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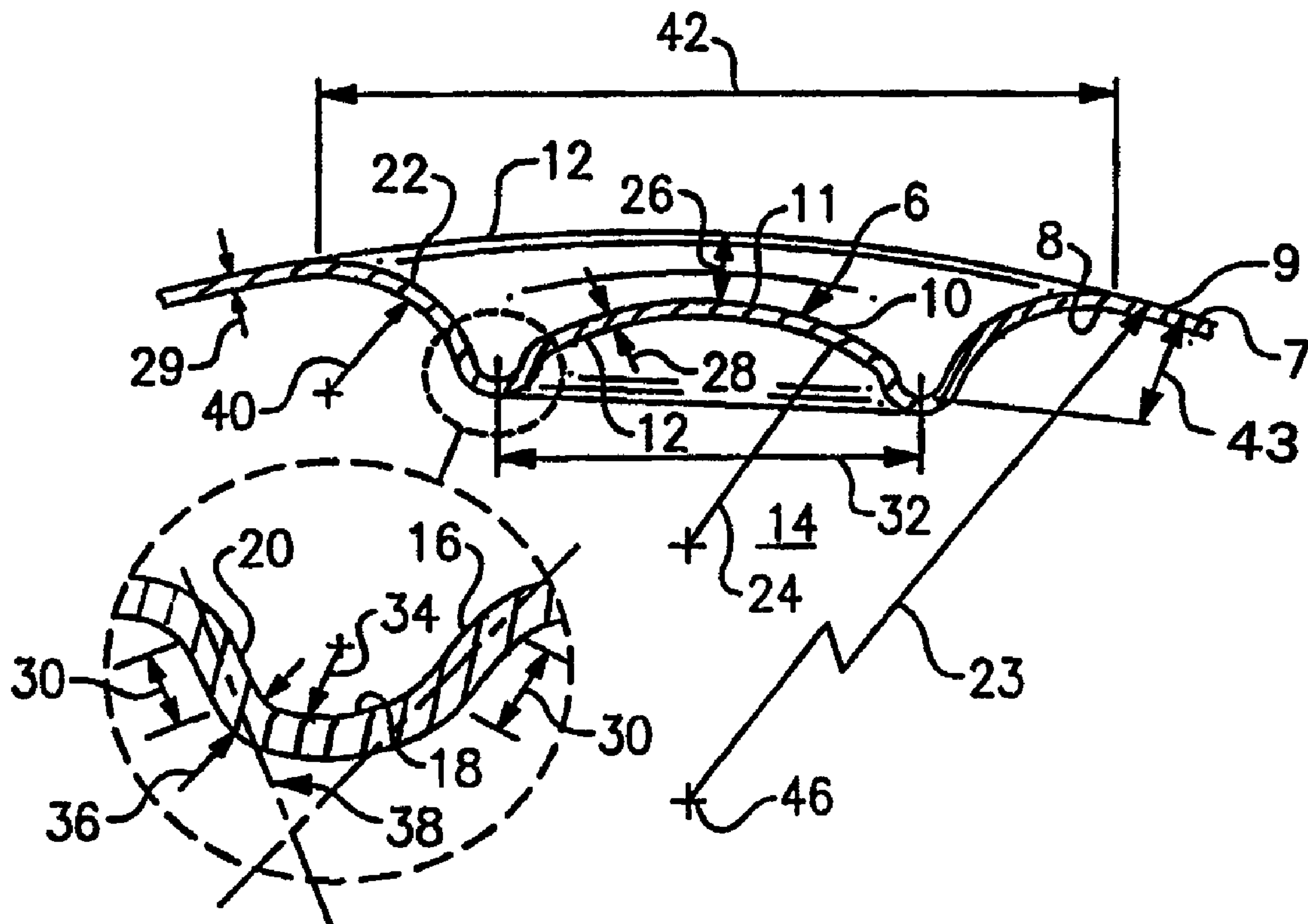
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(54) Title: PLASTIC CONTAINER WITH DECORATIVE RECESSED FEATURES AND ASSOCIATED METHOD AND APPARATUS FOR MANUFACTURE THEREOF



(57) **Abrégé/Abstract:**

A structural feature (6) formed in the wall (7) of a plastic container having, an interior surface (8), an exterior surface (9) and a wall thickness (29) and being suitable for containing a liquid under pressure e.g., a carbonated beverage, including an integral

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structural trough having an annular concave surface facing the adjacent the exterior surface (9), a frustum interconnecting the trough with an area or a curved section (22) having an annular concave surface facing toward the interior (14) and integrally formed with the container wall. An associated container for pressurized liquids and/or hot fill materials and an associated blow mold and method are also included.

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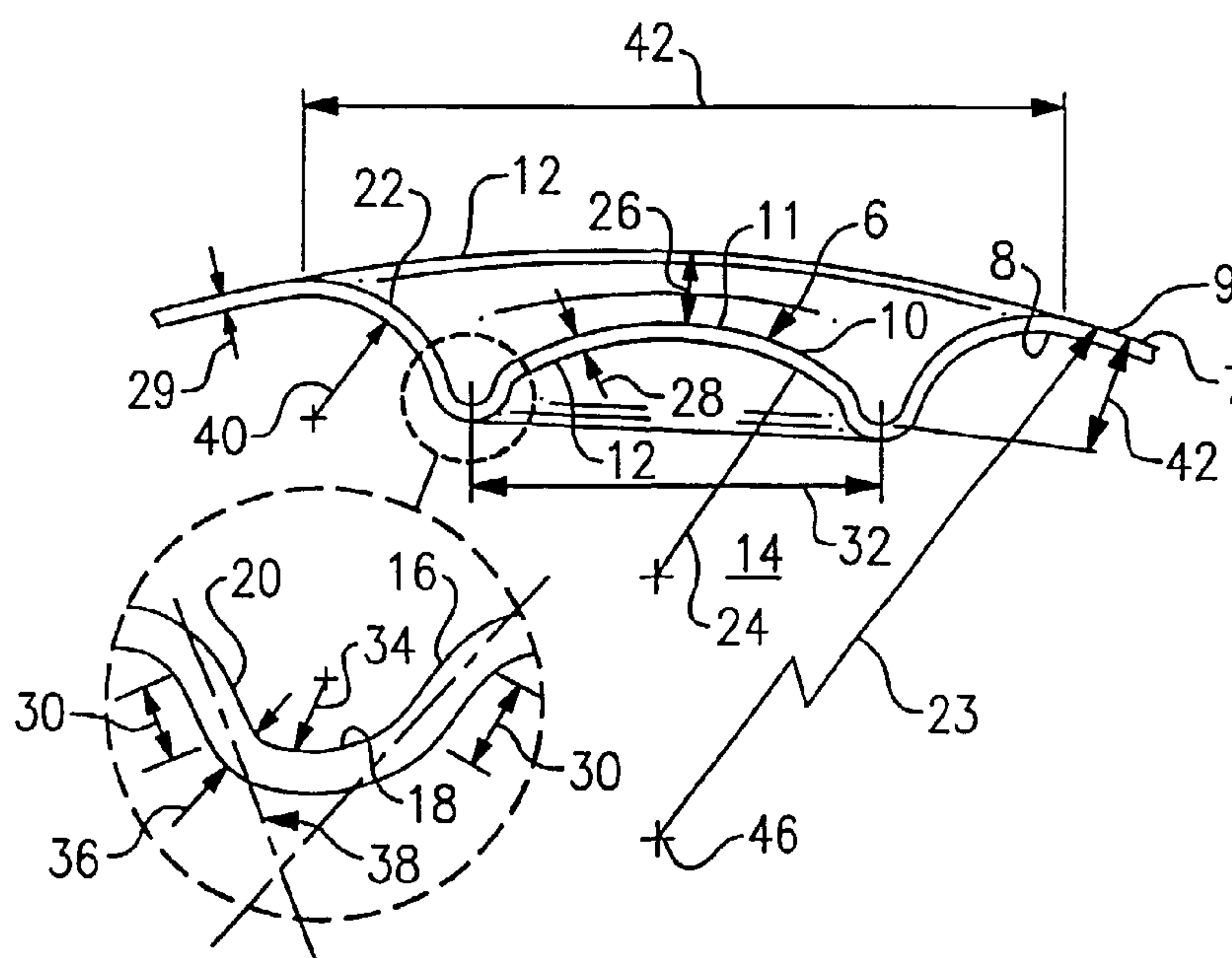
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(54) Title: PLASTIC CONTAINER WITH DECORATIVE RECESSED FEATURES AND ASSOCIATED METHOD AND APPARATUS FOR MANUFACTURE THEREOF



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ning of each regular issue of the PCT Gazette.*

**[001] PLASTIC CONTAINER WITH DECORATIVE RECESSED
FEATURES AND ASSOCIATED METHOD AND APPARATUS
FOR MANUFACTURE THEREOF**

[002] FIELD OF THE INVENTION

[003] This invention relates to groove reinforced decorative and/or structural features for carbonated beverage containers (e.g. bottles) and hot fill containers made of a plastic and to methods and apparatus for producing such containers.

[004] DEFINITIONS

[005] "Plastic" is a polymerizable material that can be bi-axially oriented, e.g. polyethylene terephthalate (PET), polypropylene (PP) and acrylonitrile (AN) suitable for use in containers for liquid under pressure e.g., carbonated beverages or for use in hot fill containers.

[006] "PET" as used herein shall be construed as including all materials defined hereinbefore as "Plastic".

[007] "Bubble" as used herein is a circular, decorative feature formed by a deformation of the wall, which includes a shoulder, of a plastic container which does not extend outwardly (relative to the axis of the container) from the exterior surface of the container even when the container contains a liquid under pressure e.g. a carbonated beverage and is exposed to industry defined test procedures for such containers including exposure to stresses resulting from pressure and elevated temperatures during filling, packaging, distribution, sale and the end user actions.

