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(54) Title: SYSTEM SUITABLE FOR STORING AND/OR TRANSPORTING TEMPERATURE-SENSITIVE MATERIALS

(57) Abstract: System for storing and/or transporting temperature-sensitive materials. In one embodiment, the system is made entirely of sustainable materials and includes an outer retaining box, an insulated container, a product box, multiple passive temperature-control members, and multiple positioning devices. The outer retaining box is made of corrugated cardboard. The insulated container is removably received in the outer retaining box and is made of corrugated cardboard boxes containing either loose-fill cellulose or cellulose batting. The product box is removably received in the insulated container and is made of corrugated cardboard. The passive temperature-control members are removably received in the insulated container above and below the product box and are made of a paper-based container containing water. The positioning devices, which are made of corrugated cardboard, are removably received in the insulated container above and below the product box and position the passive temperature-control members relative to each other and the product box.

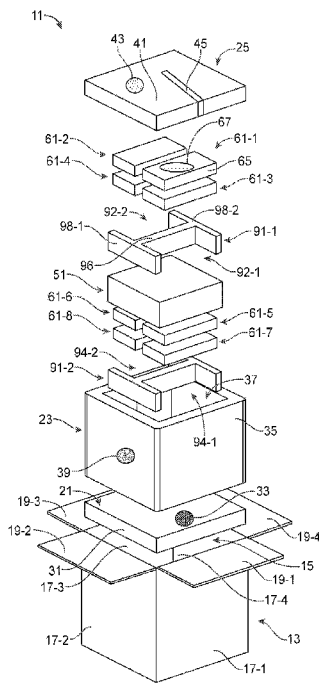


FIG. 1

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ice, or the like. Often, the temperature-sensitive materials are housed within a product box (sometimes alternatively referred to as “a payload box”) that, in turn, is housed within the insulated container along with the one or more passive temperature-control members. The thermal shipping system may additionally include one or more other components, such as, 5 but not limited to, an outer retaining box, a liner, additional insulation, and dunnage.

[0005] As can be appreciated, once the thermal shipping system has been used to transport and/or to store its payload of temperature-sensitive materials, the thermal shipping system must be disposed of in some fashion. This may be after a single use if the thermal shipping system is a single-use item or may be after a plurality of uses if the thermal shipping 10 system is a reusable item. Historically, many of the components of thermal shipping systems, whether single-use or reusable, cannot be curbside recycled or composted and must be disposed of in landfills. Clearly, such an outcome is undesirable from an environmental standpoint.

[0006] In an attempt to ameliorate the environmental impact associated with the 15 disposal of thermal shipping systems, efforts have recently been directed at replacing certain components of such thermal shipping systems with materials that are more environmentally friendly. For example, in instances where the insulated container of the thermal shipping system is made of a non-curbside recyclable, non-compostable material like expanded polystyrene, one approach has been to replace the non-curbside recyclable, non-compostable 20 insulated container with an insulated container that is made of one or more curbside recyclable and/or compostable materials. For example, in the following patents, both of which are incorporated herein by reference, there is disclosed an insulated container that is made using a starch panel that is encapsulated within a compostable film: U.S. Patent No. 10,647,497 B2, inventor Jobe, which issued May 12, 2020; and U.S. Patent No. 9,751,683 25 B1, inventor Jobe, which issued September 5, 2017. A thermal shipping system employing an insulated container of the aforementioned type is commercially available from Vericool, Inc. (Livermore, CA) as the VC Plus™ thermal shipping system. As another example, in the following patents and published patent applications, all of which are incorporated by reference, there is disclosed an insulated container that is made using a cellulose-based 30 insulation encased within a cardboard container: U.S. Patent No. 11,731,826 B2, inventors Blezard et al., which issued August 22, 2023; U.S. Patent Application Publication No. US

2023/0251011 A1, inventors Blezard et al., which published August 10, 2023; and U.S. Patent Application Publication No. US 2023/0131560 A1, inventors Blezard et al., which published April 27, 2023. A thermal shipping system employing an insulated container of the aforementioned type is commercially available from Cold Chain Technologies, LLC  
5 (Franklin, MA) as TRUEtemp Naturals<sup>®</sup> thermal shipping system.

[0007] In a similar fashion to the efforts discussed above to make the insulated containers of thermal shipping systems out of curbside recyclable and/or compostable materials, corresponding efforts are increasingly being taken to make the outer retaining boxes, liners, and dunnage of such thermal shipping systems also out of environmentally  
10 sustainable materials like corrugated cardboard and paper.

[0008] Nevertheless, even with the above-noted changes, many thermal shipping systems still rely on packaged passive temperature-control members, and packaged passive temperature-control members are not curbside recyclable or compostable. Such packaged passive temperature-control members, which are sometimes referred to as “ice packs,” “gel  
15 packs” or “refrigerant bricks,” typically include a freezable refrigerant material that is encased within a packaging material. In some cases, the freezable refrigerant material includes an organic substance or other additive that cannot be safely disposed of via a septic or sewer system. Also, in some cases, the freezable refrigerant material includes a liquid that is absorbed into a phenolic foam block (or “brick”), which phenolic foam block is also not  
20 curbside recyclable or compostable. In addition, regardless of the composition of the freezable refrigerant material, the packaging material of the packaged passive temperature-control member typically comprises a multilayer polymer film that cannot be curbside recycled or composted. Consequently, obsolete gel packs and refrigerant bricks are typically sent to landfill for disposal. Additionally, misleading marketing claims or lack of  
25 information can lead some consumers to think that the packaging material for packaged passive temperature-control members can be placed in a curbside recycling bin whereas, in practice, only #4 plastic film can be recycled and only at designated drop-off sites. In the United States, incorrectly placing non-conforming plastic film in single-stream curbside recycle bins leads to contamination of the recycling stream and/or consumes additional  
30 resources at a materials recovery facility. As can be appreciated, avoidance of such occurrences is highly desirable.

[0009] In view of the above, there is a need for packaged passive temperature-control members whose components are curbside recyclable, compostable and/or that can be disposed of via septic or sewer systems, and there is also a need for thermal shipping systems that include as many components as possible that are curbside recyclable, compostable and/or  
5 disposable via septic or sewer systems.

### SUMMARY OF THE INVENTION

[0010] It is an object of the present invention to provide a novel thermal shipping system of the type that is suitable for temperature-sensitive materials.

[0011] It is another object of the present invention to provide a thermal shipping system as described above that overcomes at least some of the shortcomings associated with existing thermal shipping systems.

[0012] According to one aspect of the invention, there is provided a system suitable for storing and/or transporting temperature-sensitive materials, the system comprising (a) an insulated container, the insulated container comprising a cavity; and (b) at least one passive temperature-control member removably disposed within the cavity of the insulated container, the at least one passive temperature-control member comprising a first passive temperature-control member, the first passive temperature-control member comprising a refrigerant container and a freezable refrigerant, the freezable refrigerant being disposed within the refrigerant container; (c) wherein the refrigerant container is at least one of curbside recyclable and compostable and wherein the freezable refrigerant comprises water.

[0013] In a more detailed feature of the invention, the system may further comprise a product box, the product box may be removably disposed within the cavity of the insulated container, and the product box may be dimensioned to removably receive the temperature-sensitive materials.

[0014] In a more detailed feature of the invention, the product box may be at least one of curbside recyclable and compostable.

[0015] In a more detailed feature of the invention, the product box may be made of corrugated cardboard.

[0016] In a more detailed feature of the invention, the insulated container may be at least one of curbside recyclable and compostable.

[0017] In a more detailed feature of the invention, the insulated container may comprise one or more thermal insulation members, and each of the one or more thermal insulation members may be made of natural wood fiber and/or plant fiber materials.

[0018] In a more detailed feature of the invention, the one or more thermal insulation members may comprise a thermal insulation base, a thermal insulation sleeve, and a thermal insulation lid, the thermal insulation base may form a bottom of the insulated container and

5 may comprise a thermal insulation base box made of corrugated cardboard and containing loose-fill cellulose, the thermal insulation sleeve may form four side walls of the insulated container and may comprise a thermal insulation sleeve box made of corrugated cardboard and containing cellulose batting, and the thermal insulation lid may form a lid for the insulated container and may comprise a thermal insulation lid box made of corrugated cardboard and containing loose-fill cellulose.

10 [0019] In a more detailed feature of the invention, the refrigerant container may be shaped to include an interior volume for receiving the freezable refrigerant, and the refrigerant container may be made of a refrigerant container material comprising a paper layer.

[0020] In a more detailed feature of the invention, the refrigerant container may be shaped to include at least one gabled end.

