that are sufficiently designed to exhibit the desired characteristics (e.g., strength, toughness, chemical resistance, heat resistance, and/or clarity) sought in large capacity bottles.

[0006] Accordingly, there is a need for a large capacity bottle that can be formed of a BPA-free material, yet still exhibit the desired characteristics.

SUMMARY

[0007] One embodiment of this invention is directed to a bottle comprising an outlet at a first end of the bottle, a base at a second end of the bottle, and a main body located between the outlet and base. A central longitudinal axis extends in a longitudinal direction between the first and second ends of the bottle. The main body of the bottle comprises a well panel and an integrally-formed handle. The well panel at least partly defines a recessed well and the handle spans at least a portion of the recessed well. The outer surface of the well panel defines a concave longitudinal panel curve along a longitudinal reference plane, which contains the longitudinal axis and extends through the centroid of the well panel. The outer surface of the well panel defines a convex transverse panel curve along a transverse reference plane that extends through the centroid of the well panel and is oriented such that the longitudinal axis is normal to the transverse reference plane.

[0008] Another embodiment of the invention is directed to a substantially BPA-free bottle comprising an outlet at a first end of the bottle, a base at a second end of the bottle, and a main body located between the outlet and base. The bottle defines a central longitudinal axis extending in a longitudinal direction between the first and second ends of the bottle. Furthermore, the main body comprises a well panel and a handle, wherein the well panel at least partly defines a recessed well and the handle spans at least a portion of the recessed well. The bottle comprises a synthetic polymeric material that makes up at least 90 percent of the total weight of the bottle, Additionally, the synthetic polymeric material comprises less than 1 weight percent of bisphenol A polycarbonate. Moreover, the bottle has a liquid holding capacity of at least 2.5 gallons and a weight of at least 600 grams and not more than 900 grams. Finally, the bottle has a drop impact resistance of at least 3 feet as measured by ASTMD 2463-95.

BRIEF DESCRIPTION OF THE FIGURES

[0009] Embodiments of the present invention are described herein with reference to the following drawing figures, wherein:

[0010] FIG. **1** is a side view of a bottle configured in accordance with one embodiment of the present invention, particularly illustrating the bottle as including a well and a handle spanning the well;

[0011] FIG. **2** is a back view of the bottle rotated 90° from the view depicted in FIG. **1**;

[0012] FIG. **3** is an isometric bottom view of the bottle depicted in FIG. **1**;

[0013] FIG. **4** is a side view of the bottle of FIG. **1**, with the handle being removed to more clearly show the well panel of the bottle;

[0014] FIG. **5** is a cross-sectional view of the bottle taken along line **5-5** in FIG. **1**, particularly illustrating the transverse (horizontal) curvature of the well panel;

[0015] FIG. **6** is a partial side view of the handle and well panel of the bottle, particularly illustrating the longitudinal (vertical) curvatures of the well panel and the handle;

[0016] FIG. **7** is a bottom view of the base of the bottle;

[0017] FIG. **8** is a partial cross-sectional side view of the base of the bottle, particularly illustrating the radii of curvature of the chime and push-up;

[0018] FIG. **9** is partial, top, isometric view of the base of the bottle, particularly illustrating the recessed tunnels and the weld; and

[0019] FIG. **10** is a partial, bottom, isometric view of the base of the bottle, particularly illustrating the recessed tunnels and the weld.

DETAILED DESCRIPTION

[0020] In one embodiment, the present invention is directed to a large bottle having enhanced strength properties such as, for example, drop impact resistance. Such bottles may be suitable for use in liquid dispensers such as water coolers.

[0021] The bottle can have a liquid holding capacity of at least 2.5, 4.0, 4.5, or 4.75 gallons and/or not more than 10, 8, 6, or 5.5 gallons. In one embodiment, the bottle can have a liquid holding capacity of about 5 gallons. Furthermore, the bottle can have a weight of at least 600, 650, 700, or 725 grams and/or not more than 900, 850, 800, or 775 grams. To ensure that the bottle can fit into a standard liquid dispenser, the bottle can have a maximum diameter of at least 6, 8, or 10 inches and/or not more than 18, 14, or 12 inches.