[008] "Circular" as used herein with respect to bubbles shall be construed to include ovals, ellipses, teardrops and other rounded shapes as well as circular shapes.

[009] "Structural feature" as used herein shall be construed to include any feature integrally formed in the wall of a plastic container which alone, or together with another such feature, forms, e.g. symbols, icons, words, names, ribs, bands, panels, decorative patterns or any combination of these.

[010] "Container" as used herein shall be construed to include, e.g. plastic bottles and hot fill containers.

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[011] "Frustum" as used herein shall be construed as a truncated hollow right circular cone in which the apex is replaced by a plane section parallel to the cone base and which has parallel inner and outer surfaces and shall be construed to include a hollow cylinder which has parallel inner and outer surfaces.

[012] BACKGROUND OF THE INVENTION

[013] PET for carbonated beverage containers has been used for many years. Many different shapes have been and are used to establish distinction between various brands of products. Some of these are decorative features formed in the surface of the container including ribs and swirls. Such decorative features may project inwardly and/or outwardly from the exterior surface of the container. In addition many prior art containers have been provided with structural features, for example, recessed or raised panels in attempts to reduce or eliminate distortion resulting from internal pressure, hot filling, etc. Some of these features also are intended to be decorative in nature.

[014] Generally CO₂ is used for carbonated soft drinks but other gases such as N₂ are also used to pressurize a plastic container. When the filled containers are exposed to typical service conditions especially higher than room temperature conditions, the pressure within the container increases while the plastic softens. This leads to creep (the plastic flows and distorts the container shape). One of the disadvantages of prior art decorative designs is that the PET will creep when exposed to excessive pressures and temperatures and many of the features will become distorted or even obliterated due to this creep. The desired distinctive features, particularly recessed features are then lost.

[015] In the case of hot fill containers the filling material is typically introduced into the container at a temperature of about 185°F plus/minus about 20°F and the container is then sealed before the filling material cools. This results in a partial vacuum being formed in the container during the cooling which leads to a potential for the collapse of the container unless strengthening features are provided which in the prior art have often been provided by the addition of material to the container which results in a heavier container and an increase of the cost of the material of the container.

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[016] One attempt at producing a circular decorative feature is illustrated by the dimple 1, shown in Fig. 1 in an unpressurized state. In Fig. 1 a container 2 defines a longitudinal axis 3 and a wall radius 4. This dimple tends to invert and/or distort upon pressurization to a form such as that shown dashed in Fig. 1. This invention can be avoided by providing a thickened wall in the region of the dimple. This is, however, an undesirable solution due to the significant increase in material costs resulting from the additional material used, particularly when there is a substantial plurality of such dimples forming a distinctive pattern on the bottle. Inversions of the dimple is particularly undesirable because of resulting handling problems, labeling problems and questions of aesthetic appearance.

[017] OBJECT OF THE INVENTION

[018] An object of the invention are to provide stable features in a wall of a container which may or may not extend outwardly of the wall and which may have decorative and/or reinforcing characteristics, for example, to form a decoration, manufactures logo or name, to provide resistance to container collapse under hot fill conditions and/or to provide resistance to distortion of the container under the service conditions to which carbonated beverage containers may be subjected.

[019] SUMMARY OF THE INVENTION

[020] According to the invention there is provided a structural feature formed in a wall of a plastic container, the wall defining an interior of the container and having an interior surface, an exterior surface and a wall thickness, the container being suitable for containing at least one of a liquid under pressure and a hot fill material; the feature comprising an integral structural trough connected with the wall by a curved section and having a first frustum connected with one of the curved section and an area remote, relative to the trough, from the curved section, the trough having a concave surface facing the adjacent portion of the exterior surface and the curved section having a concave surface facing toward the interior of the container, to join, integrally, the feature to the container wall. The area may be further curved section having a concave surface facing toward the interior of the container.

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[021] Preferably, the other of the area and the curved section is connected to the trough by way of a second frustum.

[022] Also according to the invention there is provided a plastic container suitable for containing at least one of a liquid under pressure and a hot fill material comprising a structural feature formed in a wall of the plastic container, the wall defining an interior of the container and having an interior surface, an exterior surface and a wall thickness, the container being suitable for containing at least one of a liquid under pressure and a hot fill material; the feature comprising an integral structural trough connected with the wall by a curved section and having a first frustum connected with one of the curved section and an area remote, relative to the trough, from the curved section, the trough having a concave surface facing the adjacent portion of the exterior surface and the curved section having a concave surface facing toward the interior of the container, to join, integrally, the feature to the container wall. The area may be further curved section having a concave surface facing toward the interior of the container.

[023] Preferably, the other of the area and the curved section is connected to the trough by way of a second frustum.

[024] In addition, the invention provides a blow mold for blow molding a plastic container for containing at least one of a liquid under pressure and a hot fill material comprising a structural feature formed in a wall of a plastic container, the wall defining an interior of the container and having an interior surface, an exterior surface and a wall thickness, the container being suitable for containing at least one of a liquid under pressure and a hot fill material; the feature comprising an integral structural trough connected with the wall by a curved section and having a first frustum connected with one of the curved section and an area remote, relative to the trough, from the curved section, the trough having a concave surface facing the adjacent portion of the exterior surface and the curved section having a concave surface facing toward the interior of the container, to join, integrally, the feature to the container wall. The area may be further curved section having a concave surface facing toward the interior of the container.

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[025] Preferably the other of the area and the curved section is connected to the trough by way of a second frustum. Also preferably the blow mold comprises a first projection having an outer extremity and adjacent side surfaces complimentary to the trough and first frustum. In addition projections having outer extremities and adjacent side surfaces are complimentary to the first and second frustums.

[025.1] In accordance with one aspect of the present invention, there is provided a bubble (6) formed in a container wall (7) of a plastic container, the container wall (7) defining an interior (14) of the container and having an interior surface (8), an exterior surface (9) and a wall thickness (29), the container being suitable for containing a liquid under pressure and the bubble comprising: a central dome (10) defining a convex outer surface (11) facing toward an adjacent portion of the exterior surface (9) of the container wall (7) surrounding the bubble (6); an annular trough (18) surrounding the central dome (10) and recessed below the central dome (10), the annular trough (18) having an annular concave surface facing the adjacent portion of the exterior surface (9); an annular outer ring (22) having a curved cross-section and an annular concave surface facing toward the interior (14) of the container, the outer ring (22) surrounding the annular trough (18) and connected to the container wall (7) surrounding the bubble (6); a first wall (16) interconnected with the trough (18) and the central dome (10); and a second wall (20) interconnected with the trough (18) and the outer ring (22).

[025.2] In accordance with another aspect of the present invention, there is provided a method of producing at least one bubble (6), in a plastic container suitable for containing pressurized liquids, which does not, in use, extend outwardly from the exterior surface of the container, the method comprising the steps of: a) providing a blow mold (44) having an axis (46) and at least one bubble forming feature in the form of an annular projection extending toward the axis (46) of the mold cavity and container to be formed, the annular projection having an outer extremity and adjacent side surface complimentary to a trough (18 or 66) and a first wall (16, 20); b) pre-heating a preform to facilitate blow

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molding to form the container and the bubble; c) introducing the preform into the blow mold; d) applying a gas at a pressure sufficient to inflate and deform the preform into contact with the mold cavity to form the container and into contact with at least one bubble forming feature to produce the at least one bubble in at least one of the container wall and a shoulder of the container, the bubble comprising a central dome (10) defined by an annular trough (18) and an outer ring (22) surrounding the annular trough (18) and connecting the annular trough (18) to the adjacent container wall or shoulder, the at least one bubble being formed failing to contact the mold cavity in the region of the central dome (10) and a substantial portion of the outer ring (22) of the at least one bubble; e) cooling the container, and f) removing the container with the at least one bubble formed therein from the blow mold cavity.

[025.3] In accordance with a further aspect of the present invention, there is provided a plastic container suitable for containing a liquid and including at least one bubble (6) formed in a container wall (7) of the plastic container, the container wall (7) defining an interior (14) of the container and having an interior surface (8), an exterior surface (9) and a wall thickness (29), the at least one bubble (6) comprising: a central dome (10) defining a convex outer surface (11) facing toward an adjacent portion of the exterior surface (9) of the container wall (7) surrounding the bubble (6); an annular trough (18) surrounding the central dome (10) and recessed below the central dome (10), the annular trough (18) having an annular concave surface facing the adjacent portion of the exterior surface (9); an annular outer ring (22) having a curved cross-section and an annular concave surface facing toward the interior (14) of the container, the outer ring (22) surrounding the annular trough (18) and connected to the container wall (7) surrounding the bubble (6); a first wall (16) interconnected with the trough (18) and the central dome (10); and a second wall (20) interconnected with the trough (18) and the outer ring (22).

