US 20040000533A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2004/0000533 A1
(43) Pub. Date: Jan. 1, 2004
Kamineni et al.

(54) PRESSURIZABLE CONTAINER

(76) Inventors: **Satya Kamineni**, Westmont, IL (US); **Michael R. Mooney**, Frankfort, IL (US)

Correspondence Address:
WOODCOCK WASHBURN LLP
ONE LIBERTY PLACE, 46TH FLOOR
1650 MARKET STREET
PHILADELPHIA, PA 19103 (US)

(21) Appl. No.: **10/187,634**

(22) Filed: **Jul. 1, 2002**

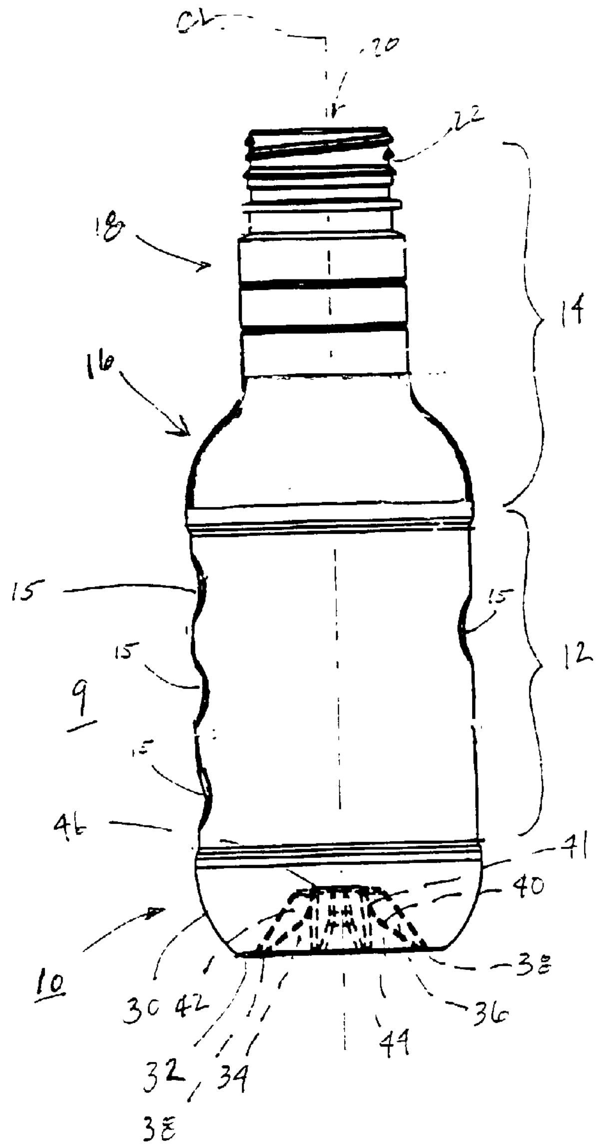
Publication Classification

(51) Int. Cl.^{7} **B65D 8/06**; B65D 90/02; B65D 6/28; B65D 8/04

(52) U.S. Cl. **215/373**; 220/606; 215/384

(57) **ABSTRACT**

A container base that is capable of receiving positive internal pressure, such as that created by introducing liquefied gas during a hot filling process, includes either ribs that substantially connect to a standing ring or a draft surface formed on the bottom of the ribs, or a combination of such features.



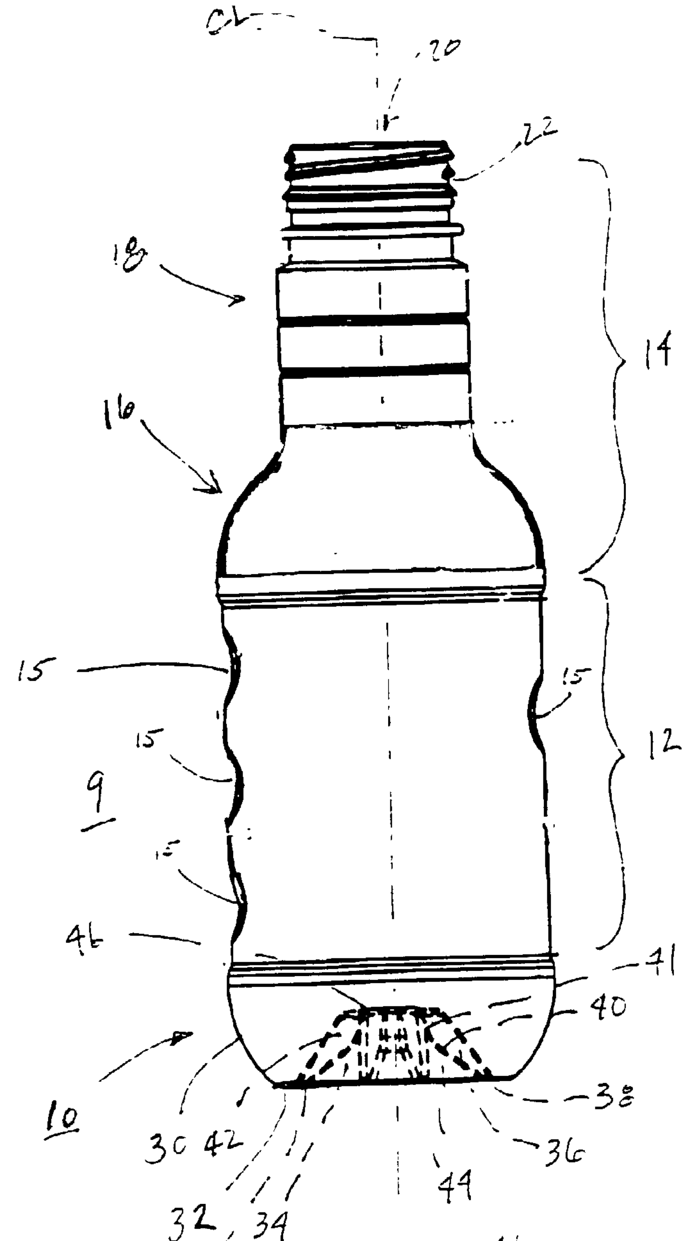

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Fig 1

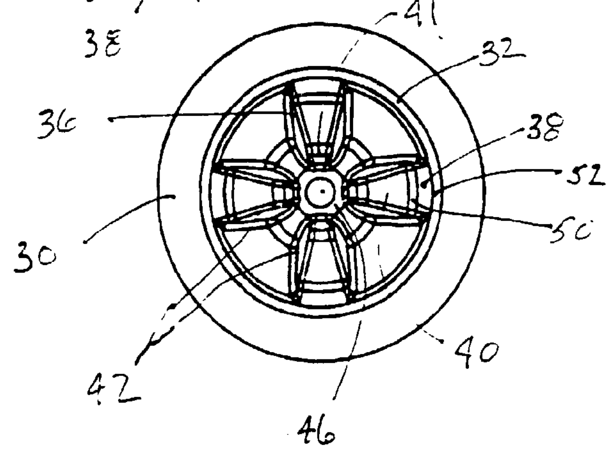
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Fig 2