[0022] The strength of the bottle can be measured in terms of drop impact resistance. In one embodiment, the bottle can have a drop impact resistance of at least 3, 4, or 5 feet as measured by ASTM D 2463-95. The enhanced strength of the bottle can be at least partly derived from its physical design. To further illustrate the physical design of the bottle, various features of the bottle are described in detail below with reference to the drawing figures.

[0023] As shown in FIGS. **1-3**, the bottle **20** comprises an outlet **22** at a first end **24** of the bottle **20**, a base **26** at a second end **28** of the bottle **20**, and a main body **30** located between the outlet **22** and the base **26**. The main body **30** comprises a well panel **32** and an integrally-formed handle **34**. The well panel **32** at least partly defines a recessed well **36** and the handle **34** at least partially spans this recessed well **36**. Additionally, the main body **30** may also include a first rib **38**, a second rib **40**, and a substantially cylindrical sidewall **42** disposed between the first rib **38** and second rib **40**. The main body **30** can also include a panel fillet **44** for joining the well panel **32** with the sidewall **42**, as well as handle fillets **46** for joining the handle **34** to the well panel **32**. As perhaps best illustrated in FIG. **2**, the panel fillet **44** can circumscribe the entire well panel **32**.

[0024] The bottle **20** depicted in FIGS. **1-3** also includes a neck **52**, an expansion section **54**, and a shoulder **56**. The neck **52** is located adjacent to the outlet **22**, the shoulder **56** is located adjacent to the main body **30**, and the expansion section **54** is located between the neck **52** and shoulder **56**. The expansion section **54** can have, for example, a generally frusta-conical shape.

[0025] FIG. **3** illustrates the central longitudinal axis **58** of the bottle **20**. The central longitudinal axis **58** extends in a longitudinal direction between the first end **24** and second end **28** of the bottle **20** and through the geometric center of the outlet **22** and the geometric center of the base **26**. The sidewall **42** can be centered on and can extend substantially parallel to the central longitudinal axis **58**.

[0026] FIG. **4** depicts a side view of the bottle **20** (not showing the handle) focusing on the well panel **32** and showing reference planes (dashed lines) used to help describe the shape of the well panel **32**. FIG. **4** also shows that the expansion section **54** can form an angle (A**1**) of at least 20, 25, or 27.5 degrees and/or not more than 40, 35, or 30 degrees from a plane oriented such that the central longitudinal axis **58** is normal thereto.

[0027] FIG. **4** illustrates a longitudinal (vertical) reference plane **60** that contains the central longitudinal axis **58** and extends through a centroid **50** of the well panel **32**. Further, FIG. **4** shows a transverse (horizontal) reference plane **61** that extends through the centroid **50** of the well panel **32** and is oriented such that the central longitudinal axis **58** is normal (perpendicular) to the transverse reference plane **61**. The longitudinal and transverse reference planes **60**, **61** will be discussed in more detail below with reference to FIGS. **5-10**.

[0028] FIG. **5** shows that the handle **34** of the bottle **20** can be substantially hollow and in fluid communication with the interior of the bottle **20**. In one embodiment, the handle **34** defines an open internal passageway **66** sized to permit a sphere having a diameter of at least 0.5, 0.75, 1, or 1.25 inches to pass entirely therethrough.

[0029] FIG. **5** also shows that the outer surface **62** of the well panel **32** can define a convex transverse panel curve **64** at the location where the well panel **32** is cut by the transverse reference plane **61**. As shown in FIG. **5**, the transverse panel curve **64** can have a radius of curvature (R**2**) that is greater than the radius of curvature (R**3**) of the sidewall **42**, measured at the location where the transverse reference plane **61** cuts through the bottle **20**. Moreover, the ratio of the radius of curvature (R**2**) of the transverse panel curve **64** to the radius of curvature (R**3**) of the sidewall **42**, as measured along the transverse reference plane **61**, can be at least 2:1, 3:1, 4:1, or 5:1 and/or not more than 20:1, 15:1, 10:1, or 8:1, The radius of curvature (R**2**) of the transverse panel curve **64** can be at least 10, 20, or 25 inches and/or not more than 60, 50, or 40 inches. Additionally or alternatively, the radius of curvature (R**3**) of the sidewall **42**, as measured along the transverse reference plane **61**, can be at least 2, 3.5, or 4.5 and/or not more than 10, 8, or 6 inches.