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[026] BRIEF DESCRIPTION OF THE DRAWINGS

[027] The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

[028] Fig. 1 is a cross-section prior art design of a decorative dimple;

[029] Fig. 2 is a cross-section of a bubble of a first embodiment of the present invention;

[030] Fig. 3 is an elevation of the bubble of Fig. 2 with solid lines used to clarify the boundaries of structural elements of the bubble;

[031] Fig. 4 is a cross-section of the bubble of Fig. 2 and of a portion of a blow mold for producing this bubble;

[032] Figs. 5a and 5b are elevations of a plastic container incorporating a decorative pattern of bubbles according to the present invention;

[033] Fig. 6 is a longitudinal cross-section of a blow mold for producing the container of Fig. 5a and 5b;

[034] Fig. 7 is a longitudinal cross-section of a bubble of a second embodiment of the present invention and a portion of a blow mold for producing this bubble;

[035] Fig. 8 is a block diagram illustrating the method of the present invention;

[036] Fig. 9 is bubble deflection versus pressure graph for various bubbles of the present invention;

[037] Fig. 10 illustrates an embodiment with the bubble divided into two parts which together define a logo;

[038] Fig. 11 is a fragmentary cross-section on section line 11-11 of Fig. 10;

[039] Fig. 12 is a variation of Fig. 10 in which the two parts are interconnected;

[040] Fig. 13 illustrates the use of parallel reinforcing troughs extending in the wall of a container extending circumferentially thereof;

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[041] Fig. 14 illustrates the use of parallel reinforcing troughs extending in the wall of a container extending longitudinally thereof;

[042] Fig. 15 illustrates a trough reinforced recessed wall panel of a container; and

[043] Fig. 16 is a fragmentary cross-section on section line 16-16 of Fig. 15.

[044] DETAILED DESCRIPTION OF THE INVENTION

[045] Referring first to Figs. 2 and 3, a bubble 6 of the first embodiment, formed in the wall 7 of container, having an interior surface 8 and an exterior surface 9, blow molded from a conventional preform of PET, is an integral structure composed of a circular central dome 10 smoothly connected to an inner frustum 16 increasing in diameter to an annular trough 18 which in turn is smoothly connected to an outer frustum 20 increasing in diameter to an annular outer ring 22 smoothly interconnecting the outer frustum 20 to the wall 7 of the container.

[046] The central dome 10 has a convex outer surface 11 extending toward the adjacent exterior surface 9 of the container wall 7 and a concave inner surface 12 parallel to the convex outer surface 11 and facing the interior 14 of the container.

[047] The following dimensions are without a pressurized interior of the container and without the container being exposed to an elevated temperature substantially above ambient room temperature. In addition, the following dimensions relate to a bubble formed in a container having a radius in a range of about 1.1 inches to about 1.6 inches, preferably about 1.3 inches. A typical central dome 10 has a radius 24 of the concave surface in a range of from about 0.19 of an inch to about 0.32 of an inch, preferably about 0.23 of an inch, a diameter of about 0.25 of an inch, a radial spacing 26 from the outer extremity of the convex outer surface 11 to the exterior surface 9 of the wall 7 of the container in a range of about 0.01 of an inch to about 0.03 of an inch, preferably about 0.013 of an inch and a thickness 28 approximately equal to the wall 8 thickness 29 of the container, for example, of about 0.013 of an inch. Wall thicknesses 29 are preferably in a range from about 0.010 of an inch to about 0.015 of an inch, but should not be construed as being limited to this range.

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- [048]** A typical inner frustum (first wall) 16 has a straight longitudinal dimension (length) 30 in cross-section in a range of about 0.003 of an inch to about 0.05 of an inch and preferably has a length of at least 0.005 of an inch and a thickness approximately equal to the thickness 29 of the wall 7. Although the presence of the inner frustum 16 and the outer frustum (second wall) 20 is preferred and enhances the stability of the bubble 6, one of the frustums 16 and 20 may be omitted.
- [049]** A typical annular trough 18 has a diameter 32 of about 0.3 of an inch and internal radius 34 in cross-section in a range of from about 0.005 of an inch to about 0.05 of an inch with a preferred radius of about 0.015 of an inch. The thickness 36 of the trough 18 wall in cross-section is approximately equal to the thickness 29 of the wall 7. The radial spacing 43 of the inner surface (the surface facing the exterior surface 9 of the container) of the trough from the exterior surface 9 of wall 7 is in the range of from about 0.07 of an inch to about 0.15 of an inch, preferably about 0.1 of an inch.
- [050]** A typical outer frustum 20 has the same dimensions and ranges of dimensions specified above for the inner frustum 16. The included angle 38 of the cross-sections of the frustums 16 and 20 is in the range of about 65° to about 80°, preferably about 73°.
- [051]** A typical outer ring 22 has a radius 40 in cross-section in a range of from about 0.09 of an inch to about 0.13 of an inch, preferably about 0.11 of an inch, and a wall thickness in cross-section approximately equal to the wall thickness 29 of wall 7.
- [052]** The diameter 42 of the bubble 6 is preferably in the range of from about 0.100 of an inch to about 0.500 of an inch. The above dimensions are chosen to allow formation of a bubble 6 having a diameter at or close to the maximum diameter of 0.500 of an inch.
- [053]** It will be appreciated that the choice of actual dimensions for the features of bubble 6 will be chosen to produce smooth transitions to between the various elements 10, 16, 20 and 22 making up the bubble 6 and to the wall 7.
- [054]** Now referring to Fig. 4 a fragmentary portion of a blow mold 44 illustrates the blow mold features which form the bubble 6 during a blow molding of a conventional

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PET preform into a container. The fragmentary portion of the blow mold is a cross-section taken normal to the longitudinal axis 46 of the blow mold and the container. The blow mold features include an annular projection 48 terminating at its outer extremity 50 in a radius in cross-section to form the internal radius of the trough 18 and providing side surfaces 52 to form the inner and outer frustums 16, 20 of the bubble 6. The annular projection decreases in diameter toward the outer extremity 50 with an included angle 53 of approximately 10° .

[055] The provision of this inwardly decreasing diameter of the projection 48 facilitates the formation of the trough 18 and frustums 16, 20 and eases removal of the container with formed bubble(s) from the blow mold.

[056] It is to be noted that the blow molding is achieved by applying a pressure to the interior of a conventionally pre-heated preform sufficient (about 400 p.s.i. or greater) to inflate and deform the preform into engagement with the blow mold and its bubble forming features. However, it should also be noted that while the cylindrical wall 7 of the container intimately contacts the wall forming portion of the blow mold the bubble 6, being formed, contacts only the outer extremity 50 and the side surfaces 52 adjacent this outer extremity.

[057] Figs. 5a and 5b show two elevations, taken at 90° to one another, of a PET footed container 54, according to the invention, with a decorative pattern of bubbles 6 formed in a wall 7 and a shoulder 56 thereof.

[058] As previously mentioned the bubbles do not extend outwardly of the container and are preferable recessed relative to the exterior surface of the wall 7 (and shoulder 56) even when the container filled with a carbonated beverage or other pressurized liquid is subjected to elevated temperatures and mechanical stresses in accordance with industry standards.

[059] Fig. 6 is a cross-section of a blow mold 58 having a blow mold cavity 60 defining bubble forming features 62, as illustrated in Fig. 4, for producing the container 54 of Fig. 5a and 5b with a decorative pattern of a plurality of bubbles 6.

[060] Fig. 7 illustrates a second embodiment of a bubble 64 according to the present invention in which the trough 18 is replaced by a trough 66 having a very small radius or a non-existent internal surface joining the frustums 16 and 20.

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The portion 44 of the blow mold shown in Fig. 7 has an annular projection 68 having an outer extremity which is complimentary to the form of the trough 66.

[061] In order to avoid distortion (e.g. bridging or gullies) of the container between bubbles, it is preferred that bubble spacing exceed 0.100 of an inch from bubble perimeter to bubble perimeter.

[062] A method of the present invention to produce structural features, such as a bubble, in the wall of a container for pressurized liquids (e.g. a carbonated beverage) or hot fill containers which, even under elevated temperatures and mechanical stresses acceptable to the industry (i.e. the carbonated beverage industry), does not unacceptably distort the container, comprises:

[063] a) providing a blow mold having structural feature forming features in the form of annular projection(s) extending toward the axis 46 of the mold cavity and container to be formed, the annular projection(s) having an outer extremity and adjacent side surface(s) complimentary to the trough 18 or 66 and frustums 16, 20 respectively

[064] b) pre-heating a preform to facilitate blow molding to form the container and bubble(s);

[065] c) introducing the preform into the blow mold;

[066] d) applying a gas at a pressure sufficient (about 400 p.s.i. or greater) to inflate and deform the preform into contact with the mold cavity to form the container and into contact with the complimentary features to produce the bubble(s) in the wall (and/or shoulder) thereof, the bubble(s) being formed failing to contact the mold cavity in the region of the/their central dome(s) 10 and a substantial portion of the outer ring(s) 22;

[067] e) cooling the container; and

[068] f) removing the container with bubble(s) formed therein from the blow mold cavity.

[069] Fig. 9 is a graphical representation of PET bubble deflection, against internal pressure in the container, for three bubble diameters (large, medium and small), for example, 0.500 of an inch, 0.300 of an inch and 0.150 of an inch, each with three wall thicknesses, namely, 0.010 of an inch, 0.0125 of an inch and

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0.015 of an inch with an arbitrary failure mode being defined as 0.10 of an inch of deflection. The failure mode is defined as a deflection outwardly of the container sufficient for the bubble to project outwardly beyond the radius of the container wall 7 or for a portion of the trough invert or kink.

[070] While the trough 18, 66 is central to the design of a bubble described in detail with reference to Figs. 2 and 3, such a trough may be used in defining and facilitating the formation of other integral features in containers blow molded from preforms, which may be conventional preforms of PET, including containers for pressurized liquids and hot fill containers.

[071] Figs. 10-16 illustrated various features as examples of those made possible by the use of trough(s) 18, 66 as described in detail with reference to Figs. 2-9. Such features may include, for example, symbols, icons, words, names, ribs, bands, panels, decorative patterns and any combination of these.

[072] Figs. 10 and 11 illustrate an icon formed, in similar manner to the bubble 6 (or 64) of Figs. 2 and 3, of two shaped domed areas 10 each defined by perimeter troughs 18 (or 66) surrounding each domed area, the domed areas being disposed adjacent one another to define the desired icon. In this case the central portion of the icon extends outwardly from the outer radius 23 of the container wall about container axis 46 and includes an elongate curved area 68 between the bubbles and troughs which is outwardly curved in cross-section (Fig. 11).