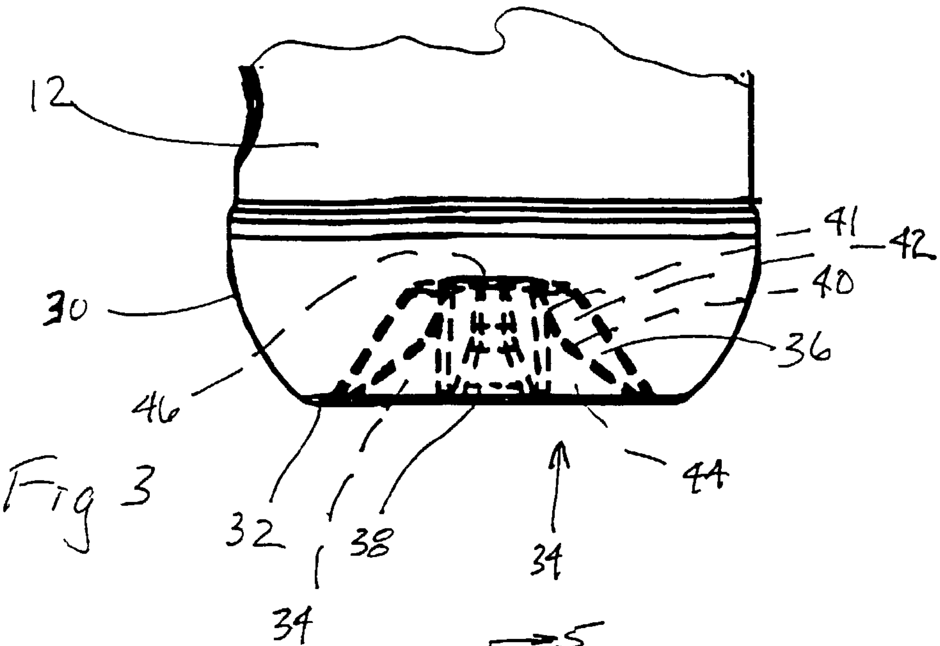
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Fig 3

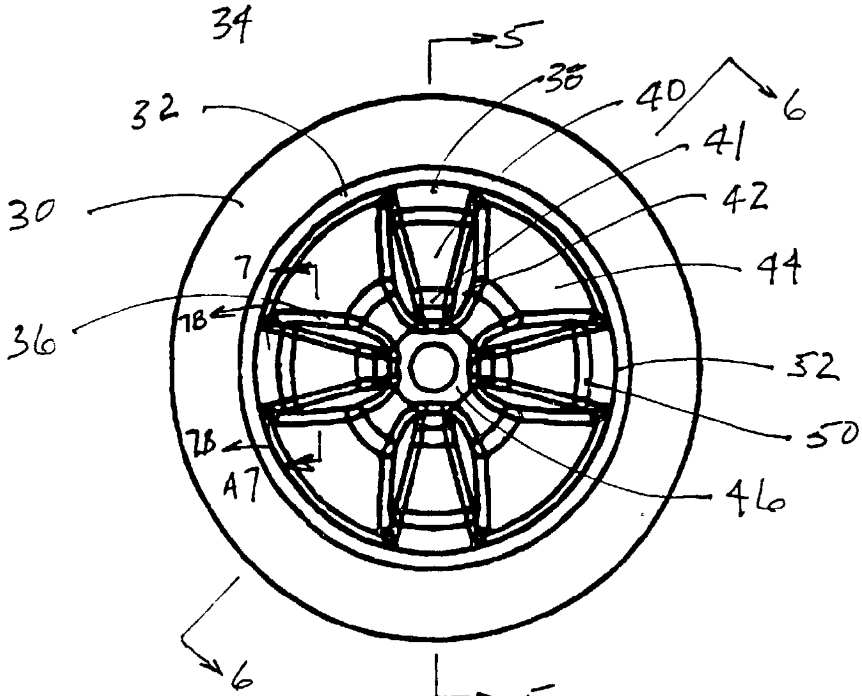
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Fig 4