[0030] As depicted in FIG. **5**, the transverse panel curve **64** can extend circumferentially through an angle (A**2**) of least 15, 25, or 30 degrees and/or not more than 90, 80, or 70 degrees. Additionally or alternatively, the transverse panel curve **64** can extend circumferentially through an angle (A**3**) of at least 90, 100, 110, or 120 degrees and not more than 180, 160, or 140 degrees, as measured relative to the central longitudinal axis **58**.

[0031] As shown in FIG. **6**, the outer surface **62** of the well panel **32** can define a concave longitudinal panel curve **72** at the location where the well panel **32** is cut by the longitudinal reference plane **60**. The radius of curvature (R**4**) of the longitudinal panel curve **72** can be at least 1, 2, or 3 inches and/or not more than 10, 6, or 4 inches. Additionally or alternatively, the longitudinal panel curve **72** can extend longitudinally through an angle (A**4**) of at least 100, 115, or 125 degrees and/or not more than 180, 160, or 145 degrees. The concave longitudinal panel curve **72** and the convex transverse panel curve **64** can provide the outer surface **62** of the well panel **32** with the shape of a hyperbolic paraboloid.

[0032] As depicted in FIG. **6**, the handle **34** can define first and second handle end points **68** and **69** located on the outermost opposite terminal ends of the handle **34**. Furthermore, a handle orientation line **70** can be defined between the first and second handle end points **68**. The handle orientation line **70** can be either parallel to the central longitudinal axis **58** or skewed relative to the central longitudinal axis **58** by an angle of less than 20, 10, 5, or 1 degrees. Further, the handle orientation line **70** can be spaced inwardly (toward the central longitudinal axis **58**) from the outer circumference **71** of the sidewall **42** by a distance of at least 0.1, 0.25, or 0.5 inches.

[0033] In addition, FIG. **6** shows that the handle **34** can have a curved outer profile **74** extending between the first and second handle end points **68**, **69**. The curved outer profile **74** of the handle **34** can have a radius of curvature (R**5**) of at least 4, 8, or 12 inches and/or not more than 30, 24, or 18 inches. Additionally or alternatively, the curved outer profile **74** of the handle **34** can extend longitudinally through an angle (A**5**) of at least 5, 10, 15 degrees and/or not more than 50, 40, 30 degrees.

[0034] As illustrated in FIGS. **7-10**, the base **26** of the bottle **20** can comprise a pair of concave tunnel recesses **76**. Additionally, the base **26** can comprise a weld **78** that extends along the transverse reference plane **61** and through the tunnel recesses **76** so as to prevent contact between the weld **78** and a planar supporting surface (not shown) on which the base **26** of the bottle **20** rests. The base **26** can also include a footprint **80** for supporting the bottle **20** on a planar surface and a concave push-up 82 positioned radially inward from the footprint **80**. As shown in FIG. **7**, the push-up 82 can have a substantially circular outer perimeter **84** having a radius (R**6**) of at least 1, 1.5, or 1.75 inches and/or not more than 5, 3, or 2.5 inches.

[0035] FIG. **8** clearly shows the concave nature of the push-up 82. The push-up 82 can have a radius of curvature (R**7**) of at least 2, 4, or 6 inches and/or not more than 18, 12, or 8 inches. Additionally or alternatively, the push-up 82 can extend through an angle (A**7**) of at least 15, 20, or 27.5 degrees and/or not more than 50, 40, or 35 degrees. In one embodiment, the push-up 82 can have the general shape of a partial sphere (i.e., the top portion of a sphere). As depicted in

FIG. **8**, the base **26** can further comprise a chime **86**. The chime **86** can have a radius of curvature (R**8**) of at least 1, 1.5, or 1.75 inches and/or not more than 4, 3, or 2 inches.

