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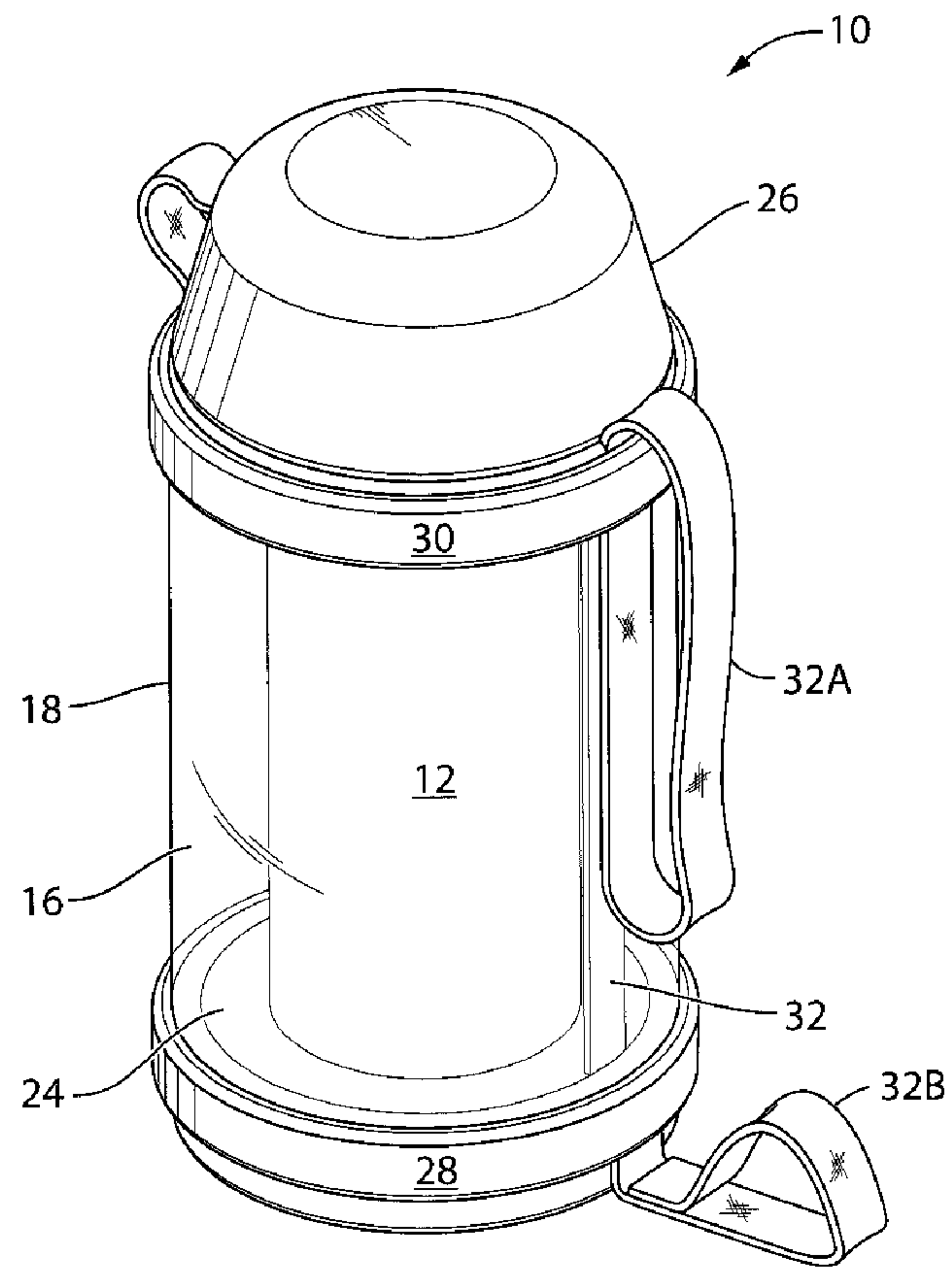
(54) Title: PORTABLE APPARATUS FOR STORING WATER AND MELTING FROZEN WATER



(57) Abrégé/Abstract:
Portable apparatus for storing liquids and melting frozen liquids using solar radiation is provided. A thermally conductive vessel is at least partially enclosed within a thermally insulative case. The case is configured to transmit incident solar radiation to the vessel. The vessel is configured to absorb incident solar radiation, and conduct heat generated thereby to its contents. An insulating and solar radiation transmissive gap is provided between the vessel and the case.

Abstract of the Disclosure

Portable apparatus for storing liquids and melting frozen liquids using solar radiation is provided. A thermally conductive vessel is at least partially enclosed within a thermally insulative case. The case is configured to transmit incident solar radiation to the vessel. The vessel is configured to absorb incident solar radiation, and conduct heat generated thereby to its contents. An insulating and solar radiation transmissive gap is provided between the vessel and the case.

Portable Apparatus for Storing Water and Melting Frozen Water

Technical Field

[0001] The invention relates to portable apparatus for storing water. Embodiments of the invention provide apparatus for melting frozen water and storing water in liquid form in low temperature environments.

Background

[0002] Liquid water can be difficult or impossible to find in high altitude locations. This is because water evaporates quickly at high altitudes due to the relatively low atmospheric pressure and the energy of solar radiation there. This is also because temperatures at high altitude locations are often below the freezing temperature of water.

[0003] Individuals partaking in high altitude activities such as hiking and mountaineering are at risk of dehydration due to dry conditions at high altitudes and physical exertion. Carrying water supplies to high altitude locations is onerous, and water supplies are susceptible to freezing at high altitudes unless stored in insulated containers. For this reason, it is common to obtain drinking water at high altitudes by melting snow or ice, typically using a stove or fire. Using a stove or fire to melt snow or ice is onerous and inconvenient. Water melted from snow or ice must be consumed before it re-freezes.

[0004] Water storage vessels used in high altitude hiking and mountaineering applications must meet performance standards not required of vessels used at lower altitudes and in less demanding applications. For example, water storage vessels used in high altitude hiking and mountaineering applications may experience impact shocks at temperatures below -20 degrees Celsius. At this temperature, some materials known to be used in water storage vessels are brittle, and prone to shattering. For another example, cooperating parts of water storage vessels commonly used in low altitude applications may be susceptible to freeze-locking in high altitude conditions. Such freeze-locking may render water within these vessels inaccessible.