[0021] In a more detailed feature of the invention, the at least one gabled end is foldable.

15 [0022] In a more detailed feature of the invention, the freezable refrigerant may consist of water.

[0023] In a more detailed feature of the invention, the water may be potable water.

[0024] In a more detailed feature of the invention, the freezable refrigerant may be at least partially frozen.

20 [0025] In a more detailed feature of the invention, the freezable refrigerant may occupy about 85-90% of the interior volume of the refrigerant container, excluding the at least one gabled end.

[0026] In a more detailed feature of the invention, the system may further comprise an outer retaining box, and the insulated container and the at least one passive temperature-control member may be disposed within the outer retaining box.

25 [0027] In a more detailed feature of the invention, the insulated container may be made exclusively of one or more materials selected from the group consisting of natural wood fiber and/or plant fiber materials.

[0028] In a more detailed feature of the invention, the at least one passive temperature-control member may further comprise a second passive temperature-control

30

member, and the second passive temperature-control member may be identical to the first passive temperature-control member.

[0029] In a more detailed feature of the invention, the system may further comprise a first positioning device, and the first positioning device may comprise a first dividing bar positioned between the first passive temperature-control member and the second passive temperature-control member.

[0030] In a more detailed feature of the invention, the first positioning device may be I-shaped and may further comprise a first transverse bar disposed at a first end of the first dividing bar and a second transverse bar disposed at a second end of the first dividing bar.

[0031] In a more detailed feature of the invention, the first positioning device may be made of corrugated cardboard.

[0032] In a more detailed feature of the invention, the system may further comprise a product box, the product box may be removably disposed within the cavity of the insulated container and may be dimensioned to removably receive the temperature-sensitive materials, the first and second passive temperature-control members and the first positioning device may be seated directly on top of the product box, and the product box, the first positioning device, and the first and second passive temperature-control members may be dimensioned so that a portion of each of the first and second passive temperature-control members may be positioned directly over opposing peripheral edges of the product box.

[0033] In a more detailed feature of the invention, the at least one passive temperature-control member may further comprise third and fourth passive temperature-control members, the third and fourth passive temperature-control members may be identical to the first passive temperature-control member, the system may further comprise a second positioning device, the second positioning device may be identical to the first positioning device, and the second positioning device may comprise a second dividing bar positioned between the third passive temperature-control member and the fourth passive temperature-control member.

[0034] According to another aspect of the invention, there is provided a system suitable for storing and/or transporting temperature-sensitive materials, the system comprising (a) an insulated container, the insulated container comprising a cavity; (b) a product box, the product box being removably disposed within the cavity of the insulated

container, the product box being designed to hold the temperature-sensitive materials; (c) a plurality of passive temperature-control members removably disposed within the cavity of the insulated container, the plurality of passive temperature-control members being identical to one another and comprising a first passive temperature-control member and a second passive temperature-control member, wherein the first and second passive temperature-control members are seated directly on top of the product box; and (d) a positioning device removably disposed within the cavity of the insulated container, wherein the positioning device comprises a dividing bar positioned between the first passive temperature-control member and the second passive temperature-control.

**[0035]** In a more detailed feature of the invention, the insulated container, the product box, and the positioning device may be made exclusively of one or more materials selected from the group consisting of natural wood fiber and/or plant fiber materials, and each of the passive temperature-control members may comprise a paper-based refrigerant container and a freezable refrigerant comprising water.

**[0036]** In a more detailed feature of the invention, the freezable refrigerant may consist of water.

**[0037]** In a more detailed feature of the invention, the water may be at least partially frozen.

**[0038]** In a more detailed feature of the invention, the product box, the positioning device, and the first and second passive temperature-control members may be dimensioned so that a portion of each of the first and second passive temperature-control members may be positioned directly over opposing peripheral edges of the product box.

**[0039]** According to still another aspect of the invention, there is provided a method for storing and/or transporting a payload of temperature-sensitive materials, the system comprising (a) providing a thermal shipping system, the thermal shipping system comprising (i) an insulated container, the insulated container comprising a cavity, and (ii) at least one passive temperature-control member removably disposed within the cavity of the insulated container, the at least one passive temperature-control member comprising a first passive temperature-control member, the first passive temperature-control member comprising a refrigerant container and a freezable refrigerant, the refrigerant container having an openable gabled end, the freezable refrigerant being disposed within the refrigerant container; (b)

positioning a payload of temperature-sensitive materials within the insulated container; (c) storing and/or transporting the payload within the insulated container; (d) then, removing the payload from the insulated container; and (e) opening the openable gabled end of the refrigerant container and emptying the freezable refrigerant from the refrigerant container.

5 [0040] In a more detailed feature of the invention, the freezable refrigerant may consist of water.

[0041] In a more detailed feature of the invention, the freezable refrigerant may be at least partially frozen during steps (c) and (e).

10 [0042] In a more detailed feature of the invention, the insulated container may be made exclusively of one or more materials selected from the group consisting of natural wood fiber and/or plant fiber materials, and the refrigerant container may be a paper-based refrigerant container.

15 [0043] For purposes of the present specification and claims, various relational terms like “top,” “bottom,” “proximal,” “distal,” “upper,” “lower,” “front,” and “rear” may be used to describe the present invention when said invention is positioned in or viewed from a given orientation. It is to be understood that, by altering the orientation of the invention, certain relational terms may need to be adjusted accordingly.

20 [0044] Additional objects, as well as features and advantages, of the present invention will be set forth in part in the description which follows, and in part will be obvious from the description or may be learned by practice of the invention. In the description, reference is made to the accompanying drawings which form a part thereof and in which is shown by way of illustration various embodiments for practicing the invention. The embodiments will be described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural changes may  
25 be made without departing from the scope of the invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is best defined by the appended claims.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0045] The accompanying drawings, which are hereby incorporated into and constitute a part of this specification, illustrate various embodiments of the invention and, together with the description, serve to explain the principles of the invention. These drawings are not necessarily drawn to scale, and certain components may have undersized and/or oversized dimensions or may be shown in a simplified form for purposes of explication. In the drawings wherein like reference numerals represent like parts:

[0046] FIG. 1 is a partly exploded simplified perspective view, broken away in part, of a first embodiment of a system suitable for storing and/or transporting temperature-sensitive material, the system being constructed according to the present invention;

[0047] FIGS. 2A and 2B are simplified front-rear and left-right longitudinal section views, respectively, of the system shown in FIG. 1;

[0048] FIG. 3 is a simplified perspective view of the system shown in FIG. 1, with the insulation members and the outer box not being shown to reveal components that would not otherwise be seen;

[0049] FIG. 4 is a right side view, broken away in part, of one of the passive temperature-control members shown in FIG. 1;

[0050] FIGS. 5A and 5B are front perspective and left side views, respectively, of the passive temperature-control member shown in FIG. 4, with the top being shown in an unfolded state;

[0051] FIG. 6 is an enlarged fragmentary section view of one embodiment of a multilayer material that may be used to make the container of the passive temperature-control member shown in FIG. 4;

[0052] FIG. 7 is a top view of one of the positioning devices shown in FIG. 1;

[0053] FIG. 8 is an alternative embodiment of the passive temperature-control member to that shown in FIG. 4;

[0054] FIGS. 9A and 9B are front and side views, respectively, of the passive temperature-control member shown in FIG. 8, with the top being shown in an unfolded state;

[0055] FIGS. 9C and 9D are perspective and top views, respectively, of the passive temperature-control member shown in FIG. 8, with the top being shown flattened but not secured to the sides;

[0056] FIG. 10 is a partly exploded simplified perspective view of a second embodiment of a system suitable for storing and/or transporting temperature-sensitive material, the system being constructed according to the present invention;

[0057] FIGS. 11A and 11B are simplified front-rear and left-right longitudinal section  
5 views, respectively, of the system shown in FIG. 10;

[0058] FIG. 12 is a partly exploded simplified perspective view of a third embodiment of a system suitable for storing and/or transporting temperature-sensitive material, the system being constructed according to the present invention;

[0059] FIGS. 13A and 13B are simplified front-rear and left-right longitudinal section  
10 views, respectively, of the system shown in FIG. 12;

[0060] FIG. 14 is a partly exploded simplified perspective view of a fourth embodiment of a system suitable for storing and/or transporting temperature-sensitive material, the system being constructed according to the present invention; and

[0061] FIGS. 15A and 15B are simplified front-rear and left-right longitudinal section  
15 views, respectively, of the system shown in FIG. 14.