[0036] Certain aspects of the above-described bottle design enable the bottle to be produced from a substantially BPA-free material, while still maintaining the desired strength for the bottle. Thus, in one embodiment, the bottle of the present invention can be made from materials other than BPA-based polycarbonates. As used herein, "substantially BPA-free" refers to an article or material that contains less than 1, 0.5, 0.1, 0.05, or 0.01 weight percent of BPA-based polycarbonate.

[0037] In one embodiment of the present invention, the bottle can be at least partly formed from a substantially BRA-free synthetic polymeric material. The synthetic polymeric material can make up at least 50, 75, 90, 95, or 100 percent of the total weight of the bottle. In one embodiment, the bottle of the present invention can be formed by blow molding the synthetic polymeric material into the desired configuration discussed in detail above.

[0038] The synthetic polymeric material used to make the bottle can have a flexural modulus of at least 100,000, 150, 000, 200,000, or 215,000 psi and/or not more than 350,000, 300, 000, 250,000, or 230,000 psi as measured by ASTM D790. The synthetic polymeric material can have a flexural yield strength of at least 5,000, 7,000, or 8,500 psi and/or not more than 12,000, 10,000, or 9,500 psi as measured by ASTM D790. The synthetic polymeric material can have a tensile strength at yield of at least 4,000, 5,000, 6,000, 6,500, or 7,250 psi and/or not more than 10,000, 9,000, 8000, or 7,000 psi as measured by ASTM D638. The synthetic polymeric material can have an impact strength of at least 8, 12, 14, or 15 ft-lb/in as measured by ASTM D256. The synthetic polymeric material can have a glass transition temperature of at least 90, 100, or 110 and/or not more than 140, 130, or 120° C. as measured by ASTM E1640-09. The synthetic polymeric material can have a melt viscosity of at least 1,000, 2,000, or 3,000 poise and/or not more than 20,000, 15,000, 12,000, 10,000, 8,000, or 6,000 poise as measured at 1 radian per second on a rotary melt rheometer at 290° C. The synthetic polymeric material can have an inherent viscosity of at least 0.4, 0.5, 0.6, 0.65, or 0.7 and/or not more than 1.0, 0.9, 0.8, or 0.75, as determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.5 grams per 100 milliliters at 25° C. The synthetic polymeric material can have a transmittance of at least 75, 85, or 88 percent as measured by ASTM D1003. The synthetic polymeric material can have a haze of less than 5, 3, or 1.5 percent as measured by ASTM D1003.

[0039] According to certain embodiments of the present invention, the synthetic polymeric material can be a polyester or copolyester. In one embodiment, the synthetic polymeric material can comprise glycol units derived from 2,2,4,4-tetramethyl-1,3-cyclobutanediol and/or 1,4-cyclohexanedimethanol. In a more specific example, the synthetic polymeric material can be a polyester having a dicarboxylic acid component and a glycol component, where the dicarboxylic component comprises at least 70, 80, 90, 95, or 100 mole percent of terephthalic acid residues and the glycol component comprises at least 10, 15, 20, or 25 mole percent and/or not more than 80, 60, 40, 35, or 30 mole percent of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and at least 20, 40, 60, 65, or 70 mole percent and/or not more than 90, 85, 80, or 75 mole percent of 2,2,4,4-tetramethyl-1,3-cyclobutanediol.

[0040] In one embodiment, the synthetic polymeric material can comprise TRITAN WX500 or TRITAN WX510, available from Eastman Chemical Company of Kingsport, Tenn.

[0041] The inventors hereby state their intent to rely on the Doctrine of Equivalents to determine and assess the reasonably fair scope of the present invention as it pertains to any apparatus not materially departing from but outside the literal scope of the invention as set forth in the following claims.

What is claimed is:

1. A bottle comprising an outlet at a first end of said bottle, a base at a second end of said bottle, and a main body located between said outlet and said base, wherein said bottle defines a central longitudinal axis extending in a longitudinal direction between said first and second ends of said bottle, wherein said main body comprises a well panel and an integrally-formed handle, wherein said well panel at least partly defines a recessed well and said handle spans at least a portion of said recessed well, wherein the outer surface of said well panel defines a concave longitudinal panel curve along a longitudinal reference plane containing said central longitudinal axis and extending through the centroid of said well panel, wherein the outer surface of said well panel defines a convex transverse panel curve along a transverse reference plane that extends through the centroid of said well panel and is oriented such that said central longitudinal axis is normal to said transverse reference plane.