[0005] Literature in the general field of water storage vessels includes the following references:

- P. Lefferts, US 3,203,306 , Optical Ray Concentrator;
- Bond, US 3,807,194, Thermodynamic Container;
- Tiede et al., US 4,240,272, Arctic Canteen;
- Crosser, US 4,823,974, Chill Cylinder for Beverage Containers;
- Padamsee, US 5,329,778, Thermally Insulated Bottle and Method of Assembly thereof;
- Liu, US 7,270,244, Polycarbonate Double Walled Liquid Holding Vessel;
- Guilford, III et al., US 7,287,656, Container for Promoting Thermal Transfer;
- Kolowich, US 7,934,537, Thermal Receptacle with Phase Change Material;
- Palena et al., US 7,942,145, Rechargeable Self-Heating Food Container;

- Thadani, US 2007/0131638, Simplified Insulated Bottle;
- Grant, US 2008/0099493, Containers Having a Space for a Materials, a Cooling Device, or a Heating Device; and
- Hemminger et al., US 2009/0283533, Thermodynamic Container.

[0006] The foregoing examples of the related art and limitations related thereto are intended to be illustrative and not exclusive. Other limitations of the related art will become apparent to those of skill in the art upon a reading of the specification and a study of the drawings.

<u>Summary</u>

[0007] The following embodiments and aspects thereof are described and illustrated in conjunction with apparatus which are meant to be exemplary and illustrative, not limiting in scope. In various embodiments, one or more of the above-described problems have been reduced or eliminated, while other embodiments are directed to other improvements.

[0008] An aspect of the invention provides portable apparatus for storing liquid. The apparatus comprises a case and a vessel that is at least partially enclosed within the case. The case is at least partially transmissive of solar radiation. The vessel has greater thermal conductivity than the case. In some embodiments according to this aspect, the vessel is more absorptive of solar radiation than the case. The vessel may be at least partially sealed within the case.

[0009] Another aspect of the invention provides portable apparatus for storing liquid in which the apparatus comprises a case comprising a hard, transparent plastic tube, a deformable plug sealing a first end of the tube, and a deformable collar sealing a second end of the tube. A metal vessel is at least partially enclosed within the case, with the vessel sealed against the collar. The vessel has a mouth accessible from outside the case communicating with the interior of the vessel.

[0010] In addition to the exemplary aspects and embodiments described above, further aspects and embodiments will become apparent by reference to the drawings and by study of the following detailed descriptions.

Brief Description of Drawings

[0011] The accompanying drawings show non-limiting example embodiments.

[0012] FIG. 1 is a perspective view of an apparatus according to an example embodiment in a capped configuration.

[0013] FIG. 2 is a perspective view of the FIG. 1 apparatus in an uncapped configuration.

[0014] FIG. 3 is a perspective cutaway view of the FIG. 1 apparatus in the capped configuration.

Description

[0015] Throughout the following description specific details are set forth in order to provide a more thorough understanding to persons skilled in the art. However, well known elements may not have been shown or described in detail to avoid unnecessarily obscuring the disclosure. Accordingly, the description and drawings are to be regarded in an illustrative, rather than a restrictive, sense.

[0016] FIGs. 1, 2 and 3 show an apparatus 10 according to an example embodiment. In particular:

- FIG. 1 is a perspective view of apparatus 10 in a capped configuration;
- FIG. 2 is a perspective view of apparatus 10 in an uncapped configuration; and
- FIG. 3 is a perspective cutaway view of apparatus 10 in the capped configuration.

[0017] Apparatus 10 comprises a vessel 12 that defines chamber 12A. Vessel 12 is at least partially enclosed within a case 16. In the illustrated embodiment, case 16 comprises a tube 18, a plug 20 and a collar 22. Tube 18 of the illustrated embodiment has circular cross-section; in other embodiments, tube 18 may have other cross-sections (e.g., oval, square, etc.). Tube 18 need not have uniform cross-section over its length.

[0018] Tube 18 is closed at a first end (in the drawings, the bottom end) by plug 20. In the illustrated embodiment, plug 20 is stepped, such that it has a first portion whose profile matches inner sidewall of tube 18 and a second portion whose profile matches the first end of tube 18. Advantageously, this configuration of plug 20 provides two interfaces between tube 18 and plug 20, namely interface 21A between the first portion and the inner sidewall of tube 18 and interface 21B between the second portion and the first end of tube 18. Plug 20 may be bonded to tube 18 on one or both of interfaces 21A and 21B by adhesive, heat bonding, or the like.

[0019] In the illustrated embodiment, plug 20 comprises a recess 20A that receives a first end (in the drawings, the bottom end) of vessel 12. Vessel 12 is supported at its first end by plug 20. Recess 20A is shaped to laterally confine the first end of vessel 12. For example, in the illustrated embodiment, recess 20A is shaped to conform to the first end of vessel 12 (i.e., in the illustrated embodiment, vessel 12 has circular cross-section at its first end and recess 20A is cylindrical). In some embodiments, recess 20A laterally confines the first end of vessel 12 even though the shape of recess 20A does not match the corresponding end of vessel 12. In some embodiments, vessel 12 is secured in recess 20A, such as by adhesive, snap-fit engagement, or the like, for example.

[0020] Tube 18 is closed at a second end (in the drawings, the top end) against vessel 12 by collar 22. In the illustrated embodiment, the radially outward surface of collar 22 is stepped such it has a first portion whose profile matches inner sidewall of tube 18, a second portion whose profile matches the second end wall of tube 18, and a third portion whose outer profile matches outer sidewall of tube 18. Advantageously, this configuration of collar 22 provides two interfaces between tube 18 and collar 22, namely interface 23A between the first portion and the inner sidewall of tube 18 and interface 23B between the second portion and the second end wall of tube 18. Collar 22 may be bonded to tube 18 on one or both of interfaces 23A and 23B by adhesive, heat bonding, or the like.

[0021] Collar 22 defines an aperture 22C that receives a second end (in the drawings, the top end) of vessel 12. In the illustrated embodiment, the second end of vessel 12 extends beyond the second end of case 16, such that a mouth 12B of vessel 12 is located outside of case 16. In other embodiments, mouth 12B is located inside case 16 (e.g., the second end of vessel 12 may be co-terminus with the second end of case 16). Mouth 12B of vessel 12 is threaded for cooperation with a vessel cap 14.