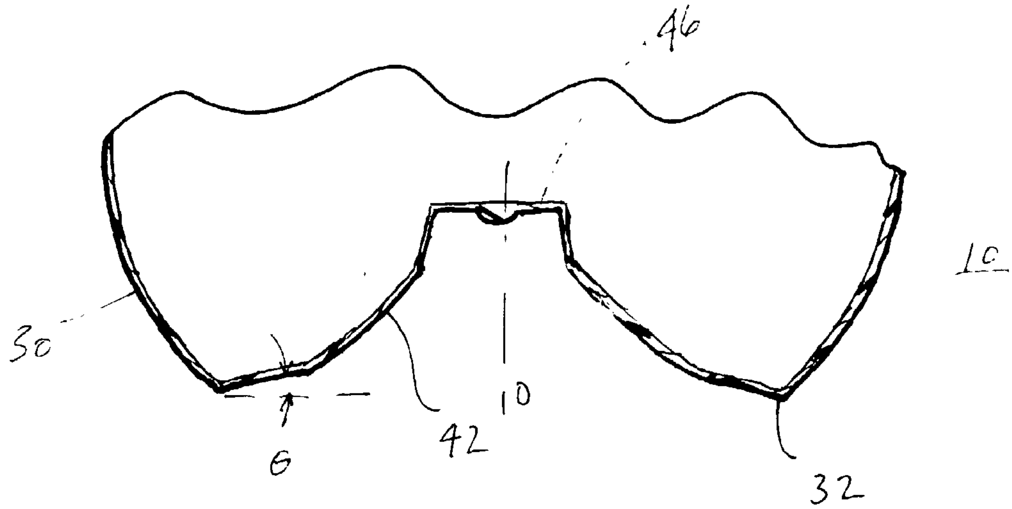

Fig 5

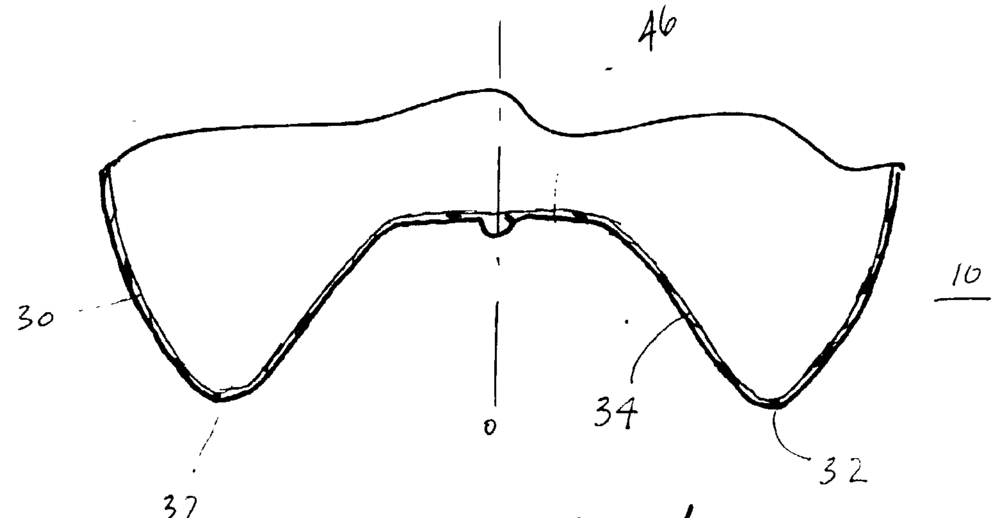

Fig 6

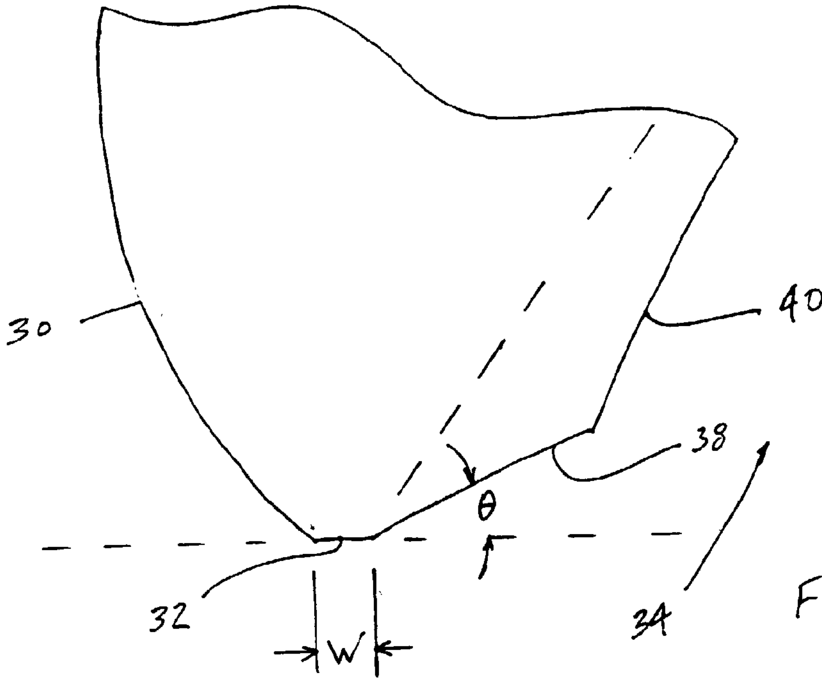

Fig 8A

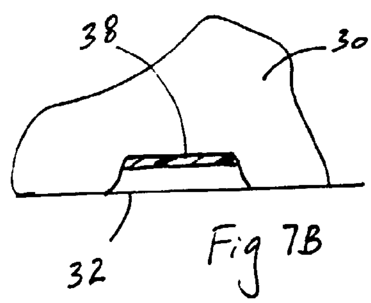

Fig 7B

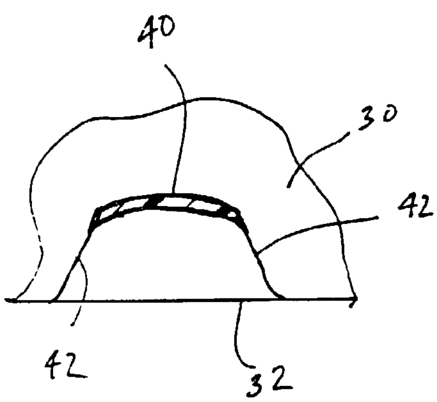

Fig 7A

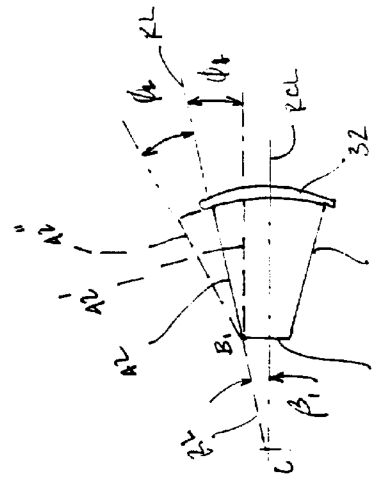

Fig 9A

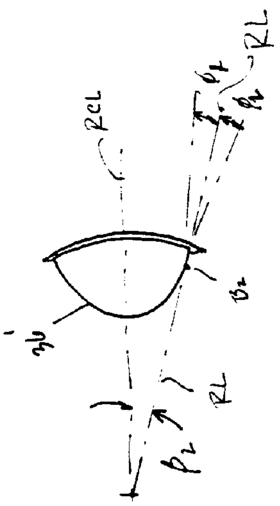

Fig 9B

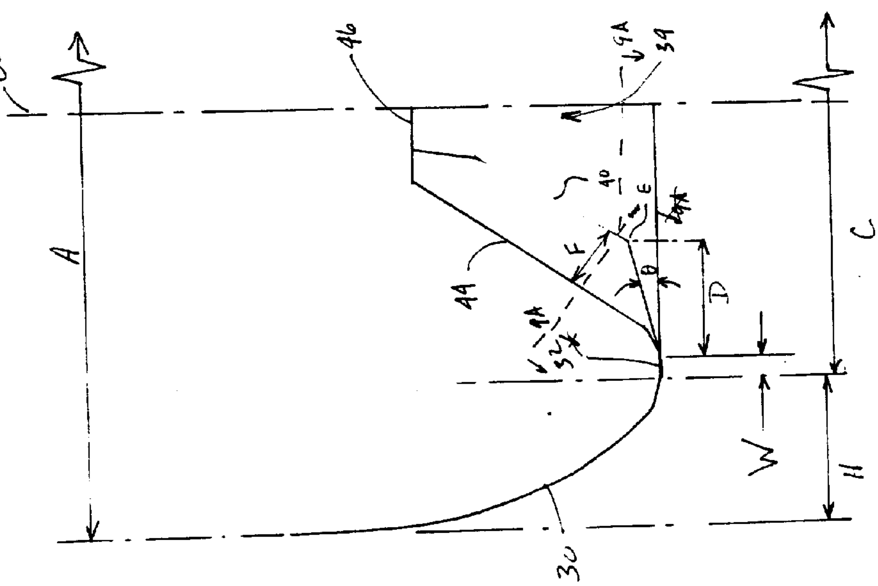

Fig 8B

PRESSURIZABLE CONTAINER

BACKGROUND OF THE INVENTION

[0001] The present invention relates to plastic containers, and more particularly to plastic containers capable of receiving positive internal pressure.