2. The bottle of claim **1**, wherein the outer surface of said well panel has the shape of a hyperbolic paraboloid.

3. The bottle of claim **1**, wherein said transverse panel curve has a radius of curvature (R**2**) of at least 10 inches and not more than 60 inches, wherein said transverse panel curve extends circumferentially through an angle (A**3**) of at least 90 degrees and not more than 180 degrees, measured relative to said central longitudinal axis.

4. The bottle of claim **1**, wherein said longitudinal panel curve has a radius of curvature (R**4**) of at least 1 inch and not more than 10 inches, wherein said longitudinal panel curve extends longitudinally through an angle (A**4**) of at least 100 degrees and not more than 180 degrees.

5. The bottle of claim **1**, wherein said main body further comprises at least one sidewall extending substantially parallel to said central longitudinal axis, wherein said sidewall has a substantially cylindrical shape and is centered around said central longitudinal axis, wherein the ratio of the radius of curvature of said transverse panel curve (R**2**) to the radius of curvature of said sidewall (R**3**), measured along said transverse reference plane, is at least 2:1 and not more than 20:1.

6. The bottle of claim **1**, wherein said handle defines an open internal passageway sized to permit a sphere having a diameter of at least 0.5 inches to pass entirely therethrough.

7. The bottle of claim **1**, wherein said handle presents a curved outer profile, wherein said curved outer profile has a radius of curvature (R**5**) of at least 4 inches and not more than 30 inches, wherein said curved outer profile extends longitudinally through an angle (A**5**) of at least 5 degrees and not more than 50 degrees.

8. The bottle of claim **1**, wherein said handle defines first and second handle end points located on the outermost opposite terminal ends of said handle, wherein a handle orientation line is defined between said first and second handle end points, wherein said handle orientation line is either parallel to said central longitudinal axis or skewed relative to said central longitudinal axis by an angle of less than 20 degrees.

9. The bottle of claim **8**, wherein said main body further comprises a substantially cylindrical sidewall to which said well panel is coupled, wherein said handle orientation line is spaced inwardly from the outer circumference of said sidewall by a distance of at least 0.1 inches.

10. The bottle of claim **1**, wherein said base comprises a chime and a concave push-up.

11. The bottle of claim **10**, wherein said push-up has a radius of curvature (R**5**) of at least 2 inches and not more than 18 inches.

12. The bottle of claim **10**, wherein said push-up has a substantially circular outer perimeter having a radius (R**6**) of at least 1.5 inches and not more than 5 inches.

13. The bottle of claim **10**, wherein said bottle comprises a weld extending along said transverse reference plane, wherein said base further comprises a pair of concave tunnel recesses, wherein said weld extends through said tunnel recesses.

14. The bottle of claim **1**, wherein bottle further comprises a neck, an expansion section, and a shoulder, wherein said neck is located adjacent said outlet, said shoulder is located adjacent said main body, and said expansion section is located between said neck and said shoulder, wherein said expansion section has a generally frusto-conical shape, wherein said expansion section forms an angle (A**1**) of at least 25 degrees and not more than 40 degrees from a plane normal to said central longitudinal axis.

15. The bottle of claim **1**, wherein said bottle has a weight of at least 600 grams and not more than 900 grams, wherein said bottle has a liquid holding capacity of at least 2.5 gallons and not more than 10 gallons.

16. The bottle of claim **15**, wherein said bottle has a drop impact resistance of at least 3 feet as measure by ASTM D 2463-95.

17. The bottle of claim **15**, wherein said bottle is at least partly formed of a synthetic polymeric material, wherein said synthetic polymeric material makes up at least 50 percent of the total weight of said bottle.

18. The bottle of claim **17**, wherein said synthetic polymeric material comprises less than 1 weight percent of bisphenol A polycarbonate.

19. The bottle of claim **17**, wherein said polymeric material has a flexural modulus of at least 100,000 psi and not more than 300,000 psi as measured by ASTM D790.