### **DETAILED DESCRIPTION OF THE INVENTION**

[0062] As noted above, thermal shipping systems for temperature-sensitive materials typically comprise a number of components. Such components often include, but are not limited to, one or more of the following: an outer retaining box, insulation (often in the form of an insulated container), a product box, one or more passive temperature-control members, a liner, and dunnage. Historically, many of these components have been made of materials that cannot be curbside recycled, composted, or safely disposed of via a septic or sewer system, and, instead, must be disposed of in landfills. Although progress has been made with respect to many of the above components, existing passive temperature-control members of the type comprising packaged refrigerant remain an obstacle to the achievement of an environmentally friendly thermal shipping system since such temperature-control members include one or more components that are not curbside recyclable, compostable or safely disposable via a septic or sewer system. Accordingly, one objective of the present invention is to provide a packaged passive temperature-control member that may be disposed of in an environmentally friendly manner, such as by one or more of curbside recycling, composting, and safe disposal via a septic or sewer system. Another objective of the present invention is to provide a thermal shipping system for temperature-sensitive materials, wherein the thermal shipping system includes one or more components that may be disposed of by one or more of curbside recycling, composting, and disposal via a septic or sewer system, and preferably is constructed entirely out of components that may be disposed of by one or more of curbside recycling, composting, and disposal via a septic or sewer system.

[0063] For purposes of the present specification and claims, “curbside recycling” is intended to refer to the collection of recyclable materials as a service provided by a local municipality. The materials that are accepted as curbside recyclable may vary depending on the capability of the local materials recovery facility (MRF); nevertheless, “curbside recyclable” is generally understood to include glass bottles, tin cans, plastic bottles (particularly #1 polyethylene terephthalate, which has a high recycling rate compared to other plastics), newsprint, office paper, cardboard, and corrugated fiberboard. Increasingly, commercial composting facilities are offering pick-up of compostable household waste to interested households, but this practice has yet to be adopted widely. Drop-off facilities are also available: in rural areas without curbside recycling, the only option for residents may be

to transport their recyclables to local facilities. Drop-off is also an option for specific materials that MRFs do not currently accept as curbside recyclable, like expanded polystyrene (EPS), which is accepted by many EPS manufacturers, and plastic bags that many grocery stores will accept on behalf of recyclers. However, the inconvenience of travel and/or narrow drop-off time windows present a barrier to adoption that makes curbside recyclable materials more desirable and more likely to be recycled than materials requiring drop-off.

[0064] For purposes of the present specification and claims, “compost” is intended to refer to the nutrient-rich material produced by decomposing plant and food waste, animal manure and other organic materials. When added to the soil, it improves fertility naturally, without the need for chemical fertilizers. The term “compostable” has come to have a specific meaning when applied to waste materials. A material that is biodegradable (capable of being broken down by microorganisms in nature) is not necessarily compostable. In the United States, a material is considered “industrially compostable” if it decomposes within a 180-day timeframe under the specific test conditions outlined in test method ASTM D6400 *Standard Specification for the Labeling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities*. Third-party certification is offered by organizations, such as the Biodegradable Products Institute (BPI). In the United States, there are relatively few composting facilities (185 in 2020). Most small and local communities do not support a commercial composter. “Home compostable” means the item will break down in a small-scale backyard composting bin, in shorter timeframes and without the high temperatures of industrial composting facilities. Currently, ASTM does not provide a test standard for home compost, and BPI does not include home compostables in their certification schemes. However, TUV Austria provides their OK compost HOME certification based on several standards, such as prEN 17427 (2020) – Packaging. In Europe, this standard is widely used to set requirements and test scheme for carrier bags suitable for treatment in well-managed home composting installations. Thus, for the present application, “compostable” is understood to encompass either “industrially compostable” or “home compostable.”

[0065] Insofar as the present specification and claims refers to the safe disposal of materials, such as refrigerant materials, via a septic or sewer system (i.e., whether such materials are “drain safe”), the answer may be more nuanced. If a refrigerant gel consists of

water and a gelling agent, the gel may be so viscous that it clogs the drain and, therefore, would not be drain safe. Gels that are not as viscous, or dissolve quickly in running water, may physically pass down the drain without blockage, but could contain chemicals that interfere with normal septic system operation or municipal wastewater treatments and, therefore, would not be drain safe. By contrast, refrigerant cartons that are filled with just water, or water with minimal additives, do not present these problems and, therefore, are clearly considered drain safe.

[0066] About one in five US households have individual septic systems or small community systems to treat their sewage. These underground structures use natural and technological processes to treat wastewater from household plumbing produced by bathrooms, showers, kitchen drains and laundry. Householders are advised not to pour grease (such as fats, butter, wax, cheese, heavy cream), liquid wastes (such as pesticides, drain cleaners, household chemicals, paints, paint thinners), oils or coffee grounds down the drain because these materials do not easily decompose and may be harmful to the healthy bacteria in a septic tank and drainfield that help break down organic matter. Thus, such materials would not be regarded as drain safe.

[0067] Wastewater from homes and businesses without septic systems is processed at municipal wastewater treatment plants. Systems of pipes and pumps that transport wastewater to wastewater treatment plants are called sanitary sewers. Water used in homes or industry is flushed through their pipes until it reaches local sewer mains owned and operated by municipal or regional sewer departments. Sewage is treated in a variety of physical, chemical and biological processes, leaving water that is safe for discharge into the environment. Biosolids and biogas may be collected and utilized. Municipalities are concerned about chemical disposal in sanitary sewers because of the potential for negative impact on the treatment processes at the wastewater treatment facility and the possible contamination of nutrient-rich "biosolids" for agricultural purposes. Chemicals that would contribute to the foregoing problems would not be considered drain safe.

[0068] Referring now to FIGS. 1, 2A, 2B, and 3, there are shown various views of a first embodiment of a system suitable for storing and/or transporting temperature-sensitive materials, the system being constructed according to the present invention and being represented generally by reference numeral 11. Details of system 11 that are discussed

elsewhere in this application or that are not critical to an understanding of the invention may be omitted from one or more of FIGS. 1, 2A, 2B and 3 and/or from the accompanying description herein or may be shown in one or more of FIGS. 1, 2A, 2B and 3 and/or described herein in a simplified manner.

5           **[0069]** System 11, which may sometimes be alternatively referred to herein as a “shipper” or “shipping system,” may comprise an outer retaining box 13. Outer retaining box 13, which may consist of or comprise, for example, a conventional corrugated cardboard container or a similarly suitable structure preferably made of one or more curbside recyclable and/or compostable materials, may comprise a rectangular prismatic cavity 15 bounded by a  
10   plurality of rectangular side walls 17-1 through 17-4, a plurality of bottom closure flaps (not shown in FIGS. 1 and 3 and collectively shown simply as a bottom wall 18 in FIGS. 2A and 2B), and a plurality of top closure flaps 19-1 through 19-4 (collectively shown simply as a top wall 20 in FIGS. 2A and 2B). One or more strips of an environmentally friendly adhesive tape or other curbside recyclable and/or compostable closure means (not shown) may be used  
15   to retain, in a closed condition, the bottom closure flaps and/or top closure flaps 19-1 through 19-4. In another embodiment (not shown), outer retaining box 13 may be equipped with one or more handles, which may be used to facilitate the carrying or other movement of outer retaining box 13, as well as any items disposed in cavity 15.

**[0070]** System 11 may further comprise one or more thermal insulation members,  
20   wherein some or all of such thermal insulation members are preferably made of curbside recyclable and/or compostable materials. In the present embodiment, such one or more thermal insulation members may comprise a thermal insulation base 21, a thermal insulation sleeve 23, and a thermal insulation lid 25. Thermal insulation base 21, thermal insulation sleeve 23, and thermal insulation lid 25 may collectively form a reversibly openable/closable  
25   6-sided thermally insulated container that may be removably positioned within cavity 15 of outer retaining box 13. Notwithstanding the above, it is to be understood that, in another embodiment (not shown), one or more of thermal insulation base 21, thermal insulation sleeve 23, and thermal insulation lid 25 may be omitted or that, in another embodiment (not shown), one or more of thermal insulation base 21, thermal insulation sleeve 23, and thermal  
30   insulation lid 25 may be integrally formed or may have one or more portions that are reversibly or permanently joined together.

[0071] Thermal insulation base 21 may comprise a box 31. Box 31 may be a generally rectangular hollow member that may consist of or comprise, for example, a conventional corrugated cardboard container or a similarly suitable structure preferably made of curbside recyclable and/or compostable material. Box 31 may be dimensioned to sit within cavity 15 of outer retaining box 13, preferably directly on top of bottom wall 18 of outer retaining box 13. The outer surfaces of the four side walls of box 31 may snugly engage the inner surfaces of rectangular side walls 17-1 through 17-4 of outer retaining box 13; alternatively, as shown in the present embodiment, there may be a small space between the outer surfaces of the four side walls of box 31 and the inner surfaces of rectangular side walls 17-1 through 17-4.