[0002] Consumers and manufacturers often prefer containers to glass containers for containing comestible products. The safety and appeal of plastic containers for such products have been enhanced by the development of hot-filling processes, in which a product is introduced into the container at an elevated temperature—typically 180 degrees to 190 degrees F.—and sealed.

[0003] Hot filling capabilities have spurred the development of related technologies to address problems of container thermal shrinkage and vacuum-induced deformation. To reduce shrinkage of polyethylene terephthalate ("PET") containers upon exposure to hot-fill temperatures, for example, PET containers typically undergo a "head-set" process. Often, a PET container is head-set by blow molding at an elevated temperature (compared with those for conventional containers for non-hot-fill applications, such as carbonated soft drinks) for predetermined times, and held at predetermined temperatures for predetermined times. Further, heat set containers are typically formed from a plastic mix having higher intrinsic viscosity that that for bottles suitable only for non-hot-fill, PET applications, such as carbonated soft drinks.

[0004] Head-set PET containers are, thus, able to be filled at conventional hot-fill temperatures with acceptable shrinkage, such as approximately one percent, as for example taught in U.S. Pat. No. 4,863,046 (Collette). Further, heat-treating or heat-setting is taught in a number of patents, including, for example, U.S. Pat. No. 4,233,022 (Brady), U.S. Pat. No. 4,711,624 (Watson), and U.S. Pat. No. 4,219,526 (Mehnert). Each of the patents and applications referred to in the specification is incorporated herein by reference in its entirety.

[0005] Vacuum deformation of a hot-filled container occurs upon capping and cooling after filling with contents at an elevated temperature. Employing vacuum panels or others structure(s) that flex or deform in response to internal container negative pressure has been a popular approach to preventing container collapse upon vacuum deformation. Numerous approaches to vacuum panels in the container sidewalls have been developed. For example, U.S. Pat. Nos. 5,178,289, 5,092,475, and 5,054,632 teach stiffening portions or ribs to increase hoop stiffness and eliminate bulges while integral vacuum panels collapse inwardly.

[0006] Other containers include a pair of vacuum panels, each of which has an indentation or grip portion enabling the container to be gripped between a user's thumb and fingers. For example, U.S. Pat. No. 5,141,120 teaches a bottle having a hinge continuously surrounding a vacuum panel, which includes indentations for gripping. In response to cooling of the container contents, the hinge enables the entire vacuum panel in collapse inwardly. U.S. Pat. No. 5,141,121 similarly teaches a bottle having an outward bulge that inverts in response to cooling of the container contents. Further, bases for heat-set, hot-fillable containers have been developed which are capable of withstanding internal negative pressures common to hot-filling applications. Such bases typically have a continuous standing ring on which the container rests and a ribbed recess portion. For example, U.S. Pat. Nos. 5,503,283; 5,642,826; 4,993,567; 4,993,566; 4,598,831; and 4,108,324 disclose conventional base configurations.

[0007] Often, a continuous standing ring is commercially beneficial because it enables the plastic bottle to mimic the overall appearance of a glass bottle. Further, bases for heat-set, hot-fillable bottles typically have a standing ring that is substantially flat and horizontal in order to accommodate internal negative pressure. In order to promote flexing or deformation of the standing ring, and thereby relieve stress inherent upon vacuum deformation or diminish the magnitude of the corresponding stress risers, such standing rings typically are relatively large.

[0008] Because conventional hot-fillable containers are subjected to negative internal pressure, the ribs of conventional hot-fillable container bases generally are configured to control only inwardly directed forces and deformation. In this regard, the magnitude of inward deformation of a portion of the base typically is inconsequential or unimportant as long as the base is sufficiently strong. The ribs of such bases are generally spaced apart from the standing ring because stiffening proximate the standing ring is unimportant, and because ribs coupled to the standing ring may interfere with the beneficial deformation of the standing ring to compensate for the negative internal pressure. Thus, conventional ribs are typically spaced apart from the standing ring to enable the base to deflect inwardly such that the base may compensate for the negative internal pressure to supplement the vacuum panels. Moreover, if ribs were to contact the standing ring under such conditions, the standing ring would transition quickly from the inner portion that is stiffened by the ribs to the unstiffened portion, which may result in stress risers or otherwise be detrimental to the strength or other attribute of the base.

[0009] U.S. Pat. No. 5,251,424 (ZENGER), which is incorporated herein by reference in its entirety, discloses another approach to enabling a container to accommodate negative internal pressure from a hot-filling application. The '424 patent discloses introducing liquefied gas into the container upon hot-filling to provide a positive internal pressure. Thus, the internal positive pressure counteracts the negative pressure induced by the shrinkage of the contents upon cooling.

[0010] It is a goal of the present invention to provide a base, and corresponding container, that is suitable for a heat-set container that is capable of withstanding positive internal pressure.

SUMMARY

[0011] A base is provided for a heat-set container that is suitable for withstanding internal pressurization without everting. The base includes a standing ring on which the container rests, a recess that extends inwardly and upwardly relative to the standing ring; and plural ribs extending substantially inwardly from the recess. Each one of the plural ribs includes a lower portion that includes a draft surface extending inwardly and upwardly from the standing ring.

[0012] Preferably, the draft surface is directly connected to the standing ring such that the draft surface extends down to a lowermost surface of the container. The angle of the draft surface preferably is approximately five degrees, although the present invention encompasses other ranges, as explained more fully herein. Various geometric relationships are employed to describe the configuration of bases, and it is understood that an independent claim may rely on any single one of the geometric relationships and/or structure described herein, as well as any combination thereof.

[0013] The draft surface deforms substantially downwardly in response to internal pressurization of the container, such as that created upon internal pressurization of the container by introducing liquefied gas upon filling. The container rests on the standing ring even after internal pressurization of the container. The ribs resist eversion of the recessed base surface such that the container is capable of withstanding internal positive pressure. A corresponding method is also provided.

BRIEF DESCRIPTION OF THE FIGURES.