[073] Fig. 12 shows a variation of Fig. 10 in which the troughs 18 (or 66) are interconnected to close and strengthen the ends of the outwardly curved area 68.

[074] In Fig. 13 a plurality of parallel troughs 18 (or 66) disposed equally spaced apart circumferentially about the axis 46 of a container to form strengthening bands or ribs 70 to reinforce a container wall 72 against internal pressure exerted by pressurized liquid or against a partial vacuum formed in the container as a result of a hot fill process. The bands or ribs 70 may be strategically placed in various parts of the wall of the container to selectively strengthen those parts as desired or needed. The bands or ribs may also be designed to enhance the appearance of the container and may be interrupted as desired by the formation of symbols, icons,

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names or other patterns, e.g. the icon of Figs. 10-12 and bubbles 6 (or 64) as previously described.

[075] Fig. 14 provides reinforcement similar to that of Fig. 13 but with the troughs 18 (or 66) forming bands or ribs 70 extending longitudinally parallel to the axis 46 of the container. Similar uses and variations are applicable here as are described with reference to Fig. 13.

[076] Figs. 15 and 16 illustrate the formation of a recessed panel 74 in the wall 72 of a container, the panel 74 being surrounded by a reinforcing trough 18 (or 66). A plurality of panels may be provided and these panels, although not shown, may project outwardly from the wall 72 and may be interrupted by, and may themselves define, features as disclosed with reference to Fig. 13. In addition, where appropriate the trough 18 (or 66) may be interrupted for structural, aesthetic or manufacturing reasons provided that the structural performance of the container is not compromised.

[077] As desired, the troughs 18 (or 66) may be stressed during blow molding to provide some crystallization of material in the troughs thereby to produce a white haze in the trough for decorative reasons and/or to more clearly define or outline features formed using the troughs. The density of the white haze may be varied by appropriately changing the radius 34 of the trough, the smaller the radius the greater the whitening of the material.

[078] By the use of features, of the present invention, appropriately arranged in the wall of a hot fill container, the containers collapse pressure under the partial vacuum produced during a typical hot fill process may be increased by about 20% compared to a container of similar wall thickness and configuration.

[079] Although described with reference to pressurized liquids e.g., carbonated beverages and hot fill materials, it will be appreciated that the container described would exhibit the same appearance characteristics when unpressurized.

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Reference Numbers

1	dimple	34	trough internal radius
2	bottle wall	36	trough thickness
3	longitudinal axis	38	included angle of frustums
4	wall radius	40	outer ring radius
6	bubble	42	bubble diameter
7	wall	44	blow mold
8	interior surface	46	axis
9	exterior surface	48	annular projection
10	dome	50	outer extremity
11	convex outer surface	52	side surfaces
12	concave inner surface	53	including angle
14	interior	54	container
16	inner frustum	56	shoulder
18	trough	58	blow mold
20	outer frustum	59	preform
22	outer ring	60	cavity
23	container radius	62	bubble forming features
24	radius of central dome	64	bubble
26	radial spacing	66	trough
28	central dome thickness	68	curved area
29	container wall thickness	70	bands or ribs
30	inner and outer frustum length	72	wall
32	trough diameter	74	panel

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What is Claimed is:

1. A bubble (6) formed in a container wall (7) of a plastic container, the container wall (7) defining an interior (14) of the container and having an interior surface (8), an exterior surface (9) and a wall thickness (29), the container being suitable for containing a liquid under pressure, and the bubble comprising:

a central dome (10) having a smoothly curved convex outer surface (11) adapted to be recessed from an adjacent portion of the exterior surface (9) of the container wall (7) surrounding the bubble (6);

an annular trough (18) surrounding the central dome (10) and recessed below the central dome (10), the annular trough (18) having an annular concave outer surface;

an annular outer ring (22) having an annular convex outer surface with a smoothly curved cross section, the outer ring (22) surrounding the annular trough (18) and adapted to be connected to the outer periphery of the container wall (7) surrounding the bubble (6);

a first wall (16) interconnected with the trough (18) and the central dome (10), the first wall (16) being generally straight in cross section; and

a second wall (20) interconnected with the trough (18) and the outer ring (22), the second wall (20) being generally straight in cross section.

2. The bubble of claim 1, wherein the first wall (16) has a straight longitudinal dimension in a range of from about 0.003 of an inch to about 0.05 of an inch.

3. The bubble of claim 2, wherein the dimension is about 0.005 of an inch.

4. The bubble of claim 1, wherein the second wall (20) has a straight longitudinal dimension in a range of from about 0.003 of an inch to about 0.05 of an inch.

5. The bubble of claim 4, wherein the dimension is at least 0.005 of an inch.

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6. The bubble of claim 1, wherein the concave cross-section of the trough (18) defines a cross-sectional surface having a radius of from about 0.005 of an inch to about 0.05 of an inch.

7. The bubble of claim 6, wherein the radius is about 0.015 of an inch.

8. The bubble of claim 1, wherein the central dome (10) has an inner surface concave to the interior and has a radius of about 0.16 of an inch to about 0.45 of an inch.

9. The bubble of claim 1, wherein the radial spacing between the central dome (10) and the adjacent exterior surface (9) is about 0.01 of an inch to about 0.03 of an inch.

10. The bubble of claim 1, wherein the concave surface of the outer ring has a radius in cross-section from about 0.08 of an inch to about 0.12 of an inch.

11. The bubble of claim 1, wherein the central dome (10), trough (18), the first wall (16), the second wall (20), the outer ring (22) and the container wall (7) smoothly blend together.

12. The bubble of claim 1, wherein the central dome (10), first and second walls (16 and 20), outer ring (22) and the container wall (7) smoothly blend together.

13. A method of producing at least one bubble (6), in a plastic container suitable for containing pressurized liquids, which does not, in use, extend outwardly from the exterior surface of the container, the method comprising the steps of:

a) providing a blow mold (44) having an axis (46) and at least one bubble forming feature in the form of an annular projection extending toward the axis (46) of the mold cavity and container to be formed, the annular projection having an outer extremity and adjacent side surface complimentary to a trough (18 or 66) and a first wall (16, 20);

b) pre-heating a preform to facilitate blow molding to form the container and the bubble;

c) introducing the preform into the blow mold;

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d) applying a gas at a pressure sufficient to inflate and deform the preform into contact with the mold cavity to form the container and into contact with at least one bubble forming feature to produce the at least one bubble in at least one of the container wall and a shoulder of the container, the bubble comprising:

a central dome (10) having a smoothly curved convex outer surface (11) recessed from an adjacent portion of the exterior surface (9) of the container wall (7) surrounding the bubble (6);

an annular trough (18) surrounding the central dome (10) and recessed below the central dome (10), the annular trough (18) having an annular concave outer surface;

an annular outer ring (22) having an annular convex outer surface with a smoothly curved cross section, the outer ring (22) surrounding the annular trough (18) and connected to the outer periphery of the container wall (7) surrounding the bubble (6);

a first wall (16) interconnected with the trough (18) and the central dome (10), the first wall (16) being generally straight in cross section; and

a second wall (20) interconnected with the trough (18) and the outer ring (22), the second wall (20) being generally straight in cross section;

e) cooling the container, and

f) removing the container with the at least one bubble formed therein from the blow mold cavity.

14. A plastic container suitable for containing a liquid, the container comprising:

a container wall (7) defining an interior (14) of the container and having an interior surface (8) and an exterior surface (9); and

a bubble (6) formed in the container wall (7), comprising:

a central dome (10) having a smoothly curved convex outer surface (11) recessed from an adjacent portion of the exterior surface (9) of the container wall (7) surrounding the bubble (6);

an annular trough (18) surrounding the central dome (10) and recessed below the central dome (10), the annular trough (18) having an annular concave outer surface;

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an annular outer ring (22) having an annular convex outer surface with a smoothly curved cross section, the outer ring (22) surrounding the annular trough (18) and connected to the outer periphery of the container wall (7) surrounding the bubble (6);

a first wall (16) interconnected with the trough (18) and the central dome (10), the first wall (16) being generally straight in cross section; and

a second wall (20) interconnected with the trough (18) and the outer ring (22), the second wall (20) being generally straight in cross section.

15. The plastic container of claim 14, wherein the first wall (16) has a straight longitudinal dimension in a range of from about 0.003 of an inch to about 0.05 of an inch.

16. The plastic container of claim 15, wherein the dimension is about 0.005 of an inch.

17. The plastic container of claim 14, wherein the second wall (20) has a straight longitudinal dimension in a range of from about 0.003 of an inch to about 0.05 of an inch.

18. The plastic container of claim 17, wherein the dimension is at least 0.005 of an inch.

19. The plastic container of claim 14, wherein the concave cross-section of the trough (18) defines a cross-sectional surface having a radius of from about 0.005 of an inch to about 0.05 of an inch.

20. The plastic container of claim 19, wherein the radius is about 0.015 of an inch.

21. The plastic container of claim 14, wherein the central dome (10) has an inner surface concave to the interior and has a radius of about 0.16 of an inch to about 0.45 of an inch.

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22. The plastic container of claim 14, wherein the radial spacing between the central dome (10) and the adjacent exterior surface (9) is about 0.01 of an inch to about 0.03 of an inch.

23. The plastic container of claim 14, wherein the concave surface of the outer ring has a radius in cross-section from about 0.08 of an inch to about 0.12 of an inch.

24. The plastic container of claim 14, wherein the central dome (10), trough (18), the first wall (16), the second wall (20), the outer ring and the container wall (7) smoothly blend together.