[0072] Box 31 may be partially or completely filled with a thermal insulation material 33. Preferably, thermal insulation material 33 consists of or comprises one or more curbside recyclable and/or compostable thermal insulation materials. For example, the one or more curbside recyclable and/or compostable thermal insulation materials may consist of or comprise one or more recyclable organic fiber materials, which may include any type of natural wood fiber and/or plant fiber materials, such as, but not limited to, cellulose fiber or other non-woven wood or paper fiber materials made of or derived from rice, hemp, flax, wool, etc. More specifically, such fibrous insulation, particularly cellulose fiber insulation, may be in the form of a loose-fill cellulose or blown cellulose insulation or, alternatively, may be in the form of a cellulose batting insulation or, if laminated to paper, a paper-backed cellulose batting insulation. (See, for example, U.S. Patent No. 10,583,977 B2, inventors Collison et al., issued March 10, 2020, which is incorporated herein by reference.) Preferably, thermal insulation material 33 comprises loose-fill or blown cellulose.

[0073] Where, for example, loose-fill or blown cellulose insulation is used, such insulation may be portioned and packed in such a manner to provide an insulating value of between R2 and R6 per inch of thickness, and preferably between R4 and R5 per inch of thickness. The density of such insulation may be in the range of about 2-6 pounds of cellulose per cubic foot, and more preferably in the range of about 3.5-5 pounds of cellulose insulating material per cubic foot. This packing density provides an insulating value very similar to that of expanded polystyrene. The thickness of the insulating material may be

about 1.0 inch to about 2.0 inch but may be as much as about 4-5 inches thick depending on the application.

[0074] The loose-fill cellulose material may, in some embodiments, further comprise one or more additives. For example, the loose-fill cellulose material may comprise a borate-treated loose-fill cellulose material, which is fire-resistant, mold-resistant, fungus-resistant, 5 mildew-resistant, and insect-resistant.

[0075] Thermal insulation sleeve 23 may comprise a box 35. Box 35, which may consist of or comprise, for example, a conventional corrugated cardboard container or a similarly suitable structure preferably made of curbside recyclable and/or compostable 10 material, may be a generally rectangular frame-like member defining a central channel 37 bounded by four hollow side walls, an open bottom, and an open top. As shown in the present embodiment, one or more of the corners of box 35 may be beveled, but they need not be. Box 35 may be dimensioned to sit within cavity 15 of outer retaining box 13, preferably directly on top of thermal insulation base 21 so that thermal insulation base 21 may close the 15 bottom end of central channel 37. As shown in the present embodiment, the outer surfaces of the four side walls of box 35 may snugly engage the inner surfaces of rectangular side walls 17-1 through 17-4 of outer retaining box 13, or there may be a small space between the outer surfaces of the four side walls of box 35 and the inner surfaces of rectangular side walls 17-1 through 17-4. The hollow walls of box 35 may be partially or completely filled with a 20 thermal insulation material 39, which may be similar or identical to thermal insulation material 33. Preferably, thermal insulation material 39 comprises a cellulose batting insulation.

[0076] Thermal insulation lid 25 may comprise a box 41. Box 41 may be a generally rectangular hollow member that may consist of or comprise, for example, a conventional 25 corrugated cardboard container or a similarly suitable structure preferably made of curbside recyclable and/or compostable material. Box 41 may be dimensioned to sit within cavity 15 of outer retaining box 13, preferably directly on top of thermal insulation sleeve 23 so as to close the top end of central channel 37. The outer surfaces of the four side walls of box 41 may snugly engage the inner surfaces of rectangular side walls 17-1 through 17-4 of outer 30 retaining box 13; alternatively, as shown in the present embodiment, there may be a small space between the outer surfaces of the four side walls of box 41 and the inner surfaces of

rectangular side walls 17-1 through 17-4. Box 41 may be partially or completely filled with a thermal insulation material 43, which may be similar or identical to thermal insulation material 33. Preferably, thermal insulation material 43 comprises loose-fill or blown cellulose. A flexible strip of material 45, which is preferably made of a curbside recyclable and/or compostable material, may be secured at one end to the top of box 41 and may be used to facilitate removal of thermal insulation lid 25 from outer retaining box 13.

[0077] System 11 may further comprise a product box (or payload box) 51. Product box 51 may be a generally rectangular hollow member and may consist of or comprise, for example, a conventional corrugated cardboard container or a similarly suitable structure preferably made of curbside recyclable and/or compostable material. Product box 51 may be appropriately dimensioned to be removably disposed within central channel 37. In the present embodiment, there may be a small space between the outer surfaces of the four side walls of product box 51 and the inner surfaces of thermal insulation sleeve 23, but this need not be the case.

[0078] System 11 may further comprise a plurality of passive temperature-control members 61-1 through 61-8, which may be removably positioned within central channel 37 of thermal insulation sleeve 23. In the present embodiment, passive temperature-control members 61-1 through 61-4 may be positioned above product box 51, and passive temperature-control members 61-5 through 61-8 may be positioned below product box 51. More specifically, passive temperature-control members 61-3 and 61-4 may be positioned directly above and in direct contact with the top surface of product box 51; passive temperature-control members 61-1 and 61-2 may be aligned with and positioned directly on top of and in direct contact with passive temperature-control members 61-3 and 61-4, respectively; passive temperature-control members 61-5 and 61-6 may be positioned directly below and in direct contact with the bottom surface of product box 51; and passive temperature-control members 61-7 and 61-8 may be aligned with and positioned directly below and in direct contact with passive temperature-control members 61-5 and 61-6, respectively, with the longitudinal axes of all of passive temperature-control members 61-1 through 61-8 being oriented left to right.

[0079] In the present embodiment, passive temperature-control members 61-1 through 61-8 may be identical in all respects including, but not limited to, size, shape,

construction, and composition. Therefore, for simplicity, the discussion below of passive temperature-control member 61-1 should be understood to apply equally well to passive temperature-control members 61-2 through 61-8. Notwithstanding the above, it is to be understood that passive temperature-control members 61-1 through 61-8 need not be identical to one another and that one or more of temperature-control members 61-1 through 61-8 may differ from the remainder of temperature-control members 61-1 through 61-8 in one or more respects. Moreover, it is to be understood that, although, in the present embodiment, system 11 may comprise eight passive temperature-control members 61-1 through 61-8, the number and arrangement of such passive temperature-control members may be varied such that system 11 may comprise as few as one such passive temperature-control member or may comprise more than eight such passive temperature-control members or may comprise eight or another number of such passive-temperature-control members arranged in a different manner.

**[0080]** Passive temperature-control member 61-1 may comprise a container 65 and a freezable refrigerant 67, wherein freezable refrigerant 67 may be removably disposed within container 65.

**[0081]** Container 65 may be designed, and preferably is designed, to be physically robust enough to hold up to the stresses imposed on it from expansion of freezable refrigerant 67 upon freezing, as well as the effects of transportation (which effects may include, but are not limited to, the effects of impact, vibration, and stacking) while in a frozen state. Since most thermal shipping systems are designed for manufacture within narrow dimensional tolerances, container 65 may be designed, and preferably is designed, to maintain its shape without excessive bulging in any dimension when frozen. The material used to make container 65 may be resistant, and preferably is resistant, to tearing during freezing and transit because leakage of freezable refrigerant 67 could damage the product being transported within system 11 or other nearby product.

**[0082]** Container 65 may be designed, and preferably is designed, to be readily openable to allow the freezable refrigerant 67 disposed therein to be easily ejected or otherwise disposed of at the end of the lifetime of passive temperature-control member 61-1. (In the case of a single-use shipper, this may be after a single payload has reached its destination; alternatively, in the case of a reusable shipper, this may be after a plurality of

uses.) Unlike beverage containers that only require enough of an opening to remove a liquid through a spout or straw, container 65 is likely to have refrigerant that is still frozen at the time that it is desired to eject or remove the refrigerant from container 65. Generally speaking, a refrigerant container with a cap would require its contents to be substantially completely in a liquid state before the contents could be emptied, thereby making a cap design less preferred for the present application. By contrast, a design that enables the refrigerant container to be fully opened is preferred since such a design would allow the contents of the container, whether solid or liquid, to be easily emptied from the container. To this end, a gable-top design may be preferred as such a design allows for much easier ejection or removal of the contents, rather than having an end user wait for the refrigerant to melt entirely before disposal. Unlike containers for food products, which users perceive as having a distinct orientation (“this way up” is typically the orientation in which printed text is legible, and the product is designed to be opened from the perceived “top”), the refrigerant container of the present embodiment may be arranged within the shipper in any orientation, and its contents can be emptied at the end of its useful lifetime in any convenient way, including opening the face that would normally be considered the bottom.