[0014] **FIG. 1** is an elevation view of a bottle, with the base shown in phantom, with that illustrates an aspects of the present invention;

[0015] **FIG. 2** is a bottom view of the bottle shown in **FIG. 1**;

[0016] **FIG. 3** is an enlarged view of the base shown in **FIG. 1**;

[0017] **FIG. 4** is an enlarged view of the bottom view shown in **FIG. 2**;

[0018] **FIG. 5** is a cross sectional view of the base taken through line **5-5** of **FIG. 4**;

[0019] **FIG. 6** is a cross sectional view of the base taken through line **6-6** of **FIG. 4**;

[0020] **FIG. 7A** is a cross sectional view of a portion of the rib taken through line **7A-7A** of **FIG. 4**;

[0021] **FIG. 7B** is a cross sectional view of a portion of the rib taken through line 7B-7B of **FIG. 4**;

[0022] **FIG. 8A** is an enlarged diagrammatic view of a portion of the base shown in **FIG. 5**;

[0023] **FIG. 8B** is an enlarged diagrammatic view of the base shown in **FIG. 5** with some geometric features labeled;

[0024] **FIG. 9A** is an enlarged cross-sectional diagrammatic view of a portion of the base shown in **FIG. 5**; and

[0025] **FIG. 9B** is an enlarged cross-sectional diagrammatic view of an alternative embodiment to the portion shown in **FIG. 9A**.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0026] A heat-set container **9** is configured to receive and contain positive internal pressure. Container **9** includes a base **25**, a body **12** extending upwardly from base **25**, and an upper portion **14** extending upwardly from body **12**. Body **12**, as shown in **FIGS. 1 and 3**, preferably is cylindrical. Because container **9** is intended to contain positive internal pressure, complex vacuum panels are not required to collapse or deform in response to negative internal pressure. Even though vacuum panels are not required, the present invention encompasses employing a gripping surface or surfaces, such as finger grips **15**, and/or vacuum panels. Thus, the invention contemplates base **25** as described or claimed herein being employed with any container type or configuration.

[0027] Container upper portion **14** includes a dome **16**, a neck **18** extending upwardly from dome **16**, an opening **20** formed in neck **18**, and a finish **22** formed on neck **18** proximate opening **20**. Dome **16** yields to body **12** at a lower portion thereof, and smoothly yields to neck **18** at an upper portion thereof. Finish **22** may be any configuration for receiving a closure (not shown) of any type. Preferably, neck **18** is elongated and dome **16** is rounded, although the present invention is not limited to any particular configuration of upper portion **14**. A shoulder may be disposed between body **12** and each of base **25** and dome **16**, as shown in **FIG. 1**, or body **12** may smoothly merge into base **25** and dome **16**.

[0028] Base **25** includes a heel **30**, a standing ring **32**, a recess **34**, and plural ribs **36**. Heel **30** extends downwardly from the lower shoulder and smoothly merges into standing ring **32**. Standing ring **32** preferably is substantially continuous. Preferably, standing ring **32** forms a planar surface that is the lowermost point of container **9** either while container **9** is in an unpressurized state or in a pressurized state.

[0029] Recess **34** extends inwardly and upwardly to enclose the underside of container **9**. Recess **34** may be substantially frustoconical, have an elliptical, parabolic, or other arcuate shape (in longitudinal cross section, not shown in the figures), or another suitable shape. Plural ribs **36** extend relatively, substantially radially inwardly from recess **34** and stiffen base **25**, especially to prevent recess **34** from everting (that is, a structural failure in which at least a portion of recess **34** outwardly collapses or bulges). A recess surface **44**, which is disposed between ribs **36**, terminates at a top portion or dome **46**.

[0030] **FIGS. 2 and 4** illustrate base **25** by showing four ribs **36**, although the present invention may employ any plural number of ribs. The quantity of ribs will depend upon container base diameter, base thickness, the magnitude of internal pressure, and like parameters, as will be understood by persons familiar with conventional container design and technology in view of the present disclosure. Further, the present invention encompasses employing one or more ribs, as described herein, in combination with conventional ribs (not shown in the Figures). The present invention is described by employing radial ribs, and the present invention encompasses non-radial ribs, such as (but not limited to, those forming a spiral configuration.

[0031] Each one of ribs **36** includes a draft surface **38** and rib face **40**, each of which merges with a pair of opposing rib sides **42**. Also, a rib upper face **41** may be disposed such that it extends upwardly from rib face **40** so as to merge with recess surface **44** and/or dome **46**, as shown in the Figures. Alternatively, rib face **40** may extend upwardly without rib upper face such that rib face **40** thereby forms a substantially continuous angle, radius of curvature, or arc. Employing rib upper face **41**, in some configurations, may provide a benefit to plastic flow during the blow molding process as the preform (not shown) expands outwardly and downwardly over an interior of base **25**. Further, rib upper face **41** may also provide a larger top portion **46** (compared with the configuration in which rib face **40** extends to and merges directly into top portion **46**), which in some configurations may enhance contact with the blow pin (not shown) or with the distal tip of the preform (not shown) during the blow molding process. Portions of surfaces **38**, **40**, and **41** may be substantially perpendicular to portions of rib sides **42**. Rib sides **42** merge with recess surface **44** to fully enclose base **25**.

[**0032**] As best shown in **FIGS. 5 through 8**, draft surface **38** extends directly from standing ring **32** at its lower end and merges into rib face **40** at its upper end. A draft surface inner point **50** is defined on draft surface **38** proximate rib face **40**, and a draft surface outer point **52** is defined on draft surface **38** proximate standing ring **32**. Preferably, a line between the draft surface outer point and the draft surface inner point forms a draft angle θ (theta) therebetween relative to a horizontal line, as best shown in **FIG. 8A**. Draft angle θ (theta) is measured in the container's as-molded state or in the mold, as distinguished from the container's hot or pressurized state, as explained more fully below.

[**0033**] It is preferred that draft surface **38** be substantially rectilinear—that is, a majority or all of draft surface **38** forms a straight line between draft surface inner point **50** and outer point **52** in longitudinal cross section (that is, in a first plane that is co-planar with a longitudinal centerline CL of container **9** and substantially bisects the subject rib **36**) as shown in FIGS. **58**A, and **8**B. Such a shape generally provides good plastic flow conditions during blow molding and a predictable deformation upon pressurization. Further, draft surface **38** may be either substantially rectilinear or curved in a second cross section that is substantially longitudinal and parallel to the longitudinal centerline CL and perpendicular to the first longitudinal centerline, as shown in **FIG. 7**. In the embodiment in which draft surface **38** is substantially rectilinear in the second cross section, opposing edges of draft surface **38** may be radiused to smoothly merge into rib sides **42**. The present invention is not limited to any particular shape of draft surface, but rather encompasses any shape, including encompassing curves, waves, steps, and the like, as well as encompassing draft surfaces that are not radial.

[**0034**] The present invention encompasses any draft angle θ (theta), although some angles provide particular advantages. For example, a draft angleθ (theta) approximately equal to zero provides a substantially horizontal surface that may enhance plastic flow during blow molding and that is pushed downwardly relative to standing ring **32** to form small feet. To enable standing ring **32** to remain the lowermost point of the container, draft angle θ (theta) preferably is at least slightly greater than zero. For a preferred embodiment, it has been found that draft angle θ (theta) is at least three degrees, and most preferably five degrees.