[0022] Advantageously, the multi-part structure of case 16 may provide improved impact resistance as compared with other structures. In some embodiments, plug 20 and collar 22 are relatively more susceptible to elastic deformation than tube 18 along radial or transverse directions. This relative susceptibility of plug 20 and collar 22 to deformation may permit plug 20 and/or collar 22 to be deformed when transverse forces deform tube 18 (e.g., by causing at least part of tube 18 to deform from its original cross-section). In some embodiments, the relative susceptibility of plug 20 and collar 22 to radial or transverse deformation as compared to tube 18 prevents rupture of case 16 that might otherwise occur due to fracture of tube 18 (e.g., where plug 20 and/or collar 22 exert normal force that prevents or limits deformation of tube 18 from its original cross-section) and/or due to separation of tube 18 from plug 20 and/or collar 22. In embodiments where plug 20 and/or collar 22 extend past their respective ends of tube 18 and comprise material that is relatively susceptible to deformation, they may also absorb longitudinal impact forces, which might otherwise fracture tube 18.

[0023] In the illustrated embodiment, the inner surface of tube 18 is spaced apart from the outer surface of vessel 12 to define a gap space 24.

Sealing all or part of vessel 12 inside case 16 so that gap space 24 is airtight may better insulate vessel 12 from ambient temperatures. In the illustrated embodiment, interfaces 21A and/or 21B between tube 18 and plug 20, interfaces 23A and/or 23B between tube 18 and collar 22, and the interface between collar 22 and vessel 12 may be sealed so that gap space 24 is airtight. Gap space 24 may comprise air or a vacuum, for example. In embodiments where case 16 and gap space 24 insulate vessel 12 from the ambient temperature outside case 16, the freezing of liquid water in vessel 12 may be delayed when the ambient temperature outside case 16 is below the freezing temperature of water. In some embodiments, gap space 24 is filled with solid or liquid. Some embodiments do not have gap space 24.

[0024] Insulation of vessel 12 from ambient temperatures may be enhanced where case 16 comprises thermally insulative material. In some embodiments, case 16 comprises material(s) having thermal conductivity less than one or more of 1 W/(m·K), 0.5 W/(m·K), 0.25 W/(m·K), 0.1 W/(m·K), and 0.05 W/(m·K). For example, plug 20 and collar 22 may comprise open cell or closed cell foam (e.g., polyethylene foam, polyurethane foam, expanded polystyrene, extruded polystyrene foam, foam rubber, and/or the like) or the like, and tube 18 may comprise solid plastic or the like.

[0025] In the illustrated embodiment, vessel 12 may be insulated from the ambient environment by case cap 26. When apparatus 10 is in the capped condition, case cap 26 abuts collar 22. Case cap 26 may comprise thermally insulating material, such as foam, for example. Where case cap 16 comprises resiliently deformable material, such as foam, for example, case cap 26 may protect vessel cap 14, vessel 12 and/or case 16 from impact forces.

[0026] In the illustrated embodiment, case cap 26 is configured for releasable press-on fitting engagement with vessel cap 14 and is tethered to case 16. Press-on fitting engagement may permit a user whose hands are gloved or in mitts to remove case cap 26 easily. In other embodiments, case cap 26 may be configured for different types of releasable engagement with vessel cap 14 (e.g., threaded, magnetic, etc.). Case cap 26 may be configured for releasable engagement with case 16, tube 18, collar 22, and/or vessel 12 (e.g., collar 22 and case cap 26 may comprise cooperating engagement features).

[0027] In the illustrated embodiment, apparatus 10 comprises bands 28 and 30, which span interfaces 21A, 21B and 23A, 23B between tube 18 and, respectively, plug 20 and collar 22. Bands 28 and 30 may form part of and/or protect (e.g., against degradation caused by solar radiation, etc.) seals at the interfaces between tube 18, plug 20, collar 22 and vessel 12. Bands 28 and 30 may comprise material that is substantially non-transmissive of ultraviolet radiation. In a particular non-limiting example embodiment, bands 28 and 30 comprise black nylon straps. In some embodiments, bands 28 and 30 comprise a coating (e.g., of paint, stain, epoxy, etc.).

[0028] Apparatus 10 also comprises an optional carry strap 32. Strap 32 passes on the inside of tube 18 and extends out the ends of tube 18 between plug 20 and collar 22. Strap 32 may be fastened to the inside wall of tube 18, such as by adhesive, for example. Loops 32A and 32B are formed at the ends of strap 32. Strap 32 may comprise a nylon strap, for example. One or more carry straps may be provided to apparatus 10 in other ways. For example, in some embodiments, separate straps are provided at each end of tube 18.

[0029] In some embodiments, apparatus 10 is configured for melting frozen water inside vessel 12 using solar radiation. More particularly, case 16 and gap space 24 may be configured to transmit solar radiation to vessel 12, and vessel 12 may be configured to convert incident solar radiation into heat energy and to conduct this heat energy to chamber 12A. In embodiments where apparatus 10 is so configured, snow or other forms of frozen water (e.g., ice chips, etc.) inserted into chamber 12A through mouth 12B may be melted when apparatus 10 is exposed to solar radiation (e.g., by being strapped to the outside of a pack during a hike or climb).

[0030] Solar radiation that is not reflected or absorbed by tube 18 passes into case 16, where it may interact with vessel 12 and be converted to heat energy. In some embodiments, tube 18 comprises material that is substantially non-absorptive and non-reflective of at least some wavelengths of solar radiation. For example, tube 18 may be, at least in part, transparent and/or translucent (i.e., substantially non-absorptive of radiation in the visible spectrum). In some embodiments, tube 18 comprises material that at 3.2 mm thickness transmits more than 85% of incident radiation over the visible spectrum (390 nm to 750 nm). In some embodiments, tube 18 comprises material that at 3.2mm thickness transmits more than 85% of incident radiation over the spectrum from 400 nm – 1100 nm. In some embodiments tube 18 is between 1 mm (0.04 inches) and 5 mm (0.2 inches) thick. In some embodiments tube 18 is between 2 mm (0.08 inches) and 3 mm (0.12 inches) thick. In a particular example embodiment, tube 18 is 2.54 mm (0.1 inches) thick.

[0031] Preferably, tube 18 comprises material that, in addition to being substantially non-absorptive and non-reflective of at least some wavelengths of solar radiation, is also thermally insulative, durable and lightweight. Non-limiting examples of materials that tube 18 may comprise include:

- polycarbonate;
- polyurethane;
- polymethyl methacrylate;
- polystyrene;
- polypropylene;
- fluorinated ethylene propylene; and
- the like.