[0083] Container 65 may be designed, and preferably is designed, so that the freezable refrigerant 67 disposed therein may provide coverage of the product load in a manner deemed most efficient for that particular system. Uniformly rectangular refrigerant containers without caps or gables, packed tightly together without gaps, may provide the most complete thermal protection coverage in many instances. A cap may take additional space, depending on where it is located on the container, and, therefore, may not be as desirable in certain instances. Designing a refrigerant container to have gables that can be folded during use and then unfolded and opened at the time of disposal may allow for a reduction in overall shipper size. Folding the gable top over may be desirable in some cases whereas, in other cases, the gable top may not need to be folded over and could serve a useful design purpose. For example, the shipper may be designed such that the gable top may fit into the shipper edges. In one embodiment, two gable-top containers may be placed sideways, with the bottom surfaces of both containers pushed or glued together and the gable tops oriented against opposite edges of the shipper. In such an embodiment, the gable top may provide a way of securing the two refrigerant containers snugly together with the least

amount of refrigerant in the sides and corners of the shipper and the densest packing of refrigerant in the center of the shipper side faces. Additionally, the refrigerant containers could be designed to have gable-type closures on opposite sides (e.g., the top and bottom of the carton). In such a case, the refrigerant containers may be placed sideways in the shipper, and the gabled ends may act as stand-offs from the interior corners of the shipping system.

[0084] Referring now to FIGS. 4, 5A and 5B, passive temperature-control member 61-1 is shown in greater detail. Details of passive temperature-control member 61-1 that are discussed elsewhere in this application or that are not critical to an understanding of the invention may be omitted from one or more of FIGS. 4, 5A, and 5B and/or from the accompanying description herein or may be shown in one or more of FIGS. 4, 5A, and 5B and/or described herein in a simplified manner.

[0085] As can be seen, in the present embodiment, container 65 may be a generally rectangular hollow member and may comprise a front 69, a rear 71, a top 73, a bottom 75, a left side 77, and a right side 79. Top 73 may be gabled and may be capable of being folded over to minimize the space it occupies when positioned within central channel 37 of thermal insulation sleeve 23. In another embodiment (not shown), bottom 75 may have a construction similar to top 73.

[0086] Container 65, which may be made of a curbside recyclable material of the type commonly used in the packaging of beverages and liquid foods, may comprise a shelf-stable or aseptic carton made of a multilayer material. Referring now to FIG. 6, there is shown an enlarged fragmentary section view of one embodiment of a multilayer material suitable for use in making container 65 according to the present invention, the multilayer material being represented generally by reference numeral 81. Details of multilayer material 81 that are discussed elsewhere in this application or that are not critical to an understanding of the invention may be omitted from FIG. 6 and/or from the accompanying description herein or may be shown in FIG. 6 and/or described herein in a simplified manner.

[0087] In the present embodiment, multilayer material 81 may be a curbside recyclable material and may comprise a paper layer 83, which may be, but is not limited to, paperboard. Paper layer 83 may serve as a principal structural material to provide carton stability. Multilayer material 81 may further comprise a first polyethylene layer 85, which may be positioned relative to paper layer 83 as an innermost layer, and a second polyethylene

layer 87, which may be positioned relative to paper layer 83 as an outermost layer. Multilayer material 81 may further comprise an aluminum foil layer 89, which may be positioned between first polyethylene layer 85 and paper layer 83 as a barrier to water and gas permeation. The paper content of multilayer material 81 may be 70% or more by weight.

5 In many parts of the United States and Canada, cartons made of a material like multilayer material 81 can be placed in the single-stream recycling stream, where they are sorted for recycling, either by separating the paper component as pulp for use in new paper products, or by utilizing the entire carton in specific recycling processes, e.g., creating building materials.

[0088] During freezing, liquid water crystallizes to form ice. Since the density of ice  
10 is lower than that of water, a paper-based container filled with water will experience expansion of its contents upon freezing. In order to withstand the rigors of freezing, container 65 may be constructed using a thicker than typical polyethylene layer 85 and/or 87. If container 65 is insufficiently thick, there may be a greater percentage of containers 65 that experience tearing during the preconditioning (freezing) step, which, in turn, may lead to  
15 more shippers experiencing leakage during use. In addition to providing better protection during freezing, a thicker polyethylene layer may also provide additional robustness.

[0089] Referring back now to FIG. 4, freezable refrigerant 67 may consist of water or may comprise water in combination with one or more other components. In a preferred embodiment, freezable refrigerant 67 consists of water. To ensure a phase change  
20 temperature of about 0°C, the water used as freezable refrigerant 67 should be reasonably free of contaminants. Drinking water provided by most municipal water supplies should be reasonably free of contaminants without requiring further purification. Water used as freezable refrigerant 67 does not need to be potable since it is not intended for drinking; nevertheless, potable water could be used as freezable refrigerant 67.

25 [0090] Where freezable refrigerant 67 comprises water in combination with one or more other components, such one or more other components may comprise additives, such as, but not limited to, one or more salts for reducing the phase change temperature, one or more thickeners for aiding in the manufacture of the refrigerant or for mitigating the spread of the refrigerant if spilled, one or more preservatives for reducing or preventing mold  
30 growth, and/or one or more ice nucleating agents for reducing or preventing subcooling. Since freezable refrigerant 67 is preferably safe for disposal via septic or sewer systems, any

potential additives should be evaluated carefully to minimize negative impact on the environment.

[0091] In a preferred embodiment, freezable refrigerant 67 may lack added salts or thickeners so that a user may be more comfortable with disposal of freezable refrigerant 67 via a home septic system or municipal wastewater stream. A nucleating agent, if used, may be added at very low concentrations, for example, 0.5% or less, or preferably 0.2% or less, and may comprise a material compatible with septic systems and municipal wastewater streams. For example, kaolinite, a naturally occurring silicate mineral, may be suitable as a nucleating agent since it is a particularly effective ice nucleating agent at concentrations as low as 0.1% to 0.2% and is a drain-safe additive.

[0092] If a nucleating agent is used, its effectiveness often depends upon its being delivered equally to each carton during the manufacturing process. In conventional refrigerant systems, such as gel-containing pouches, the use of a thickener may help to maintain the nucleating agent in suspension within the bulk gel and to enable its uniform delivery to each pouch using common types of pumping and dosing equipment. Nevertheless, since freezable refrigerant preferably lacks such a thickener, a nucleating agent may readily float or settle, depending upon its density relative to water. Silver iodide and kaolinite, with density values of 5.7 g/cm<sup>3</sup> and 2.7 g/cm<sup>3</sup> respectively, will typically settle quickly in water. Conversely, pentadecanol, with a density of 0.84 g/cm<sup>3</sup>, will typically readily float. If the nucleating agent is added to a bulk tank of water, it would likely not remain dispersed unless subjected to vigorous continuous mixing, sonication or other means to ensure delivery of the same amount of nucleating agent to each container. Another preferred approach may be to dose each container with the desired amount of nucleating agent in a separate step from water addition; however, even after taking such steps to ensure that each carton contains the correct amount of nucleating agent, once inside the carton, the nucleating agent may settle or float under the effects of gravity.

[0093] According to one embodiment, a combination of two types of nucleating agent may be used, one of greater density than the bulk refrigerant and one of lower density than the bulk refrigerant. With this embodiment, the settling/floating characteristics of the nucleating agents may be somewhat counterbalanced. More specifically, when the refrigerant-containing cartons are preconditioned (frozen) prior to use in the shipping system,

the nucleating agents may not all be concentrated in one region within the carton as might happen if only one type were used. Irrespective of carton orientation at the time of freezing, the tendency of one nucleating agent to settle while the other tends to float may result in a more efficient nucleation and, therefore, result in less subcooling than would otherwise occur.