[**0035**] It has also been determined that draft angle θ (theta) preferably is less than 45 degrees to facilitate plastic flow during blow molding. Further, angles of 40 degrees, 30 degrees, and 15 degrees have also been determined to be beneficial in this regard. The width of standing ring **32** preferably is small, which provides the benefits of stiffening the ring and diminishing the transition from stiffened to unstiffened portions. Further, in some circumstances, a wide standing ring may deform outwardly upon internal positive pressurization and destabilize the standing surface. Thus, it has been found that the land dimension or width W (**FIGS. 5**, **6**, **8**A, and **8**B) of standing ring **32** is less than approximately 0.100 inches. For hot fill beverage bottles of about a 64-ounce size, width W preferably is less than approximately 0.060 inches, and more preferably less than approximately 0.050 inches. In theory, width W could be zero and provide the advantages referred to herein, but a practical lower limit is applied because of blow-molding considerations. As stated herein, the present invention is not limited to such dimensions.

[**0036**] The magnitude of the variables provided herein may apply to a container of any size, and especially to a container having a base that is consistent with a single serving container, such as about 10 to 16 ounces. Because base **10** may be applied to any size container, some geometric relationships are provided to aid in describing its features. In this regard, referring to **FIG. 8**B, base **10** may have an overall base diameter A, and a standing ring diameter C, which is defined as the outside rim of standing ring **32**. Preferably, standing ring diameter C is between 60% and 80% of base diameter A, and more preferably between 65% and 70% of base diameter A. Thus, it is beneficial, although not strictly necessary, for the heel to have a narrow profile, such as having a heel dimension H no more than approximately 20 percent of base diameter A, and more preferably no more than approximately 10 percent of base diameter A.

[**0037**] The relationship of diameters A and C is helpful, among other things, to indicate a beneficial geometry of heel **30**. Further, standing ring land width W preferably is no more than about four percent of standing ring diameter C, and more preferably no more than about three percent of standing ring diameter C, and even more preferably no more than about two percent of standing ring diameter C.

[**0038**] A point E is defined at the juncture between draft surface **38** and rib face **40**. For the configurations in which draft surface **38** and rib surface **40** are substantially straight (in longitudinal cross section, as shown in **FIG. 8B**), point E is defined at the intersection between the lines formed by the surfaces. For a configuration in which the juncture between surfaces **38** and **40** is rounded, E may be defined as the midpoint on the surface of the rib between surface **38** and **40**. The present invention encompasses configurations in which either or both of draft surface **38** and rib face **40** are curved in transverse cross section. In such a configuration, point E may be defined as the point proximate the junction between surfaces **38** and **40** having the highest rate of change of slope. Draft surface width D is defined as the distance between standing ring **32** and point E. Preferably, draft surface dimension D is no more than approximately one-third A minus four times standing ring land width W (that is, $((A/3)-(4W))$). Even more preferably, draft surface dimension D is no more than approximately 80 percent of one-third A minus four times standing ring land width W (that is, $0.80((A/3)-(4W)))$.

[**0039**] The depth of rib **36** should be sufficient to resist internal container pressure, as described more fully herein. In this regard, a depth F (measured perpendicular to recess surface **44**) of rib **36** near point E preferably is at least D divided by two times cosine theta (that is, $(D/(2 \cos \theta))$. Even more preferably, the depth F or rib **36** is at least 1.2 times D divided by two times cosine theta (that is, $(1.2 D/(2 \cos \theta))$.

[**0040**] **FIG. 9A** diagrammatically shows a cross section of rib **36** taken proximate point E and approximately along line **9A-9A** in **FIG. 8B**. Origin O is defined through the longitudinal centerline CL (**FIGS. 1, 5**, and **6**) of the container **9**. Point B_1 is defined as the juncture between rib face **40** and rib side **42**,and an angle β_1 is formed between a radial line RL—which intersects point B_1 and origin O—and a centerline line RCL of rib **36**. Rib sidewall **42** preferably is substantially collinear with line RL and substantially radial.

[**0041**] Alternatively, the sidewall of rib **36** may be formed by an angle that is not substantially radial. Such alternative configurations are indicated by sidewalls **42'** and **42"**, each of which is shown in dashed lines. First embodiment sidewall **42'** forms an angle ϕ_1 (measured substantially clockwise—that is, inwardly toward the rib centerline RCL—as oriented in **FIG. 9A**) from the radial line RL that preferably is no more than approximately angle β_1 plus 5 degrees. Thus, rib **36** may be narrower at its outer potion than at its inner portion. As another alternative, second embodiment rib sidewall **42"** may form an angle ϕ_2 (measured substantially counterclockwise that is, outwardly away from the rib centerline RCL—as oriented in **FIG. 9A**) from the radial line RL that preferably is no more than approximately two times angle β_1.

[**0042**] The present invention is not limited to employing ribs having straight sidewalls. For illustration, **FIG. 9B** shows a cross section of a rib **36'** that has an arcuate cross section. An angle β_2 is formed between a rib center line RCL and a line between origin O and a point B_2, which is a point on the outer surface of sidewall **36'**. Angle β_2 and point B_2 are formed such that angle β_2 is the largest angle at which line RL contacts rib **36'**, and point B_2 is the point of contact. Angles ϕ_1 and ϕ_2 are formed between line RL and the tangent of the curve formed by the sidewall at point B_2. Thus, the angle formed between the line RL and the tangent taken at point B_2 preferably is within the range of magnitudes of angles ϕ_1 and ϕ_2, as described above.

[**0043**] The present invention is not limited to bases with ribs having the angle ranges disclosed herein, but rather encompasses ribs of any configuration. The geometry of the ribs **36** and **36'** is recited to provide guidance to optimize base performance under some circumstances, but is not intended to limit the scope of the invention unless expressly recited in the claim. Further, the description above employs diameters and a container of circular transverse cross section to describe base **10**. The present invention is not limited to containers having such circular cross section, but rather encompasses any cross sectional shape. Thus, for example, diameters A and C may be measured along major or minor axes of an elliptical or oval base, or along the major or minor lengths of a container having substantially flat sides (in transverse cross section).

[**0044**] Container **9** having base **10** as described herein is intended to be filled at an elevated temperature, and base **10** is configured to receive contents at up to approximately 212 degrees F. without failure, although such temperature is not a limit to the scope of the invention. In this regard, a plastic resin having an intrinsic viscosity of over 0.75 may be employed, and most preferably an intrinsic viscosity of approximately 0.84 may be employed. The present invention is not limited to such viscosities, which are provided only for guidance.

[**0045**] Upon introduction of the contents into container **9**, a predetermined quantity of liquefied gas is introduced therein. The liquefied gas, which preferably is liquefied nitrogen, quickly vaporizes. After capping, such vaporization increases the internal pressure within container **9**. Preferably, the internal pressure range is 15 to 35 psi at hot-fill temperature, and 0 to 10 psi upon cooling to ambient temperature (that is, approximately 72 degrees). The pressure ranges are provided to be exemplary, and the scope of the present invention is not limited to such pressure ranges.