[0032] Tube 18 may comprise stabilizers to inhibit degradation due to exposure to ultraviolet radiation. For example, tube 18 may comprise polyurethane having a hindered amine light stabilizer (HALS) added to inhibit degradation due to exposure to solar radiation.

[0033] Solar radiation incident on vessel 12 may be absorbed and converted to heat energy, which may be conducted through vessel 12 to the contents of chamber 12A. The efficiency with which solar radiation incident on vessel 12 is applied to heat the contents of chamber 12A is greater where vessel 12 is:

- more thermally conductive (e.g., so that a greater proportion of heat energy arising from absorption of incident solar radiation is conducted to chamber 12A),
- more absorptive of incident solar radiation (e.g., so that a greater proportion of incident solar radiation is converted to heat energy) and conversely less reflective of solar radiation (e.g., so that a smaller proportion of incident solar radiation is reflected), and
- less thermally emissive (e.g., so that a smaller proportion of heat energy arising from absorption of incident solar radiation is radiated into and/or through gap space 24).

[0034] In some embodiments, vessel 12 comprises material that, as compared with tube 18, absorbs a greater proportion of incident solar radiation and/or has greater thermal conductivity. Vessel 12 may comprise material and/or features that promote or provide one or more of relatively high absorptivity, relatively high thermal conductivity and relatively low emissivity.

[0035] In some embodiments, vessel 12 comprises material having thermal conductivity greater than one or more of 120 W/(m·K), 180 W/(m·K), 200 W/(m·K), and 400 W/(m·K). Non-limiting examples of materials that vessel 12 may comprise include:

- aluminium,

- copper,
- alloys incorporating either of the foregoing,
- other metals, and
- the like.

Vessel 12 may comprise an impact extruded aluminium beverage bottle of the type made by Exal Corporation of Youngstown, OH, or a re-usable aluminium bottle of the type made by SIGG USA Inc. of Stamford, CT, for example.

[0036] In some embodiments, vessel 12 comprises an outer layer of material that promotes absorption of solar radiation. For instance, an outer surface of vessel 12 may comprise a layer of material having low reflectivity (e.g., having solar reflectance (or albedo) less than one or more of 20%, 15%, 10% and 5%), such as material which provides darkly colored diffuse outer surface. Such a layer may be applied as a coating by dying, staining, painting, glazing, anodizing, plating, powder coating, or the like, for example.

[0037] By way of example, in some embodiments vessel 12 comprises a black dyed matte anodized finish having solar reflectance of about 11%. This may be compared with solar reflectance of about 60% for polished stainless steel and about 44% for brushed stainless steel.

[0038] In some embodiments, an outer surface of vessel 12 is textured to promote absorption of solar radiation (e.g., by increasing the probability of that reflected light is reflected back onto the surface, rather than away from the surface). For example, an outer surface of vessel 12 may comprise a surface that is rough. Texture may be applied to surfaces of vessel 12 by machining, abrading, media blasting, mechanical pitting, chemical pitting, polishing, etching, coating, and/or like processes.

[0039] In some embodiments, a surface of vessel 12 comprises a selective surface which exhibits an advantageous combination of high absorption factor and low emissivity. Non-limiting examples of selective surfaces that may be used in vessel 12 include:

- anodic cobalt,
- black sulphide,
- black chromium;
- Thurmalox ™ coating manufactured by Dampney Company of Everett, MA;
- CrystalClear™ coatings manufactured by Thermafin Holding, LLC of Jacksonville, FL; and
- the like.

[0040] Preferably any coating applied to vessel 12 does not unduly interfere with conduction of heat generated by absorption of solar radiation to the contents of chamber 12A. Where an exterior surface of vessel 12 is coated with a material having lower thermal conductivity than the material of vessel 12, it may be preferable that the coating is thin.

[0041] The size of gap space 24 relative to vessel 12 and tube 18 can affect the performance of apparatus 10 in melting frozen water using solar radiation. In general, a larger gap space may provide better insulation of vessel 12 from ambient conditions outside tube 18. However, where the size of gap space 24 is increased by decreasing the cross-section of vessel 12, the surface area of vessel 12 available for absorbing solar radiation is decreased, which may lead to less heat being provided to the contents of chamber 12A. Also, where the size of gap space 24 is increased by increasing the cross-sectional area of tube 18, the effective size and mass of apparatus 10 is also increased, which may make apparatus 10 less convenient to carry.

[0042] In some embodiments where vessel 12 and tube 18 have cylindrical cross section, the ratio of the outside diameter of vessel 12 to the inside diameter of tube 18 is between 0.75 and 0.9. In some embodiments where vessel 12 and tube 18 have cylindrical cross section, the ratio of the outside diameter of vessel 12 to the inside diameter of tube 18 is between 0.8 and 0.85. In a particular example embodiment, the ratio of the outside diameter of vessel 12 to the inside diameter of tube 18 is 0.83.

[0043] In some embodiments, an outer surface of vessel 12 is spaced apart from an opposed inner surface of tube 18 by one or more of: at least 0.5 inches (1.27 centimeters), at least 0.65 inches (1.65 centimeters), about 0.7 inches (1.78 centimeters), less than 0.75 inches (1.9 centimeres) and less than 1 inch (2.54 centimeters). For example, where vessel 12 and tube 18 have cylindrical cross section, the difference between the outside diameter of vessel 12 and the inside diameter of tube 18 may be between 0.5 inches (1.27 centimeters) and 1 inch (2.54 centimeters), between 0.65 inches (1.65 centimeteres) and 0.75 inches (1.9 centimeters), or about 0.7 inches (1.78 centimeters). In some embodiments, all outer surfaces of vessel 12 are spaced apart from opposed inner surfaces of tube 18 by one or more of: at least 0.5 inches (1.27 centimeters), at least 0.65 inches (1.65 centimeters), about 0.7 inches (1.78 centimeters), less than 0.75 inches (1.9 centimeres) and less than 1 inch (2.54 centimeters).

[0044] In some embodiments, the ratio of the cross-sectional area of gap 24 space to the cross-sectional area of the interior of tube 18 is between 0.2 and 0.4. In some embodiment, the ratio of the cross-sectional area of gap space 24 to the cross-sectional area of the interior of tube 18 is between 0.25 and 0.35. In a particular example embodiment, the ratio of the cross-sectional area of gap space to the cross-sectional area of the interior of tube 18 is 0.3.