5           **[0094]** Preferably, the amount of freezable refrigerant 67 in liquid form that is present within container 65 is less than the entire usable volume of container 65 and may be, for example, only about 85-90% of the usable volume of container 65, wherein the usable volume of container 65 may not include the gabled top portion of the container 65. The amount of freezable refrigerant 67 in container 65 is preferably less than the entire usable  
10 volume of container 65 because the density of liquid water is  $998 \text{ kg/m}^3$  at  $20^\circ\text{C}$  and is  $1000 \text{ kg/m}^3$  at  $0^\circ\text{C}$  whereas the density of ice is  $917 \text{ kg/m}^3$  at  $0^\circ\text{C}$ . As a result, it is reasonable to expect that a paper-based container or carton that is filled completely at  $20^\circ\text{C}$  would experience an expansion of about 9% by volume when the water freezes to ice. A rectangular carton might be expected to bulge in the middle, and a simple calculation may show that  
15 approximately an 8% reduction in weight of water should compensate for this expansion. However, in practice, underfilling a rectangular carton by 8% is typically not sufficient to avoid bulging. This is because water inside a carton does not freeze uniformly, taking on the shape of the carton; instead, a variety of shapes may be formed, and large bulges may be seen near the top, sides, or bottom of the carton, deforming the carton and, in some cases, causing  
20 it to tear. Occasionally, small surface obtrusions may appear that are not only clearly visible but feel sharp to the touch. These obtrusions often cause tearing of the carton within which they are located, and, if used in a shipping system (where vibration and impact are common), may also cause damage to adjacent refrigerant cartons. Some of the design features described above that may be desirable for other reasons also may have the effect of reducing freeze-  
25 induced carton damage. These features include use of ice nucleating agent, use of two ice nucleating agents (one of higher density and one of lower density than the refrigerant), the use of thicker gauge polyethylene, and preconditioning the cartons within the assembly, instead of freezing them separately and then inserting them into the assembly once frozen.

**[0095]** Referring back now to FIGS. 1, 2A, 2B and 3, system 11 may further comprise  
30 a plurality of positioning devices 91-1 and 91-2, which may be removably positioned within central channel 37 of thermal insulation sleeve 23. In the present embodiment, positioning

devices 91-1 and 91-2 may be dimensioned so that there may be a small space between the outer surfaces of positioning devices 91-1 and 91-2 and the inner surfaces of thermal insulation sleeve 23, but this need not be the case since, alternatively, positioning devices 91-1 and 91-2 may fit snugly within thermal insulation sleeve 23. In the present embodiment, positioning device 91-1 may be positioned above product box 51, and positioning device 91-2 may be positioned below product box 51. More specifically, positioning device 91-1 may be positioned above and proximate to, or in direct contact with, the top surface of product box 51, and positioning device 91-2 may be positioned below and proximate to, or in direct contact with, the bottom surface of product box 51. Positioning device 91-1 may be shaped to include a first cavity 92-1, which may be dimensioned to removably receive passive temperature-control members 61-1 and 61-3, and may further be shaped to include a second cavity 92-2, which may be dimensioned to removably receive passive temperature-control members 61-2 and 61-4. In an analogous manner, positioning device 91-2 may be shaped to include a first cavity 94-1, which may be dimensioned to removably receive passive temperature-control members 61-5 and 61-7, and may further be shaped to include a second cavity 94-2, which may be dimensioned to removably receive passive temperature-control members 61-6 and 61-8. It is to be understood that, although, in the present embodiment, first cavities 92-1 and 94-1 and second cavities 92-2 and 94-2 may have heights that are slightly less than the collective heights of the respective passive temperature-control members received therein, this need not be the case since, alternatively, the heights of the respective cavities may be equal to or greater than the collective heights of the respective passive temperature-control members received therein. Also, it is to be understood that the respective cavities of positioning devices 91-1 and 91-2 may have footprints that are substantially equal to the footprints of the respective passive temperature-control members received therein, in which case the passive temperature-control members may fit snugly in their respective cavities, or the respective cavities may have footprints that are greater than the footprints of the respective passive temperature-control members received therein, in which case the passive temperature-control members may fit loosely in their respective cavities.

30 [0096] In the present embodiment, positioning devices 91-1 and 91-2 may be identical in all respects including, but not limited to, size, shape, construction, and

composition. Therefore, for simplicity, the discussion below of positioning device 91-1 should be understood to apply equally well to positioning device 91-2. Notwithstanding the above, it is to be understood that positioning devices 91-1 and 91-2 need not be identical to one another and may differ from one another in one or more respects. Moreover, it is to be understood that, although, in the present embodiment, system 11 may comprise two positioning devices 91-1 and 91-2, the number and arrangement of such positioning devices may be varied such that system 11 may comprise no such positioning devices or may comprise more than two such positioning devices or may comprise two or another number of such positioning devices arranged in a different manner.

10 [0097] Positioning device 91-1, which is also shown separately in FIG. 7, may be a unitary (i.e., one-piece) structure that may be made of a curbside recyclable or compostable material, such as corrugated cardboard. Positioning device 91-1 may be generally I-shaped and may comprise a dividing bar 96, a first transverse bar 98-1, which may be disposed at a first end of dividing bar 96, and a second transverse bar 98-2, which may be disposed at a second end of dividing bar 96. Dividing bar 96 may be used to space apart passive temperature-control members 61-1 and 61-3 from passive temperature-control members 61-2 and 61-4. Such spacing apart of passive temperature-control members 61-1 and 61-3 from passive temperature-control members 61-2 and 61-4 may minimize damage that such passive temperature-control members may otherwise inflict upon each other through contact with one another during movement of system 11, particularly when the refrigerant material within such passive temperature-control members is frozen. In addition, as discussed further below, such spacing apart of passive temperature-control members 61-1 and 61-3 from passive temperature-control members 61-2 and 61-4 may position the passive temperature-control members closer to opposing edges of product box 51, which may be advantageous in limiting thermal loss of the payload through such opposing edges of product box 51. Also, the combination of dividing bar 96 and transverse bars 98-1 and 98-2 may delimit movement of passive temperature-control members 61-1 through 61-4 within thermal insulation sleeve 23, which may be advantageous in keeping passive temperature-control members 61-1 through 61-4 relatively stationary relative to product box 51 and from limiting collisions with each other and with other components of system 11, which could result in damage to system 11.

[0098] As alluded to above, positioning device 91-1 may be dimensioned relative to passive temperature-control members 61-1 through 61-4 and product box 51 so that a portion of each of passive temperature-control members 61-1 through 61-4 may be positioned directly over, or proximate to, a portion of the perimeter of product box 51. It is believed that such positioning of passive temperature-control members 61-1 through 61-4 relative to product box 51 may minimize thermal loss of the payload through the portion of the product box 51 that is covered, or nearly covered, by passive temperature-control members 61-1 through 61-4.

[0099] According to one embodiment, positioning device 91-1 may have the following dimensions: an outer length  $l_1$  of about 9.50 in; an inner length  $l_2$  of about 7.87 in; an overall width  $w_1$  of about 8.50 in; a width  $w_2$  of dividing bar 96 of about 1.25 in; and a height of about 2.5 in. Container 65 may have approximate outer dimensions of 7.7 in x 4.1 in x 1.4 in and may have approximate inner dimensions of 7.5 in x 4.0 in x 1.25 in. Product box 51 may have approximate outer dimensions of 9.25 in x 9.06 in x 2.88 in and may have approximate inner dimensions of 8.88 in x 8.88 in x 2.75 in. Central channel 37 may have approximate inner dimensions of 10.0 in x 10.0 in x 9.13 in.

[00100] As can be appreciated, one advantageous feature of system 11 is that all of its components may be made from materials that are curbside recyclable, compostable or disposable via a septic or sewer system.

[00101] Referring now to FIGS. 8, 9A, 9B, 9C and 9D, there is shown a perspective view of an alternative embodiment of a passive temperature-control member to passive temperature-control member 61-1, the alternative passive temperature-control member being represented generally by reference numeral 101. Details of passive temperature-control member 101 that are discussed elsewhere in this application or that are not critical to an understanding of the invention may be omitted from one or more of FIGS. 8, 9A, 9B, 9C and 9D and/or from the accompanying description herein or may be shown in FIGS. 8, 9A, 9B, 9C and 9D and/or described herein in a simplified manner.

[00102] Passive temperature-control member 101 may be similar in many respects to passive temperature-control member 61-1, the principal difference between the two passive temperature-control members being that, whereas passive temperature-control member 61-1 may comprise a container 65, passive temperature-control member 101 may instead comprise

a container 103. Container 103 may differ primarily from container 65 in that container 103 may comprise a top 105 that may include a pair of flaps 107-1 and 107-2 that may be secured to opposing sides 109-1 and 109-2, respectively, of container 103. Top 105 may be gabled but preferably does not extend upwardly as high as top 73 of container 65. FIGS. 9A and 9B  
5 show temperature-control member 101, with top 105 in a completely unfolded state, and FIGS. 9C and 9D show temperature-control member 101, with top 105 flattened but not secured to sides 109-1 and 109-2.