[**0046**] Co-pending U.S. patent application Ser. No. ______ (Attorney Docket Number CC-3412), entitled "Method For Diminishing Delamination Of A Multilayer Plastic Container," and co-pending U.S. patent application Ser. No. ______ (Attorney Docket Number CC-3449), entitled "Method For Extending The Effective Life Of An Oxygen Scavenger In A Container Wall," describe nitrogen dosing techniques with which the container according to any aspect of the present invention may be employed. Further, U.S. Pat. Nos. 5,955,527; 5,639,815; 5,049,624; and/or 5,021,515 disclose an oxygen scavenging material that is suitable for use in bottles in hot-fillable and other containers, and that may be employed in container **9**. Each of the applications and patents referred to herein is incorporated herein by reference in its entirety.

[**0047**] Techniques for introducing liquefied gas into container **9** are well known, especially by persons familiar with such technology for introducing liquefied nitrogen into metal cans. Such nitrogen dosing systems are commercially available and nearly exhaustively described in the literature. The present invention is not limited to a particular means for introducing liquefied gas, but rather encompasses any introduction technology. The magnitude of the dose of liquefied gas introduced into the container may be determined according to such parameters as contents temperature, headspace volume, characteristics of the container (including its elasticity or relationship between volume change and pressure), order of introduction of the product and nitrogen dose (that is, whether the nitrogen dose is introducing into the container before, concurrently with, or after the contents), and the time period between introducing the nitrogen dose and capping or sealing. Choosing the magnitude of the dose of liquefied gas for a particular application will be straightforward for persons familiar with liquefied gas dosing technology, such as, for example, as used in the metal can industry, in light of the present disclosure and the above parameters.

[**0048**] The internal positive pressure within container **9** acts on all surfaces of base **10**. Thus, pressure urges top portion or dome **46** substantially downwardly, urges against the interior surfaces of recess **34** and ribs **36** substantially downwardly and substantially inwardly, urges against the interior surface of standing ring **32** substantially downwardly, and urges against the interior of heel **30** substantially outwardly and somewhat downwardly. Each of the downward components of the pressure vectors, as well as most of the other components of the pressure vectors, urges base **10** toward eversion. The term "substantially downwardly" as used herein refers generally to the downward direction when the container is upright, and nay also include a lateral component.

[0049] Conventional bases often fail under such conditions either by complete eversion, which is a complete failure mode in which much of recess **34** is pushed fully out the bottom of base **10** to break the plane defined by standing ring **32**, or by partial eversion, in which a portion of standing ring **32** (most often at a single circumferential location) is pushed downwardly relative to the plane defined by the as-molded standing ring. Even a partial eversion of small magnitude might destroy or inhibit the container's ability of the container to solidly rest on a flat surface or its ability to stand.

[0050] Standing ring **32** is stiffened by ribs **36**, thereby diminishing downward deflection of standing ring **32**, upon pressurization of base **10**, compared with an unstiffened configuration. Draft surface **38** being directly connected to standing ring **32** enhances such stiffening. Also, because standing ringland dimension or width W, as described above, is small (compared, for example, to configurations common to hot-fill bottles that are subject to internal negative pressure), the total force and moments acting on standing ring **32** (about, for example, the interface between heel **30** and standing ring **32**) contributes to keeping the deformation of standing ring **32** small.

[0051] Thus, the stiffening of standing ring **32** by ribs **36** and the standing ring's small dimension W each enhance the stability of container **9** when standing upright on standing ring **32** and inhibiting partial or localized eversion. Each of such features may be employed independently of the other such that the present invention is not limited to employing both features. Rather, the present invention encompasses a base employing a standing ring having the dimensions provided herein in combination with ribs that are spaced apart therefrom. As well, the present invention encompasses a base employing ribs that extend from the standing ring in combination with a standing ring having a dimension W that is outside that described herein.

[0052] Upon pressurization of container **9**, draft surface **38** deforms downwardly such that, for the embodiment in which draft surface **38** is flat in its as molded state, draft surface **38** forms a convex bow (relative to a plane) in draft surface **38** when viewed from below base **10**. Further, the draft angle θ (theta) decreases upon such pressurization. The magnitude of the bow may be small, such as a few thousandths of an inch for containers in the 48 to 64 ounce container size. Alternatively, if draft surface **38** is sufficiently stiff, by, for example, the stiffening effect of rib sides **42** on draft surface **38**, draft surface may deflect downwardly by a few thousands in such a way that no bow if formed. Thus, the present invention encompasses any deflection or deformation of draft surface **38**.

[0053] Preferably, draft surface **38** in its fully deformed or deflected state (that is, upon pressurization of container **9** as described herein), does not interfere with standing ring **32** such that standing ring **32** remains circumferentially continuous. in this regard, draft surface **38** does not extend downwardly below standing ring **32** even in its deformed or deflected state such that substantially all of standing ring **32** is substantially planar. However, the present invention encompasses any configuration in which draft surface **38** deflects downwardly in response to internal pressurization, as described above.

[0054] Persons familiar with preform and blow molding processes and technology in light of the present disclosure will be enabled to configure a container that employs the present invention(s), such as a container base in which its draft surface deforms as described above.

[0055] Further, a method is provided in which hot-fillable container base **10** is provided that is capable of receiving positive internal pressure. Upon introducing hot product contents and introducing liquefied gas and subsequent sealing or capping, draft surface **38** flexes downwardly about its junction with standing ring **28** or about a draft surface outer point **52** proximate standing ring **28**, and may otherwise perform as described above with respect to the description of the structural aspects of base **10**.

[0056] The geometry of draft surface **38** and the width of standing ring **28** each contribute to the capability of base **10** to receive internal positive pressure as described above. The present invention, however, is not limited to simultaneously employing both (or any other) features described herein, but rather each feature may be employed alone or with any other feature to provide the positive pressure capabilities.

We claim:

1. A heat-set, pressurizable container suitable for filling at an elevated temperature, said container comprising:

a body;

an upper portion extending upwardly from the body and including a finish and an opening therein;

an enclosed base disposed below the body, said base including:

a standing ring on which the container rests;

a recess that extends inwardly and upwardly relative to the standing ring; and

plural ribs extending substantially inwardly from the recess, each one of the plural ribs including a lower portion that includes a draft surface extending inwardly and upwardly from the standing ring;

whereby (i) the draft surface deforms substantially downwardly in response to internal pressurization of the container, (ii) the container rests on the standing ring even after internal pressurization of the container, and (iii) the ribs resist eversion of the recessed base surface such that the container is capable of withstanding internal positive pressure.

2. The container of claim 1 wherein the container is formed of a heat-set plastic.

3. The container of claim 1 wherein the internal pressurization is formed by introducing a liquefied gas into the container prior to capping.