20. The bottle of claim **17**, wherein said polymeric material comprises a dicarboxylic acid component and a glycol component, wherein said dicarboxylic acid component comprises at least 70 mole percent of terephthalic acid residues, wherein said glycol component comprises at least 10 mole percent and not more than 80 mole percent of 2,2,4,4-tetramethyl-1,3-cyclobutanediol, wherein said glycol component comprises at least 20 mole percent and not more than 90 mole percent of 2,2,4,4-tetramethyl-1,3-cyclobutanediol.

21. A substantially BPA-free bottle comprising an outlet at a first end of said bottle, a base at a second end of said bottle, and a main body located between said outlet and said base, wherein said bottle defines a central longitudinal axis extending in a longitudinal direction between said first and second ends of said bottle, wherein said main body comprises a well panel and a handle, wherein said well panel at least partly defines a recessed well and said handle spans at least a portion of said recessed well, wherein said bottle comprises a synthetic polymeric material that makes up at least 90 percent of the total weight of said bottle, wherein said synthetic polymeric material comprises less than 1 weight percent of bisphenol A polycarbonate, wherein said bottle has a liquid holding capacity of at least 2.5 gallons, wherein said bottle has a weight of at least 600 grams and not more than 900 grams, wherein said bottle has a drop impact resistance of at least 3 feet as measured by ASTMD 2463-95.

22. The bottle of claim **21**, wherein said polymeric material has a flexural modulus of at least 100,000 psi and not more than 300,000 psi as measured by ASTM D790.

23. The bottle of claim **21**, wherein said polymeric material has a transmittance of at least 85 percent as measured by ASTM D1003, wherein said polymeric material has a haze of less than 3 percent as measured by ASTM D1003.

24. The bottle of claim **21**, wherein said polymeric material is a polyester or copolyester.

25. The bottle of claim **21**, wherein said polymeric material comprises a dicarboxylic acid component and a glycol component, wherein said dicarboxylic acid component comprises at least 70 mole percent of terephthalic acid residues, wherein said glycol component comprises at least 10 mole percent and not more than 80 mole percent of 2,2,4,4-tetramethyl-1,3-cyclobutanediol, wherein said glycol component comprises at least 20 mole percent and not more than 90 mole percent of 2,2,4,4-tetramethyl-1,3-cyclobutanediol.

26. The bottle of claim **21**, wherein said polymeric material is TRITAN WX500 or TRITAN WX510.

27. The bottle of claim **21**, wherein said well panel has the shape of a hyperbolic paraboloid.

28. The bottle of claim **21**, wherein said main body further comprises at least one sidewall extending substantially parallel to said central longitudinal axis, wherein said sidewall has a substantially cylindrical shape and is centered around said central longitudinal axis, wherein the outer surface of said well panel defines a convex transverse panel curve along a transverse reference plane extending normal to said central longitudinal axis and through the centroid of said well panel, wherein the ratio of the radius of curvature of said transverse panel curve (R**2**) to the radius of curvature of said sidewall (R**3**), measured along said transverse reference plane, is at least 2:1 and not more than 20:1.

29. The bottle of claim **21**, wherein the outer surface of said well panel defines a convex transverse panel curve along a transverse reference plane that extends through the centroid of said well panel and is oriented such that said central longitudinal axis is normal to said transverse reference plane, wherein a radius of curvature of said transverse panel curve (R**2**) is at least 10 inches and not more than 60 inches, wherein said transverse panel curve extends circumferentially through an angle (A**3**) of at least 90 degrees and not more than 180 degrees as measured relative to said central longitudinal axis, wherein the outer surface of said well panel defines a concave longitudinal panel curve along a longitudinal reference plane containing said central longitudinal axis and extending through the centroid of said well panel, wherein a radius of curvature of said longitudinal panel curve (R**4**) is at least 1 inch and not more than 10 inches, wherein said longitudinal panel curve extends longitudinally through an angle (A**4**) of at least 100 degrees and not more than 180 degrees.

30. The bottle of claim **21**, wherein said handle is substantially hollow and is in fluid communication with the interior of said bottle.

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