[00103] Referring now to FIGS. 10, 11A, and 11B, there are shown various views of a second embodiment of a system suitable for storing and/or transporting temperature-sensitive materials, the system being constructed according to the present invention and being  
10 represented generally by reference numeral 211. Details of system 211 that are discussed elsewhere in this application or that are not critical to an understanding of the invention may be omitted from one or more of FIGS. 10, 11A, and 11B and/or from the accompanying description herein or may be shown in one or more of FIGS. 10, 11A, and 11B and/or  
15 described herein in a simplified manner.

[00104] System 211 may be similar in many respects to system 11 and, consequently, may comprise an outer retaining box 213, a thermal insulation base 221, a thermal insulation sleeve 223, a thermal insulation lid 225, and a payload box 251. Outer retaining box 213 may be generally similar to outer retaining box 13 of system 11, and product box 251 may be  
20 generally similar to product box 51 of system 11, the principal difference between the two sets of boxes being their respective dimensions. Similarly, thermal insulation base 221, thermal insulation sleeve 223, and thermal insulation lid 225 may be generally similar to thermal insulation base 21, thermal insulation sleeve 23, and thermal insulation lid 25, respectively, of system 11, the principal difference between the two sets of insulated  
25 container components being their respective dimensions.

[00105] System 211 may differ notably from system 11 in that, whereas system 11 may comprise positioning devices 91-1 and 91-2, system 211 may lack such a positioning device, and in that, whereas system 11 may comprise passive temperature-control members 61-1 through 61-8, system 211 may instead comprise passive temperature-control members  
30 261-1 through 261-4. Passive temperature-control members 261-1 through 261-4 may be generally similar to passive temperature-control members 61-1 through 61-8 but may differ

dimensionally with respect to their respective containers. In addition, passive temperature-control members 261-1 through 261-4 may be arranged in a pinwheel configuration around product box 251, with passive temperature-control member 261-1 positioned proximate to, or directly against, the top of product box 251, with passive temperature-control member 261-2 positioned proximate to, or directly against, the bottom of product box 251, with passive temperature-control member 261-3 positioned proximate to, or directly against, the left side of product box 251, with passive temperature-control member 261-4 positioned proximate to, or directly against, the right side of product box 251, and with the longitudinal axes of all of passive temperature-control members 261-1 through 261-4 being oriented front to back. Notwithstanding the above, it is to be understood that the number of passive temperature-control members in system 211 and the arrangement of passive temperature-control members in 211 may be modified.

**[00106]** According to one embodiment, the container for passive temperature-control members 261-1 through 261-4 may have approximate outer dimensions of 6.7 in x 4.1 in x 1.4 in and may have approximate inner dimensions of 6.5 in x 4.0 in x 1.25 in. Product box 251 may have approximate outer dimensions of 6.13 in x 2.50 in x 2.88 in and may have approximate inner dimensions of 5.75 in x 2.31 in x 2.75 in. The central channel formed by the combination of thermal insulation base 221, thermal insulation sleeve 223, and thermal insulation lid 225 may have approximate inner dimensions of 6.81 in x 5.81 in x 6.00 in.

**[00107]** Referring now to FIGS. 12, 13A, and 13B, there are shown various views of a third embodiment of a system suitable for storing and/or transporting temperature-sensitive materials, the system being constructed according to the present invention and being represented generally by reference numeral 311. Details of system 311 that are discussed elsewhere in this application or that are not critical to an understanding of the invention may be omitted from one or more of FIGS. 12, 13A, and 13B and/or from the accompanying description herein or may be shown in one or more of FIGS. 12, 13A, and 13B and/or described herein in a simplified manner.

**[00108]** System 311 may be similar in many respects to system 11 and, consequently, may comprise an outer retaining box 313, a thermal insulation base 321, a thermal insulation sleeve 323, a thermal insulation lid 325, and a payload box 351. Outer retaining box 313 may be generally similar to outer retaining box 13 of system 11, and product box 351 may be

generally similar to product box 51 of system 11, the principal difference between the two sets of boxes being their respective dimensions. Similarly, thermal insulation base 321, thermal insulation sleeve 323, and thermal insulation lid 325 may be generally similar to thermal insulation base 21, thermal insulation sleeve 23, and thermal insulation lid 25, respectively, of system 11, the principal difference between the two sets of insulated container components being their respective dimensions.

[00109] System 311 may differ notably from system 11 in that, whereas system 11 may comprise positioning devices 91-1 and 91-2, system 311 may lack such a positioning device, and in that, whereas system 11 may comprise passive temperature-control members 61-1 through 61-8, system 311 may instead comprise passive temperature-control members 361-1 through 361-5. Passive temperature-control members 361-1 through 361-5 may be identical to passive temperature-control members 61-1 through 61-8 but may be arranged such that passive temperature-control members 361-1 and 361-2 may be positioned proximate to, or directly against, the top of product box 351, passive temperature-control member 361-3 may be positioned proximate to, or directly against, the bottom of product box 351, passive temperature-control member 361-4 may be positioned proximate to, or directly against, the left side of product box 351, and passive temperature-control member 361-5 may be positioned proximate to, or directly against, the right side of product box 351, with passive temperature-control members 361-1 and 361-2 having a longitudinal axis oriented generally left to right and with passive temperature-control members 361-3 through 361-5 having a longitudinal axis oriented generally front to back. Notwithstanding the above, it is to be understood that the number of passive temperature-control members in system 311 and the arrangement of passive temperature-control members in 311 may be modified.

[00110] According to one embodiment, product box 351 may have approximate outer dimensions of 9.00 in x 4.69 in x 2.88 in and may have approximate inner dimensions of 8.63 in x 4.50 in x 2.75 in. The central channel formed by the combination of thermal insulation base 221, thermal insulation sleeve 223, and thermal insulation lid 225 may have approximate inner dimensions of 9.50 in x 7.94 in x 6.00 in.

[00111] Referring now to FIGS. 14, 15A, and 15B, there are shown various views of a fourth embodiment of a system suitable for storing and/or transporting temperature-sensitive materials, the system being constructed according to the present invention and being

represented generally by reference numeral 411. Details of system 411 that are discussed elsewhere in this application or that are not critical to an understanding of the invention may be omitted from one or more of FIGS. 14, 15A, and 15B and/or from the accompanying description herein or may be shown in one or more of FIGS. 14, 15A, and 15B and/or  
5 described herein in a simplified manner.

[00112] System 411 may be similar in many respects to system 11 and, consequently, may comprise an outer retaining box 413, a thermal insulation base 421, a thermal insulation sleeve 423, a thermal insulation lid 425, and a payload box 451. Outer retaining box 413 may be generally similar to outer retaining box 13 of system 11, and product box 451 may be  
10 generally similar to product box 51 of system 11, the principal difference between the two sets of boxes being their respective dimensions. Similarly, thermal insulation base 421, thermal insulation sleeve 423, and thermal insulation lid 425 may be generally similar to thermal insulation base 21, thermal insulation sleeve 23, and thermal insulation lid 25, respectively, of system 11, the principal difference between the two sets of insulated  
15 container components being their respective dimensions.

[00113] System 411 may differ notably from system 11 in that, whereas system 11 may comprise positioning devices 91-1 and 91-2, system 411 may lack such a positioning device, and in that, whereas system 11 may comprise passive temperature-control members 61-1 through 61-8, system 411 may instead comprise passive temperature-control members  
20 461-1 through 461-8. Passive temperature-control members 461-1 through 461-8 may be identical to passive temperature-control members 61-1 through 61-8 but may be arranged such that passive temperature-control members 461-1 through 461-3 may be positioned proximate to, or directly against, the top of product box 451, passive temperature-control members 461-4 through 461-6 may be positioned proximate to, or directly against, the  
25 bottom of product box 451, passive temperature-control member 461-7 may be positioned proximate to, or directly against, the front of product box 451, and passive temperature-control member 461-8 may be positioned proximate to, or directly against, the rear of product box 351, with the longitudinal axes of all of passive temperature-control members 461-1 through 461-8 being oriented generally left to right. Notwithstanding the above, it is to be  
30 understood that the number of passive temperature-control members in system 411 and the arrangement of passive temperature-control members in 411 may be modified.

[00114] According to one embodiment, product box 451 may have approximate outer dimensions of 12.50 in x 6.81 in x 2.88 in and may have approximate inner dimensions of 12.13 in x 6.63 in x 2.75 in. The central channel formed by the combination of thermal insulation base 221, thermal insulation sleeve 223, and thermal insulation lid 225 may have  
5 approximate inner dimensions of 15.75 in x 7.88 in x 6.00 in.