[0045] Some advantages of the invention are demonstrated by the performance of a non-limiting prototype embodiment. The prototype embodiment has construction generally similar to apparatus 10 shown in FIGs. 1-3. In the prototype embodiment:

- tube 18 comprises a clear, colorless Markrolon™ ET3227 polycarbonate tube having 4” (10.2 cm) outside diameter, 8.5” (21.6 cm) length and 0.1” (2.5 mm) wall thickness;
- vessel 12 comprises a 1 litre wide-mouth aluminium bottle with black anodized finish made by SIGG USA Inc. of Stamford CT, which bottle has 3.25” (8.25 cm) outside diameter;
- plug 20, collar 22, and case cap 26 are made from closed cell polyurethane foam;
- all but the mouth of vessel 12 is sealed inside case 16; and
- gap space 24 comprises air.

[0046] The prototype embodiment weighs less than 460 grams.

[0047] In a first test of the prototype, approximately 500ml of ice was placed in the vessel's chamber at room temperature, the vessel cap and case cap closed, and the apparatus placed in an outdoor environment with ambient temperature of approximately 5 degrees centigrade and exposure to low angle sunlight (12h00 to 14h00 at approximately 49 degrees latitude on November 15th). After two hours, the vessel contained approximately 400 ml of liquid water.

[0048] In a second test of the prototype, approximately 900 ml of ice was placed in the vessel's chamber at room temperature, the vessel cap and case cap left open, and the apparatus placed in an indoor environment with ambient temperature of approximately 15 degrees centigrade and no exposure to sunlight. After six hours, the vessel contained approximately 260ml of liquid water.

[0049] Where a component is referred to above (e.g., a case, vessel, tube, plug, collar, recess, case cap, vessel cap, seal, band, etc.), unless otherwise indicated, reference to that component (including a reference to a "means") should be interpreted as including as equivalents of that component any component which performs the function of the described component (i.e., that is functionally equivalent), including components which are not structurally equivalent to the disclosed structure which performs the function in the illustrated exemplary embodiments of the invention.

[0050] Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise," "comprising," and the like are to be construed in an inclusive sense, as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to." Where the context permits, words in the above description using the singular or plural number may also include the plural or singular number respectively. The word "or," in reference to a list of two or more items, covers all of the following interpretations of the word: any of the items in the list, all of the items in the list, and any combination of the items in the list.

[0051] The above detailed description of example embodiments is not intended to be exhaustive or to limit this disclosure and claims to the precise forms disclosed above. While specific examples of, and examples for, embodiments are described above for illustrative purposes, various equivalent modifications are possible within the scope of the technology, as those skilled in the relevant art will recognize.

[0052] These and other changes can be made to the apparatus in light of the above description. While the above description describes certain examples of the technology, and describes the best mode contemplated, no matter how detailed the above appears in text, the technology can be practiced in many ways. As noted above, particular terminology used when describing certain features or aspects of the apparatus should not be taken to imply that the terminology is being redefined herein to be restricted to any specific characteristics, features, or aspects of the system with which that terminology is associated. In general, the terms used in the following claims should not be construed to limit the system to the specific examples disclosed in the specification, unless the above description section explicitly and restrictively defines such terms. Accordingly, the actual scope of the technology encompasses not only the disclosed examples, but also all equivalent ways of practicing or implementing the technology under the claims.

[0053] From the foregoing, it will be appreciated that specific examples of apparatus have been described herein for purposes of illustration, but that various modifications, alterations, additions and permutations may be made without departing from the practice of the invention. The embodiments described herein are only examples. Those skilled in the art will appreciate that certain features of embodiments described herein may be used in combination with features of other embodiments described herein, and that embodiments described herein may be practised or implemented without all of the features ascribed to them herein. Such variations on described embodiments that would be apparent to the skilled addressee, including variations comprising mixing and matching of features from different embodiments, are within the scope of this invention.

[0054] As will be apparent to those skilled in the art in light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. For example:

- Vessel 12 may have an interior lining, such as made from non-toxic polymers, enamel, or the like, for example. Preferably such lining has low thermal resistance (R).
- Vessel 12 may comprise plug 20 (e.g., plug 20 may provide one or more surfaces of vessel 12).
- Vessel 12 may comprise collar 22 (e.g., collar 22 may provide one or more surfaces of vessel 12).
- Case 16 need not include plug 20 (e.g., the bottom of case 16 may be integral with the sidewall of case 16, and vessel 12 may be suspended above the bottom of case 16 or spaced apart from the bottom of case 16 by a spacer).
- Case 16 need not include collar 22 (e.g., case 16 may be sealed directly against vessel 12, such as by adhesive, heat bonding, etc.).
- Case 16 need not have a multi-part construction (e.g., case 16 may be of unitary construction).
- Vessel cap 14 and case cap 26 may be provided as a single cap.

[0055] While a number of exemplary aspects and embodiments have been discussed above, those of skill in the art will recognize certain modifications, permutations, additions and sub-combinations thereof. It is therefore intended that the following appended claims and claims hereafter introduced are interpreted to include all such modifications, permutations, additions and sub-combinations as are within their true spirit and scope.

WHAT IS CLAIMED IS:

1. Portable apparatus for storing consumable liquid, the apparatus comprising:

a case that is at least partially transmissive of solar radiation; and

a vessel at least partially enclosed within the case, the vessel having greater thermal conductivity than the case.

2. Apparatus according to claim 1 wherein the vessel is more absorptive of solar radiation than the case.

3. Apparatus according to claim 1 or 2 wherein the vessel is at least partially sealed within the case.

4. Apparatus according to any one of claims 1 to 3 wherein the vessel comprises metal.

5. Apparatus according to claim 4 wherein the vessel comprises aluminium.

6. Apparatus according to any one of claims 1 to 5 wherein the case comprises plastic.

7. Apparatus according to claim 6 wherein the case comprises polycarbonate.

8. Apparatus according to any one of claims 1 to 7 wherein an outer surface of the vessel is spaced apart from an opposed inner surface of the case by at least 0.5 inches.

9. Apparatus according to any one of claims 1 to 8 wherein all outer surfaces of the vessel are spaced apart from opposed inner surfaces the case by at least 0.5 inches.

10. Apparatus according to any one of claims 1 to 9 wherein the vessel has a mouth accessible from outside the case communicating with an interior of the vessel, and wherein only the mouth of the vessel is not enclosed within the case.