4. The container of claim 1 wherein the draft surface is substantially linear, in a first longitudinal cross section that is coplanar with a longitudinal centerline of the rib, while the container is in an unpressurized state.

5. The container of claim 4 wherein the draft surface is substantially planar while the container is in an unpressurized state.

6. The container of claim 4 wherein the draft surface is curved in a second longitudinal cross section that is perpendicular to the first longitudinal cross section.

7. The container of claim 1 wherein the draft surface is directly connected to the standing ring.

8. The container of claim 1 wherein each one of the plural ribs include a face surface that extends inwardly from the draft surface.

9. The container of claim 8 wherein draft surface includes a outer point proximate the standing ring and an inner point proximate the rib face, a line between the draft surface outer point and the draft surface inner point forming a draft angle relative to a horizontal line that is between approximately 0 degrees and 45 degrees.

10. The container of claim 9 wherein the draft angle is between about 3 degrees and about 40 degrees.

11. The container of claim 9 wherein the draft angle is between about 5 degrees and about 30 degrees.

12. The container of claim 9 wherein the draft angle is between about 5 degrees and about 15 degrees.

13. The container of claim 9 wherein the draft angle is between about 5 and 25 degrees.

14. The container of claim 9 wherein the draft angle is about 5 degrees.

15. The container of claim 9 wherein the draft surface is directly coupled to the standing ring proximate the draft surface outer point and is directly coupled to the rib face proximate the draft surface inner point, whereby the draft surface couples the standing ring and the rib face together.

16. The container of claim 9 wherein the standing ring defines a standing ring diameter and a standing ring land width, and the draft surface has a radial dimension of no more than approximately one-third the standing ring diameter minus four times the standing ring land width.

17. The container of claim 16 wherein the draft surface radial dimension is no more than approximately 80 percent of one-third the standing ring diameter minus four times the standing ring land width.

18. The container of claim 16 wherein the ribs have a depth measured proximate the draft surface that is at least the draft surface radial dimension divided by two times cosine of the draft angle.

19. The container of claim 16 wherein the ribs have a depth measured proximate the draft surface that is at least 1.2 times the draft surface radial dimension divided by two times cosine of the draft angle.

20. The container of claim 1 wherein the standing ring is substantially continuous and circumferential.

21. The container of claim 1 wherein the standing ring is circumferentially discontinuous.

22. The container of claim 21 wherein the standing ring is interrupted by the draft surface of the ribs.

23. The container of claim 1 wherein the standing ring has a width that is less than approximately 0.100 inches.

24. The container of claim 23 wherein the standing ring width is less than about 0.060 inches.

25. The container of claim 23 wherein the standing ring width is less than about 0.050 inches.

26. The container of claim 23 wherein the standing ring width is less than about 0.025 inches.

27. The container of claim 23 wherein the standing ring width is about 0.10 inches.

28. The container of claim 18 wherein the standing ring width no more than approximately four percent of standing ring diameter.

29. The container of claim 18 wherein the standing ring width no more than approximately three percent of standing ring diameter.

30. The container of claim 18 wherein the standing ring width no more than approximately two percent of standing ring diameter.

31. The container of claim 23 wherein the standing ring width is as small as the blow molding process will allow.

32. The container of claim 1 wherein the base further includes a heel extending upwardly from the standing ring toward the body.

33. The container of claim 32 wherein the heel is coupled to the base.

34. The container of claim 1 wherein the upper portion includes a dome from which the finish extends.

35. The container of claim 34 wherein the upper portion includes an elongated neck extending from the dome, the finish formed on the neck.

36. The container of claim 1 wherein the base further includes a heel that is coupled between the standing ring and the body, the standing ring defines a standing ring diameter, and the heel has a radial heel dimension that is no more than approximately 20 percent of the standing ring diameter.

37. The container of claim 36 wherein the heel radial dimension is at least approximately 10 percent of the standing ring diameter.

38. The container of claim 36 wherein the heel radial dimension is more than approximately 17.5 percent of the standing ring diameter.

39. The container of claim 38 wherein the heel radial dimension is at least approximately 15 percent of the standing ring diameter.

40. The container of claim 1 wherein the standing ring defines a standing ring diameter that is between approximately 60% and approximately 80% of a base diameter.

41. The container of claim 40 wherein the standing ring diameter between approximately 65% and approximately 70% of the base diameter.

42. The container of claim 1 wherein the internal pressurization is between approximately 15 and approximately 35 psi at hot fill temperatures.

43. The container of claim 1 wherein the internal pressurization is between approximately 0 and approximately 10 psi at ambient temperatures.

44. The container of claim 1 wherein said container is formed of a material having an intrinsic viscosity greater than approximately 0.75.

45. A heat-set, pressurizable container suitable for filling at an elevated temperature, said container comprising:

a body;

an upper portion extending upwardly from the body and including a finish and an opening therein;

an enclosed base disposed below the body, said base including:

a standing ring on which the container rests;

a recess that extends inwardly and upwardly relative to the standing ring; and plural ribs extending substantially inwardly from the recess, each one of the plural ribs including a lower portion that includes a draft surface extending inwardly and upwardly from the standing ring, the draft surface being directly coupled to the standing ring and forming a draft angle of between approximately 0 degrees and approximately 45 degrees, the draft surface is directly coupled to the standing ring proximate a draft surface outer point and is directly coupled to the rib face proximate a draft surface inner point, whereby the draft surface couples the standing ring and the rib face together.

46. The container of claim 44 wherein the draft angle is between about 3 degrees and about 40 degrees.

47. The container of claim 44 wherein the draft angle is between about 5 degrees and about 30 degrees.

48. The container of claim 44 wherein the draft angle is between about 5 degrees and about 15 degrees.

49. The container of claim 44 wherein the draft angle is about 5 degrees.

50. The container of claim 44 wherein the standing ring has a width that is less than approximately 0.100 inches.

51. The container of claim 44 wherein the standing ring width is less than about 0.075 inches.

52. The container of claim 44 wherein the standing ring width is less than about 0.050 inches.

53. The container of claim 44 wherein the standing ring width is less than about 0.025 inches.

54. The container of claim 44 wherein the standing ring width is less than about 0.10 inches.

55. A method of filling a container with a flowable product, said method comprising:

providing a container comprising a body and a base, the base including:

a standing ring on which the container rests;

a recess that extends inwardly and upwardly relative to the standing ring; and

plural ribs extending substantially inwardly from the recess, each one of the plural ribs including a lower portion that includes a draft surface extending inwardly and upwardly from the standing ring;

introducing hot contents and liquefied gas into the container;

sealing the container before all of the liquefied gas vaporizes to create a positive internal pressure within the container;

whereby the draft surface deforms substantially downwardly in response to internal pressurization of the container, the container rests on the standing ring even after internal pressurization of the container, and the ribs resist eversion of the recessed base surface such that the container is capable of withstanding internal positive pressure.

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