25. The plastic container of claim 14, wherein the central dome (10), first and second walls (16 and 20), outer ring and the container wall (7) smoothly blend together.

26. The plastic container of claim 36, further including a plurality of bubbles (6), wherein the bubbles (6) increase the collapse pressure of the container by up to 20%.

27. The plastic container of claim 36, further including a plurality of bubbles (6), wherein the bubbles (6) are arranged in an asymmetrical arrangement on the container wall (7).

28. The bubble of claim 1, wherein the first wall (16) and the second wall (20) each comprise an annular frustum that is straight in cross section.

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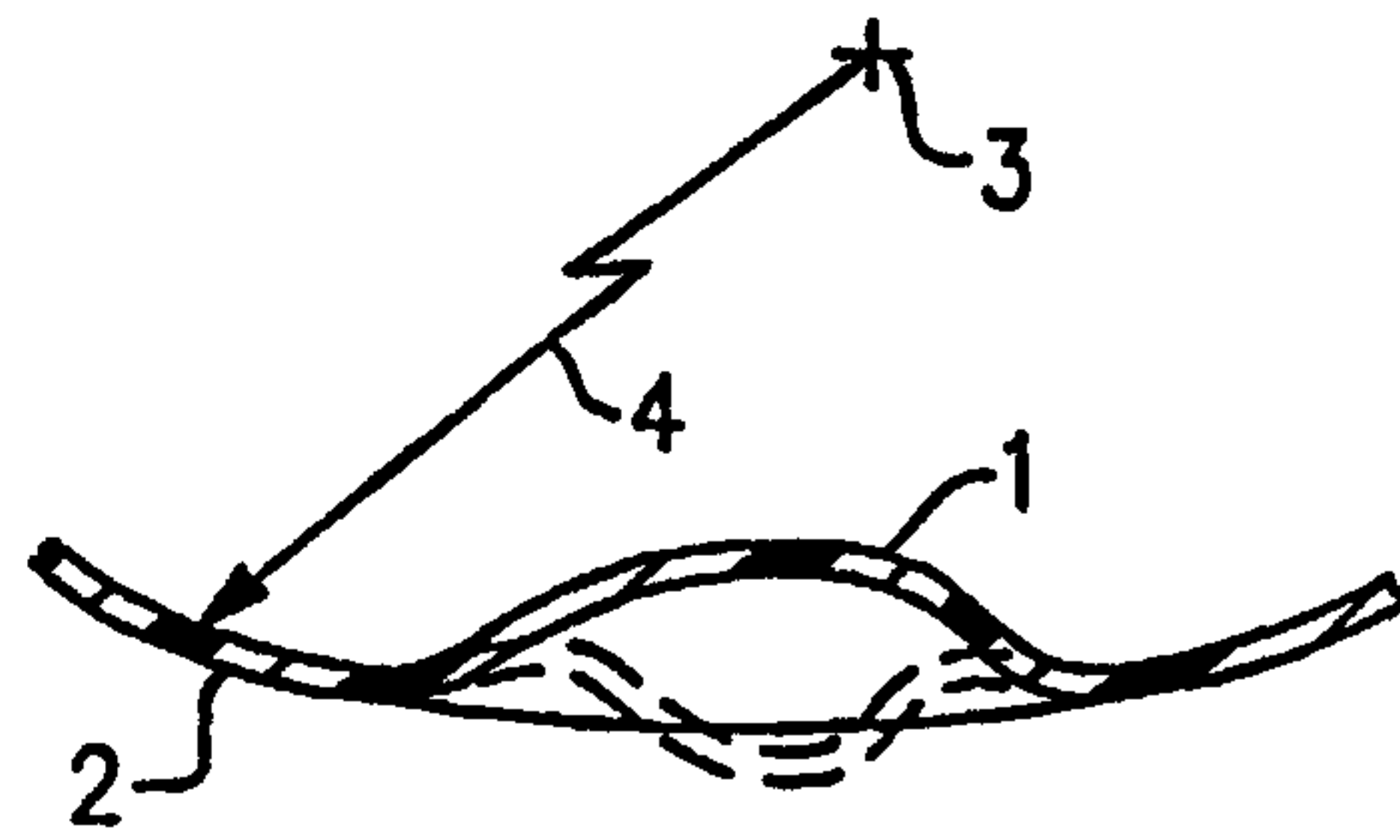