11. Apparatus according to claim 9 comprising a cap configured to close the mouth of the vessel.

12. Apparatus according to any one of claims 1 to 11 wherein the case comprises a tube and a collar closing an end of the tube against the vessel.

13. Apparatus according to claim 12 wherein collar is relatively more susceptible to transverse deformation than the tube.

14. Apparatus according to claim 12 wherein the collar extends past the end of the tube.

15. Apparatus according to any one of claims 1 to 14 wherein the case comprises a tube and a plug closing an end of the tube.

16. Apparatus according to claim 15 wherein the plug is relatively more susceptible to transverse deformation than the tube.

17. Apparatus according to claim 15 the case the plug extends past the end of the tube.

18. Apparatus according to claim 15 wherein an end of the vessel is supported by the plug, and a recess defined in the plug laterally confines the end of the vessel.

19. Apparatus according to any one of claims 1 to 18 wherein the case and a portion of the vessel enclosed within the case define a gap space comprising one or the other of air and a vacuum.

20. Apparatus according to any one of claims 1 to 19 comprising a removable, thermally insulative cap, the cap configured to insulate a portion of the vessel not enclosed within the case.

21. Apparatus according to any one of claims 19 and 20 wherein a ratio of the cross-sectional area of the gap space to the cross-sectional area of the interior of the vessel is between 0.2 and 0.4.

22. Apparatus according to any one of claims 1 to 21 wherein the case and vessel have circular cross section, and an inside diameter of the tube is greater than an outside diameter of the vessel by at least 0.5 inches.

23. Apparatus according to any one of claims 1 to 22 wherein the case and vessel have circular cross section and a ratio of an outside diameter of the vessel to an inside diameter of the tube is less than 0.9.

24. Apparatus according to any one of claims 1 to 23 wherein a wall of the case is configured to transmit at least 85% of solar radiation over the spectrum from 400 nm – 1100 nm.

25. Apparatus according to any one of claims 1 to 24 wherein a wall of the case comprises material having thermal conductivity less than 0.5 W/(m·K).

26. Apparatus according to any one of claims 1 to 25 wherein a wall of the case comprises material having thermal conductivity less than 0.25 W/(m·K).

27. Apparatus according to any one of claims 1 to 26 wherein a wall of the vessel comprises material having thermal conductivity greater than 120 W/(m·K).

28. Apparatus according to any one of claims 1 to 27 wherein a wall of the vessel comprises material having thermal conductivity greater than 200 W/(m·K).

29. Apparatus according to any one of claims 1 to 28 wherein an outer surface of the vessel comprises has solar reflectance less than 20%.

30. Apparatus according to any one of claims 1 to 29 wherein an outer surface of the vessel comprises has solar reflectance less than 15%.

31. Portable apparatus for storing consumable liquid, the apparatus comprising:

a case comprising:

a hard, transparent plastic tube,

a deformable plug sealing a first end of the tube, and

a deformable collar sealing a second end of the tube; and

a metal vessel at least partially enclosed within the case, the vessel sealed against the collar and having a mouth accessible from outside the case communicating with an interior of the vessel.

32. Apparatus according to claim 31 wherein the vessel and tube have circular cross-section and are co-axial with one another.

33. Apparatus according to claim 32 wherein opposed surfaces of the vessel and tube are spaced apart by at least 0.8 inches.

34. Apparatus according to any one of claims 32 and 33 a ratio of the outside diameter of the vessel to the inside diameter of the tube is between 0.8 and 0.85.

35. Portable apparatus for storing consumable liquid, the apparatus comprising:

a case; and

a vessel at least partly insulated by the case,

wherein the case is configured to transmit at least a portion of solar radiation incident thereon to the vessel, and

wherein the vessel is configured to convert at least a portion of the solar radiation transmitted thereto via the case into heat energy, and to conduct at least some of the heat energy to an interior of the vessel.