FIG. 1
Prior Art

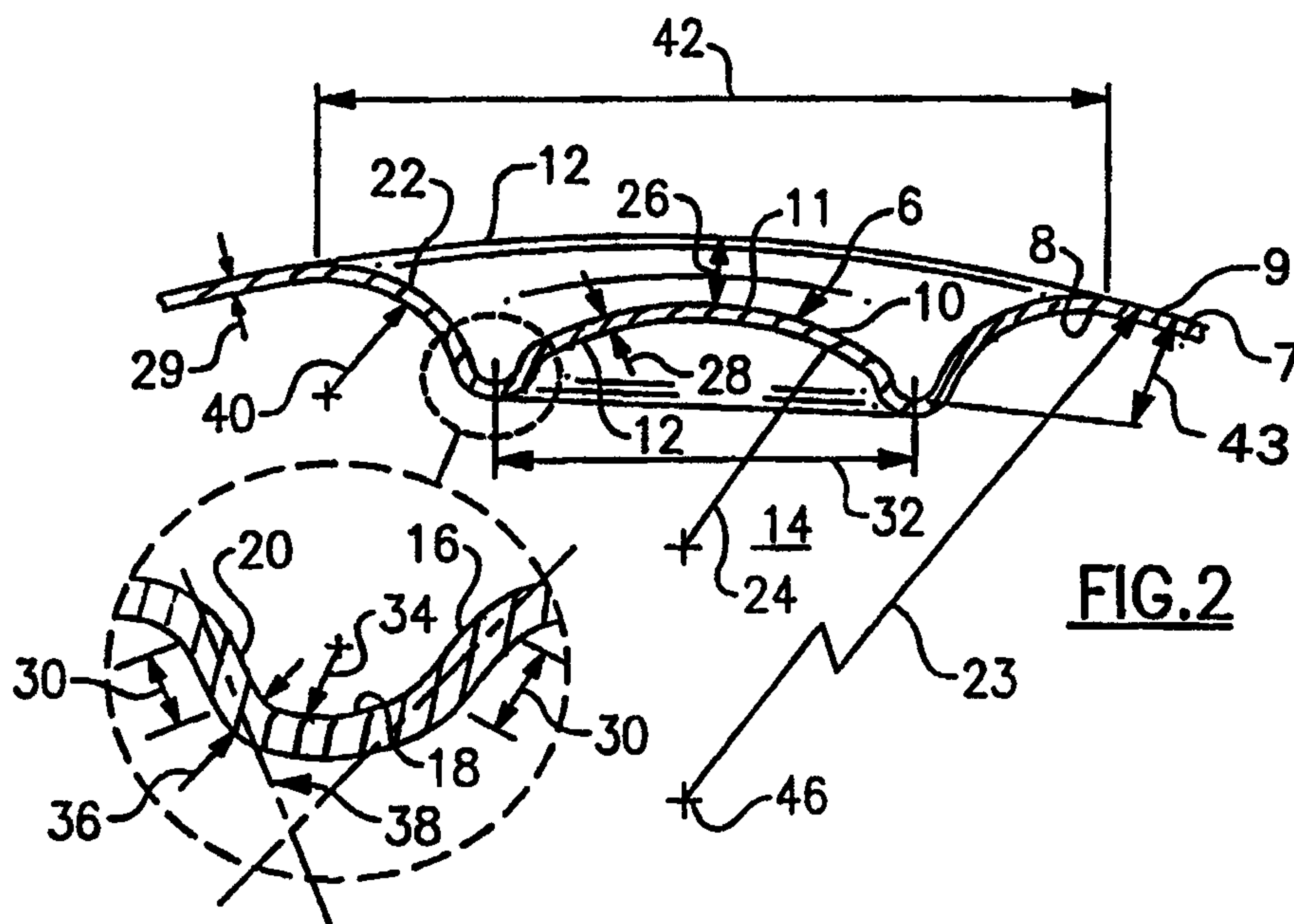


FIG. 2

FIG. 2A

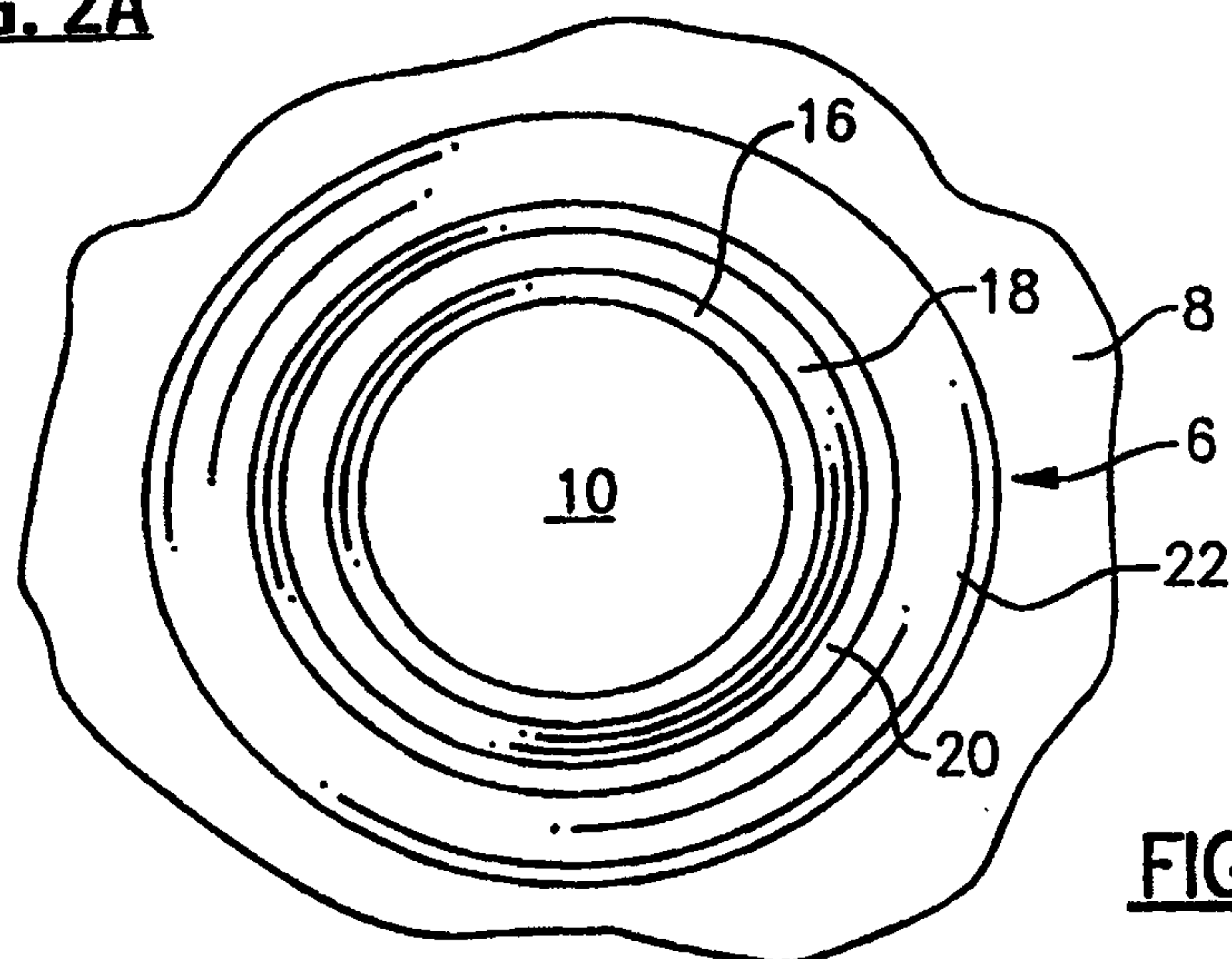
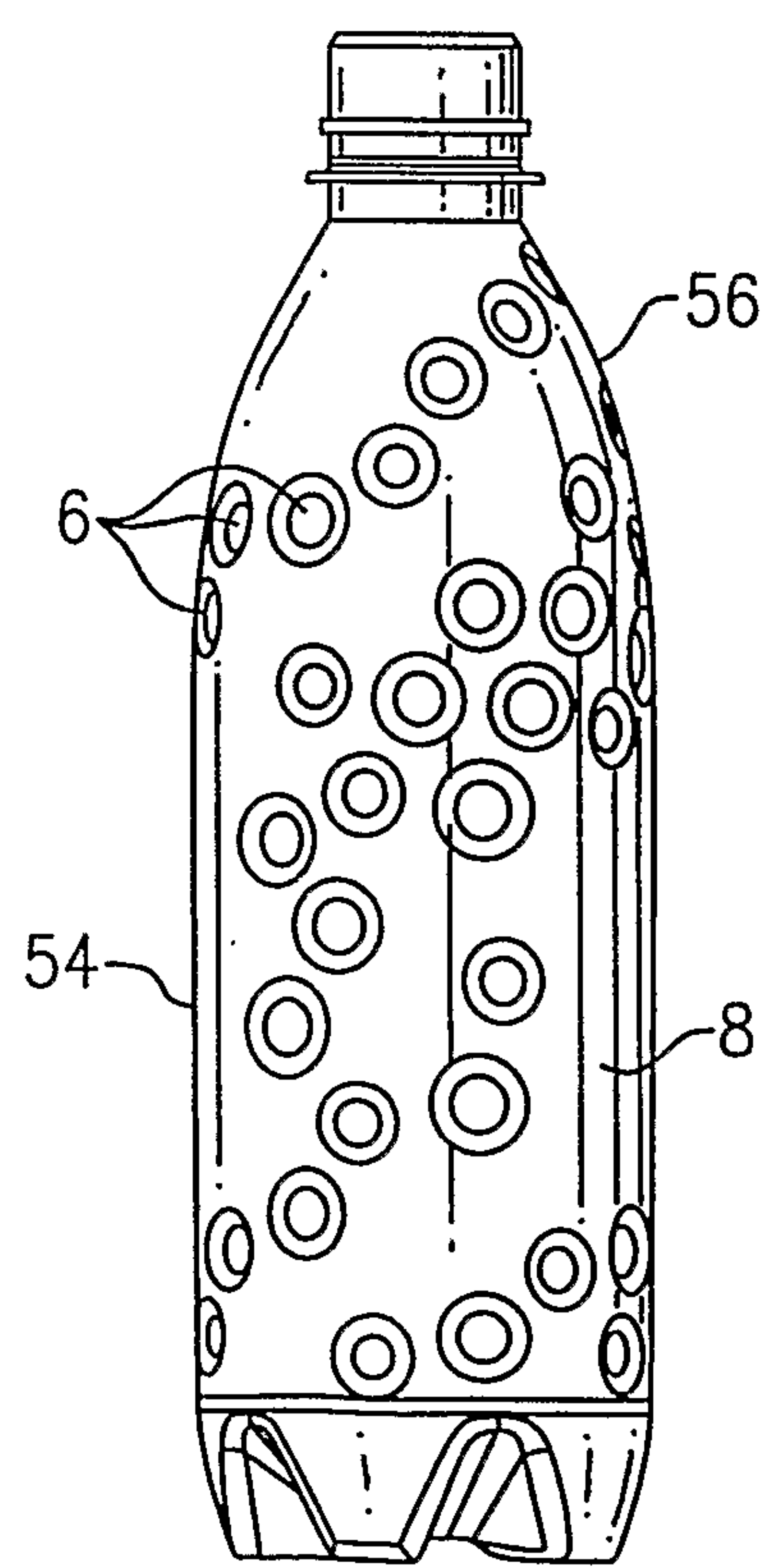
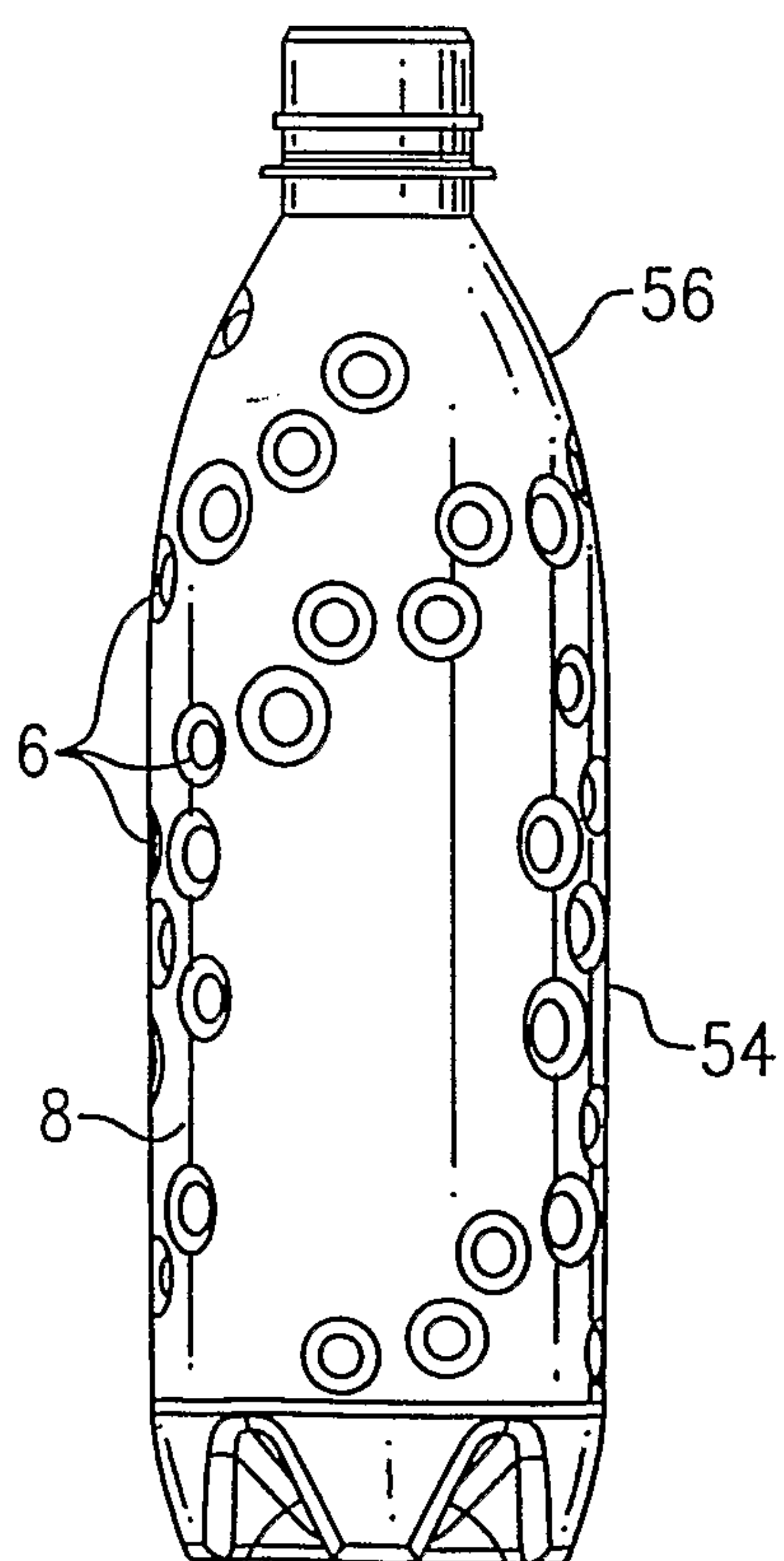
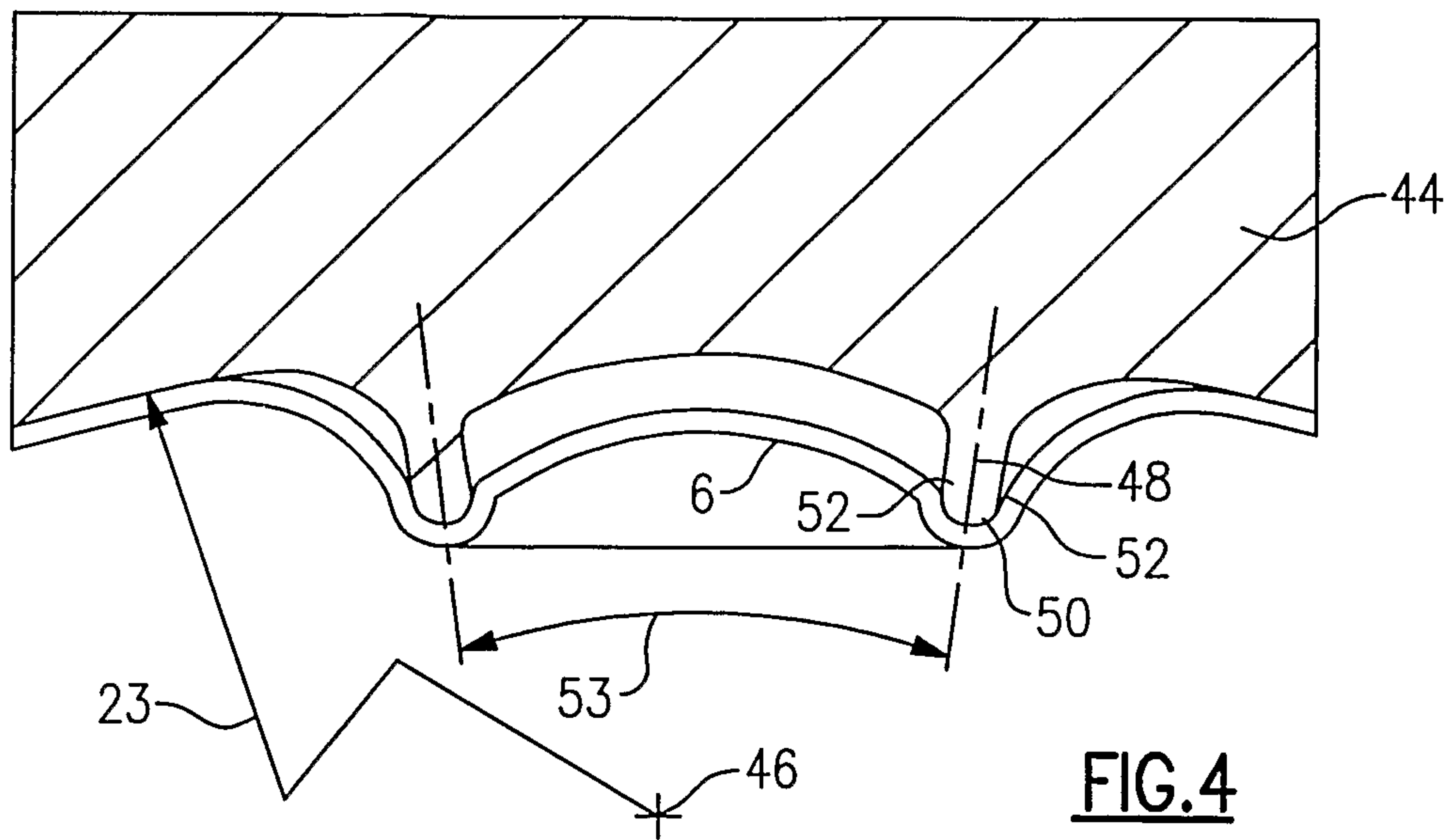
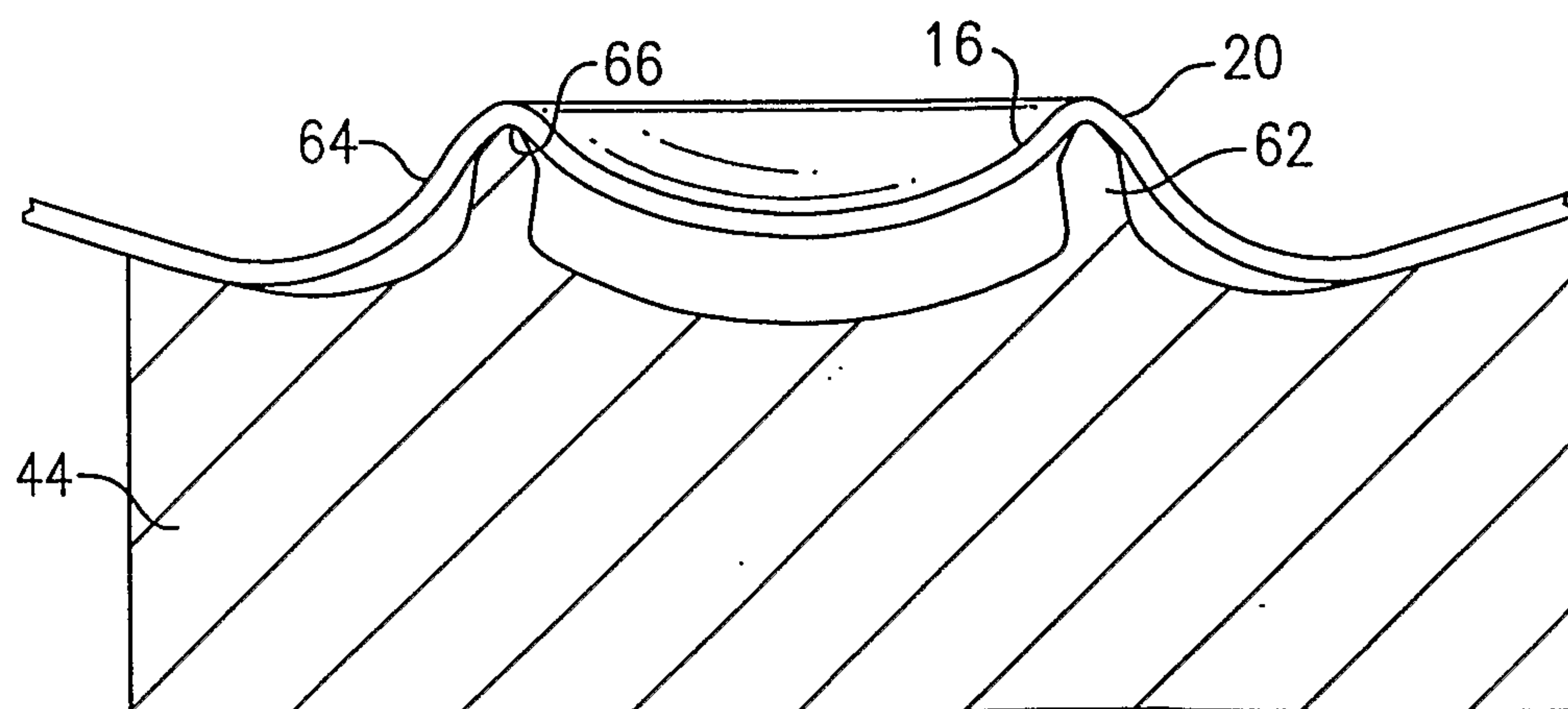
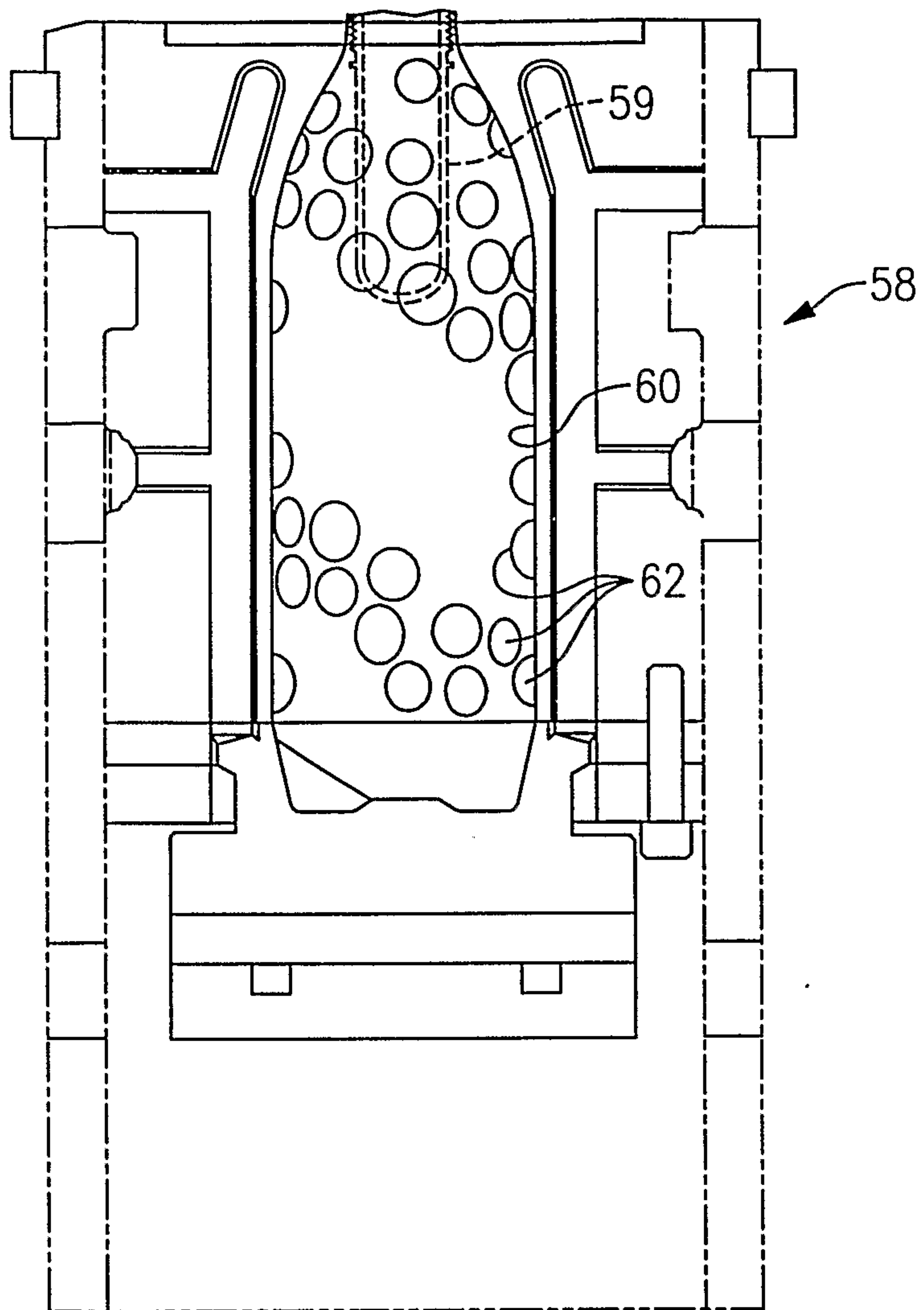