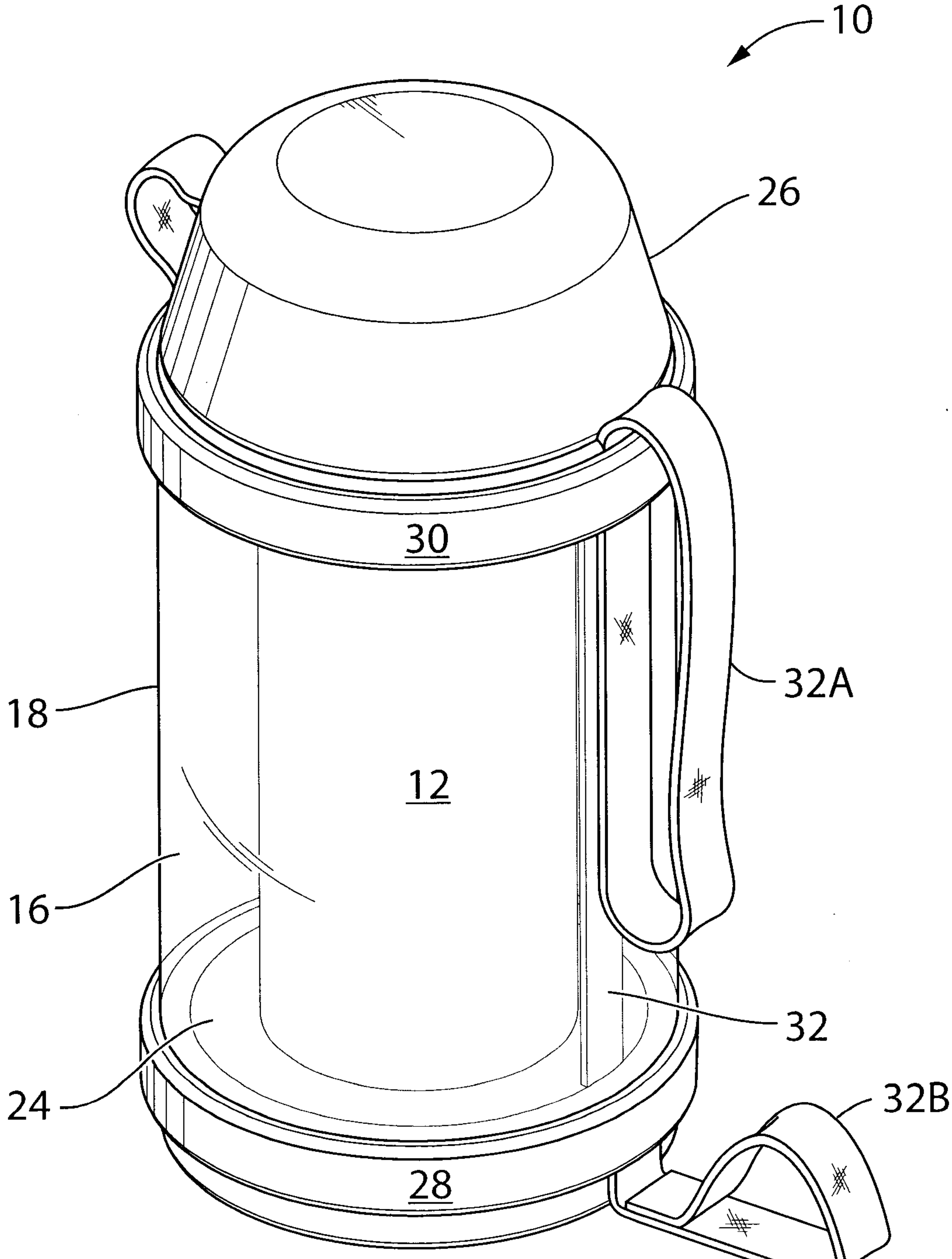


FIG. 1

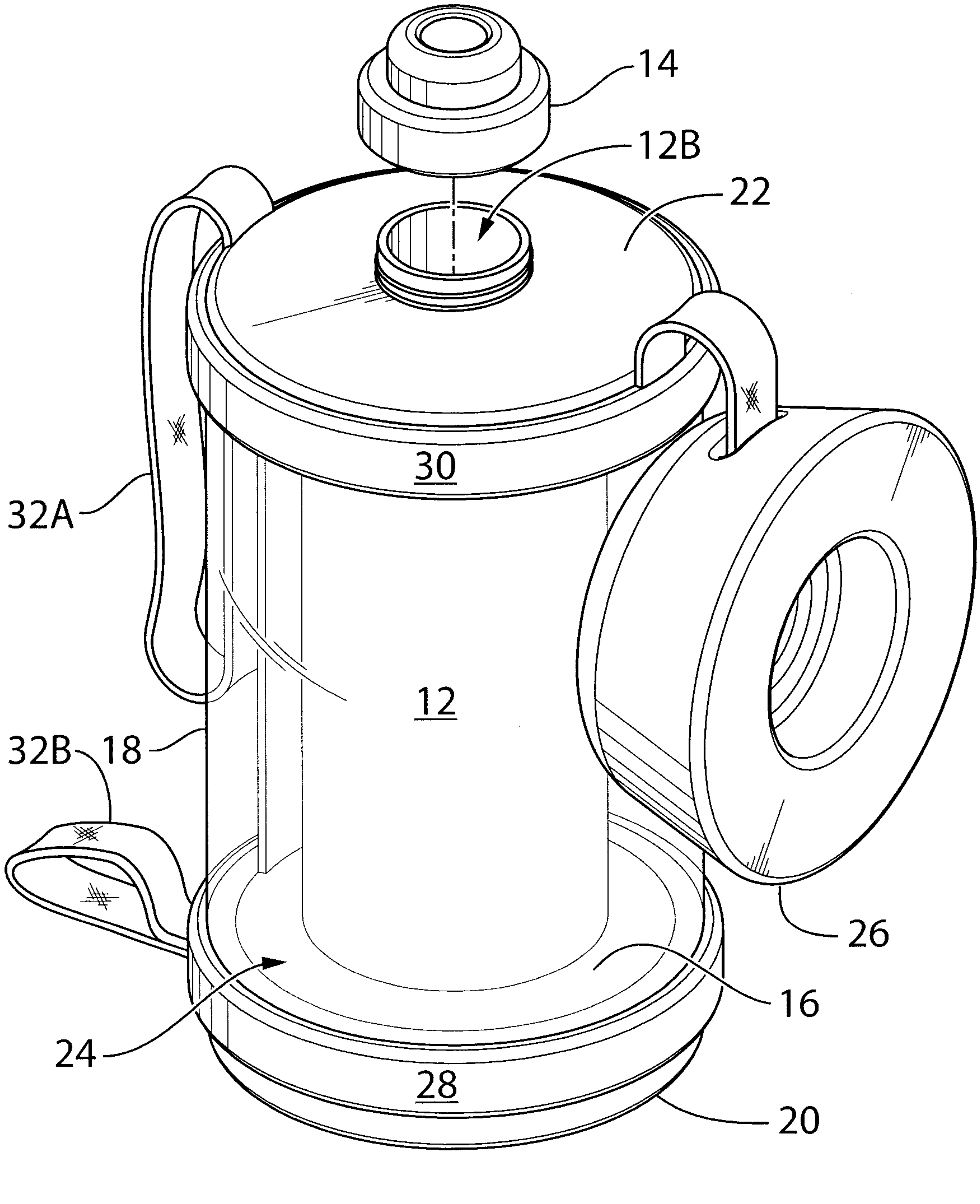


FIG. 2

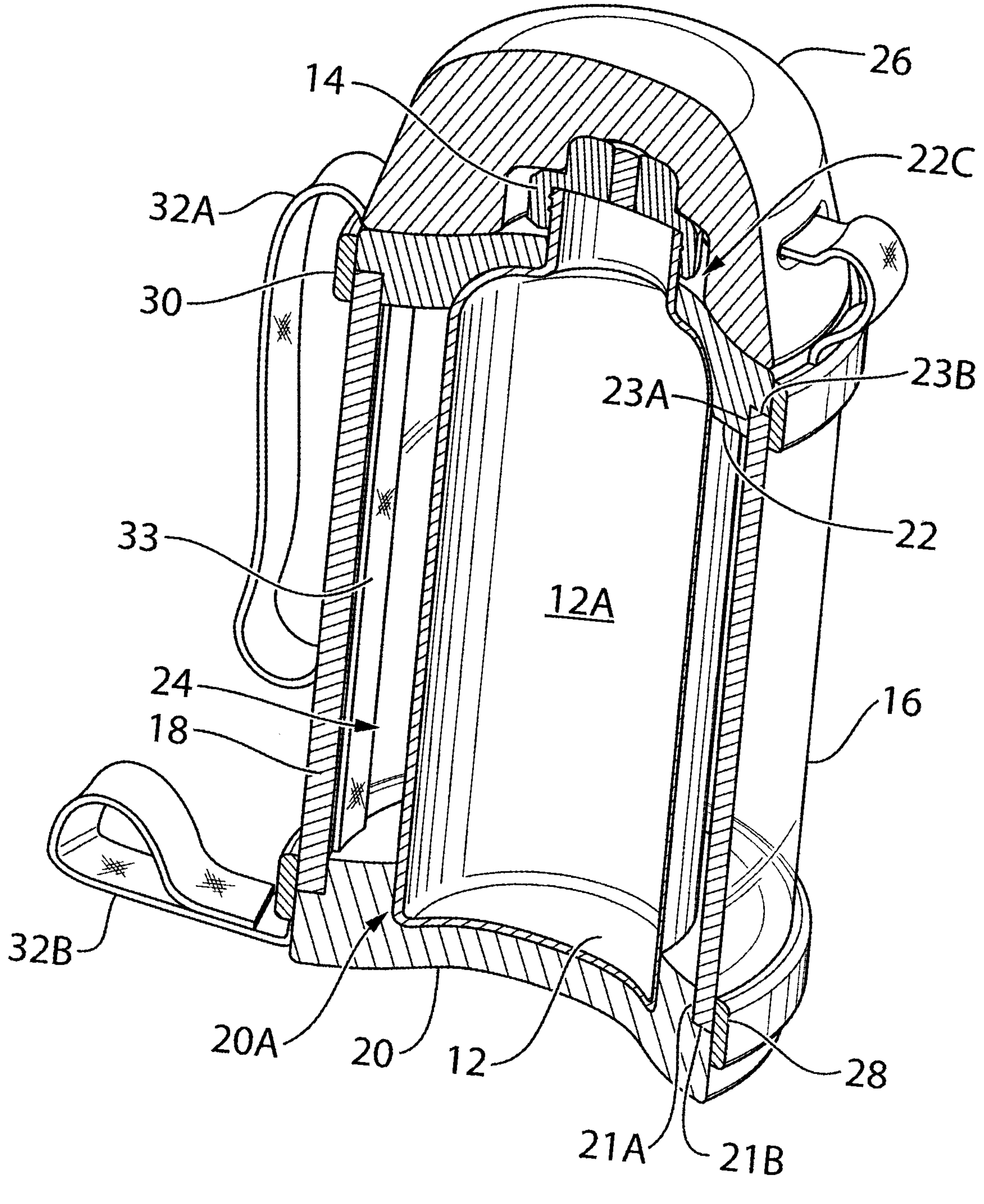
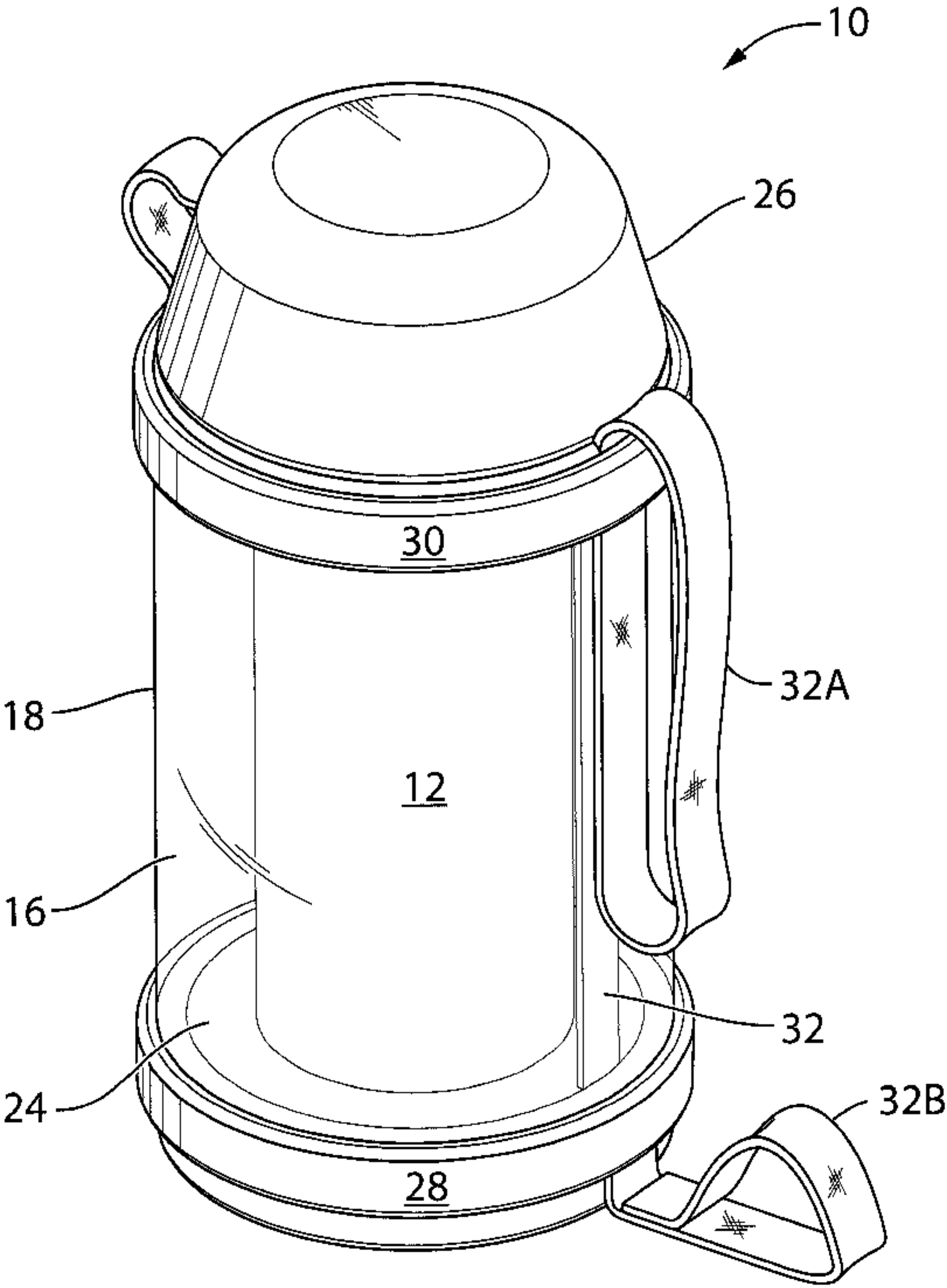


FIG. 3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