FIG. 3

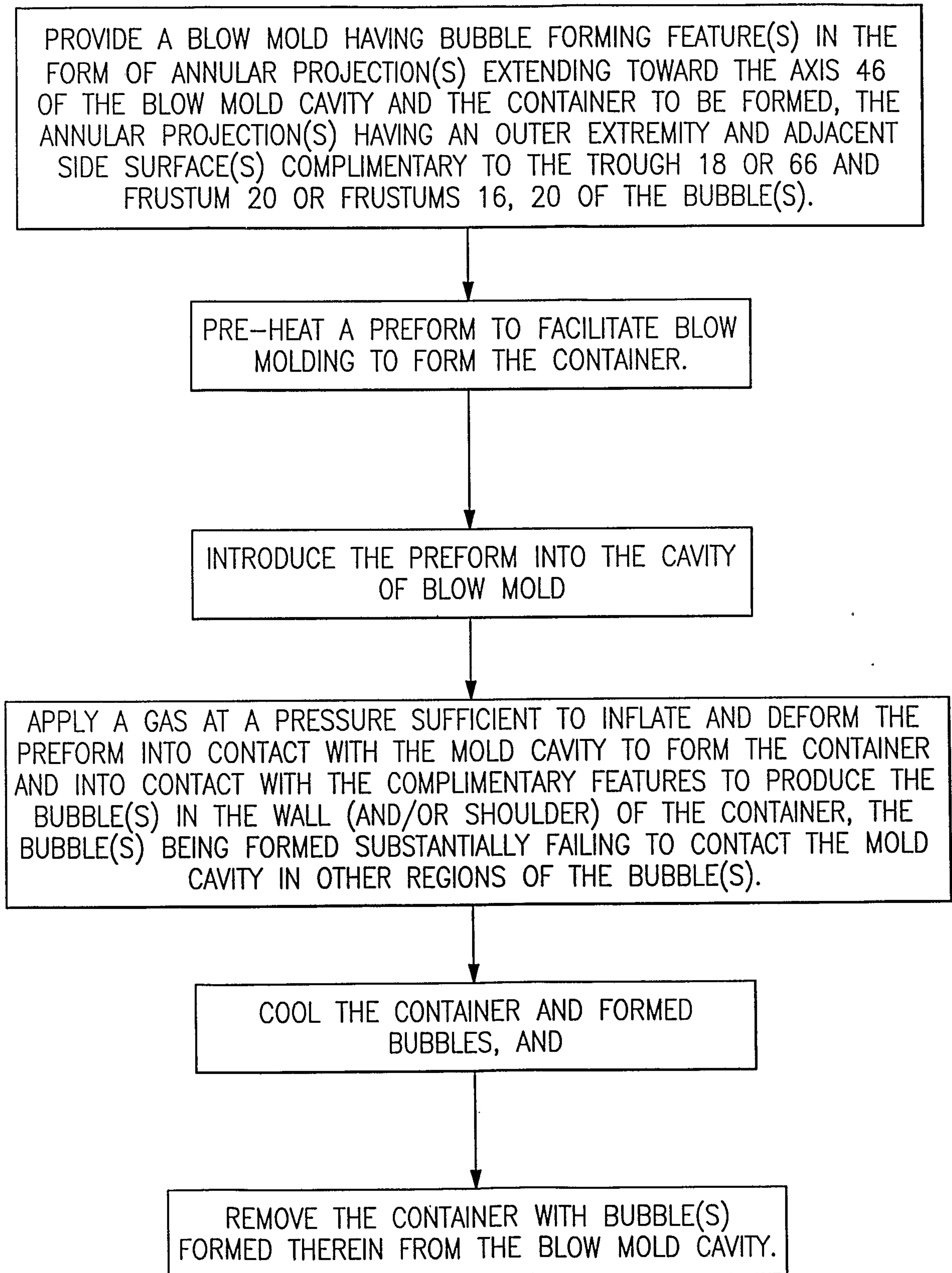
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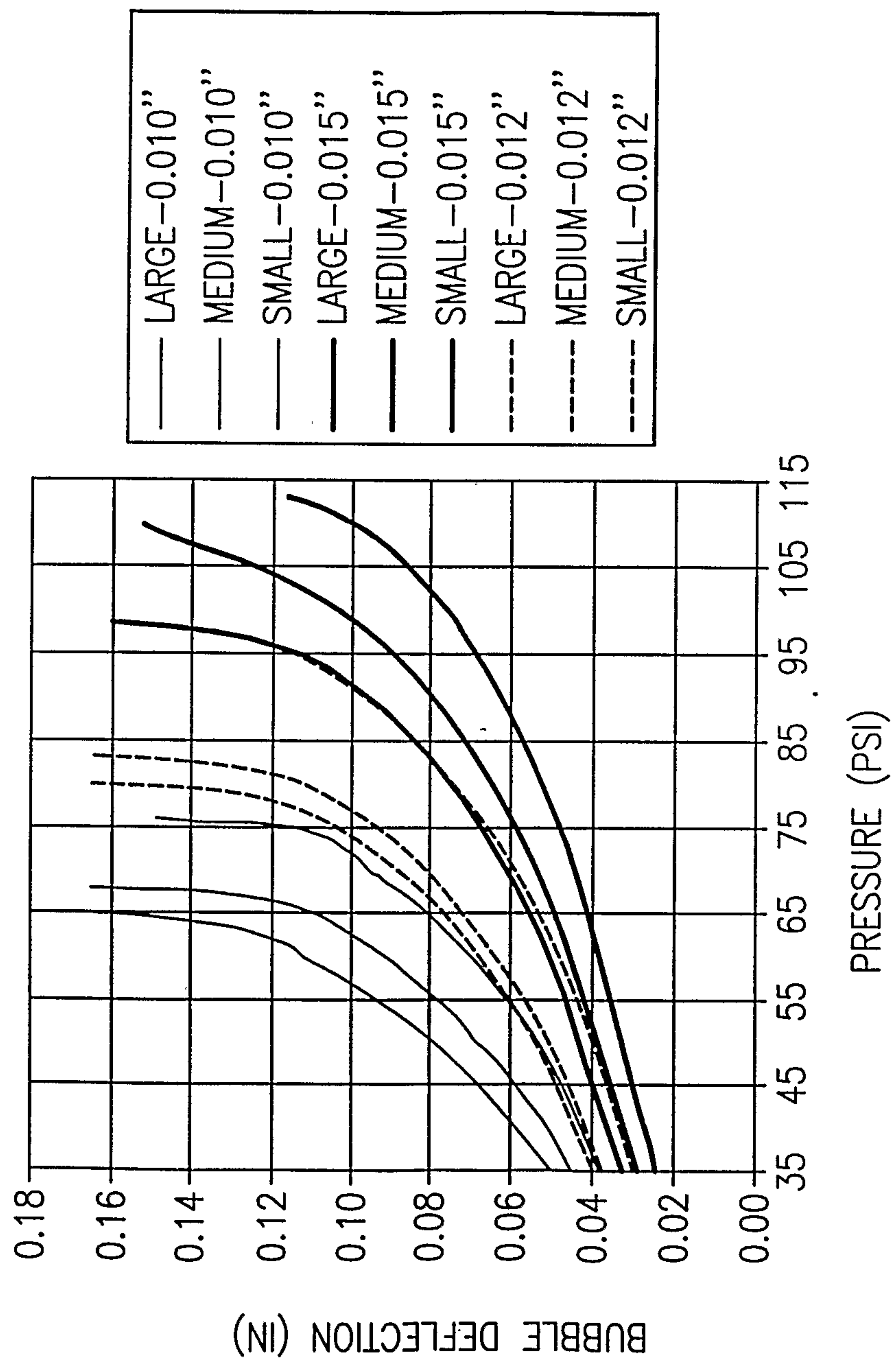
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FIG.6FIG.7

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FIG.8

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FIG.9