[00115] In another embodiment (not shown), one or more passive temperature-control members may be positioned relative to a payload (either in a product box or otherwise) and/or to one another using a refrigerant sleeve. Such a refrigerant sleeve may be made of a curbside recyclable material, such as corrugated cardboard or the like. The refrigerant sleeve  
10 may have a plurality of pockets, wherein each pocket may be used to receive, removably or otherwise, an individual passive temperature-control member. Adjacent pockets of the refrigerant sleeve may be connected by a seam or by a strip of material. If desired, some of the pockets may be devoid of a passive temperature-control member. The refrigerant sleeve may be flexible and may be dimensioned to partially or completely surround or wrap around  
15 a payload and may also include or define a cavity for receiving, removably or otherwise, the payload. The pockets of the refrigerant sleeve may be positioned so that each passive temperature-control member disposed therein may be placed in a defined position relative to the payload. For example, if the shipper design requires that there be four passive temperature-control members positioned on the top, bottom, left side, and right side of a  
20 payload and that the top and bottom refrigerants be centered on the top and bottom faces, respectively, but that the side passive temperature-control members be held on the top portions of the side faces of the payload, then the refrigerant sleeve may have asymmetric or non-equivalent spacing that accomplishes different coverage placement on the payload. The pockets of the refrigerant sleeve may have a variety of shapes including, but not limited to, a  
25 top opening, a closed bottom and closed sides or an open top, an open bottom, and closed sides or open on one side and closed on the other side, as well as the top and bottom. The pockets of the refrigerant sleeve may be dimensioned to provide substantially full coverage of the passive temperature-control members or only partial coverage and may be dimensioned to provide a loose fit or a snug fit of the passive temperature-control members. Where a strip of  
30 material is positioned between adjacent pockets, the dimensions of the strip may affect how much freedom of movement there will be. The strip of material may also create a standoff,

which may be used to offset the passive temperature-control members from adjacent components, which may be desirable. With such a standoff, the strip may be folded along a central crease and used to create conventional channels that allow for air circulation within the shipping system. The height of the refrigerant sleeve may vary. In some cases, the sleeve height may be much less than the height of the passive temperature-control member, and it may be centrally positioned such that the refrigerant sleeve may appear more like a belt. In some cases, more than one such refrigerant sleeve may be used, giving the appearance of an upper belt and a lower belt.

[00116] In another embodiment (not shown), instead of inserting the passive temperature-control members into a refrigerant sleeve, the passive temperature-control members may be interconnected using a backing material. The backing may be a curbside recyclable material, such as, but not limited to, paper, paperboard, or thin corrugate with creases to assist in folding. The backing may be of the same height as the passive temperature-control members. The passive temperature-control members may be attached to the backing using an adhesive that is compatible with paper recycling processes (e.g., a repulpable adhesive). In one case, the passive temperature-control members may be spaced from one another on the backing by approximately 1.125 to 1.25 inches. Such spacing may allow for the passive temperature-control members to be wrapped in a pinwheel configuration around the payload, providing complete refrigerant coverage on four sides of the payload.

[00117] Additional advantages, features and/or aspects of the present invention that may be applicable to one or more embodiments disclosed herein may include the following:

[00118] In at least some embodiments, many of the components of the thermal shipping system, and, in some cases, all of the components of the thermal shipping system, may be curbside recyclable, compostable and/or disposable safely via a septic or sewer system.

[00119] In at least some embodiments, the passive temperature-control members may use water, with or without additives, as the freezable refrigerant. If water, without any additives is used, such water may be potable and, thus, may be consumed after use of the thermal shipping system; nevertheless, such water need not be potable to be suitable as the freezable refrigerant.

[00120] Designing the container for the passive temperature-control member to have gables that can be folded during use, and then unfolded and opened at the time of disposal, may allow for a reduction in overall shipper size and may maximize the possibility that both the empty freezable refrigerant container and the remaining packaging will be recycled.

5 Conversely, since most refrigerants arrive partially or fully frozen to a recipient, the entire passive temperature-control member (refrigerant and container) is likely to be landfilled if a recipient is unable to eject the frozen contents and must wait hours before the task can be completed.

[00121] The use of the positioning device may help to minimize thermal loss along

10 some of the edges of the product box and/or may help to keep at least some of the passive temperature-control members from banging into each other and/or to other objects in the shipper, potentially causing damage, during transportation of the shipper.

[00122] The same type of passive temperature-control members may be used in a plurality of differently sized thermal shipping system, thereby minimizing the number of

15 different parts that may be used in connection with multiple types of shipping systems.

[00123] The embodiments of the present invention described above are intended to be merely exemplary and those skilled in the art shall be able to make numerous variations and modifications to it without departing from the spirit of the present invention. All such variations and modifications are intended to be within the scope of the present invention as

20 defined in the appended claims.

**WHAT IS CLAIMED IS:**

1. A system suitable for storing and/or transporting temperature-sensitive materials, the system comprising:
  - (a) an insulated container, the insulated container comprising a cavity; and
  - 5 (b) at least one passive temperature-control member removably disposed within the cavity of the insulated container, the at least one passive temperature-control member comprising a first passive temperature-control member, the first passive temperature-control member comprising a refrigerant container and a freezable refrigerant, the freezable refrigerant being disposed within the refrigerant container;
  - 10 (c) wherein the refrigerant container is at least one of curbside recyclable and compostable and wherein the freezable refrigerant comprises water.
2. The system as claimed in claim 1 further comprising a product box, the product box being removably disposed within the cavity of the insulated container, the product box being
- 15 3. The system as claimed in claim 2 wherein the product box is at least one of curbside recyclable and compostable.
4. The system as claimed in claim 3 wherein the product box is made of corrugated cardboard.
5. The system as claimed in claim 1 wherein the insulated container is at least one of
- 20 6. The system as claimed in claim 5 wherein the insulated container comprises one or more thermal insulation members and wherein each of the one or more thermal insulation members is made of natural wood fiber and/or plant fiber materials.
7. The system as claimed in claim 6 wherein the one or more thermal insulation members
- 25 30 comprise a thermal insulation base, a thermal insulation sleeve, and a thermal insulation lid, wherein the thermal insulation base forms a bottom of the insulated container and comprises a thermal insulation base box made of corrugated cardboard and containing loose-fill cellulose, wherein the thermal insulation sleeve forms four side walls of the insulated container and comprises a thermal insulation sleeve box made of corrugated cardboard and containing cellulose batting, and wherein the thermal insulation lid forms a

- lid for the insulated container and comprises a thermal insulation lid box made of corrugated cardboard and containing loose-fill cellulose.
8. The system as claimed in claim 1 wherein the refrigerant container is shaped to include an interior volume for receiving the freezable refrigerant and wherein the refrigerant container is made of a refrigerant container material comprising a paper layer.
- 5 9. The system as claimed in claim 8 wherein the refrigerant container is shaped to include at least one gabled end.
10. The system as claimed in claim 9 wherein the at least one gabled end is foldable.
11. The system as claimed in claim 1 wherein the freezable refrigerant consists of water.
12. The system as claimed in claim 11 wherein the water is potable water.
- 10 13. The system as claimed in claim 1 wherein the freezable refrigerant is at least partially frozen.
14. The system as claimed in claim 9 wherein the freezable refrigerant occupies about 85-90% of the interior volume of the refrigerant container, excluding the at least one gabled end.
- 15 15. The system as claimed in claim 1 further comprising an outer retaining box, wherein the insulated container and the at least one passive temperature-control member are disposed within the outer retaining box.
16. The system as claimed in claim 1 wherein the insulated container is made exclusively of one or more materials selected from the group consisting of natural wood fiber and/or plant fiber materials.
- 20 17. The system as claimed in claim 1 wherein the at least one passive temperature-control member further comprises a second passive temperature-control member and wherein the second passive temperature-control member is identical to the first passive temperature-control member.
- 25 18. The system as claimed in claim 17 further comprising a first positioning device and wherein the first positioning device comprises a first dividing bar positioned between the first passive temperature-control member and the second passive temperature-control member.

19. The system as claimed in claim 18 wherein the first positioning device is I-shaped and further comprises a first transverse bar disposed at a first end of the first dividing bar and a second transverse bar disposed at a second end of the first dividing bar.
20. The system as claimed in claim 19 wherein the first positioning device is made of corrugated cardboard.
- 5 21. The system as claimed in claim 18 further comprising a product box, wherein the product box is removably disposed within the cavity of the insulated container and is dimensioned to removably receive the temperature-sensitive materials, wherein the first and second passive temperature-control members and the first positioning device are seated directly on top of the product box, and wherein the product box, the first positioning device, and the first and second passive temperature-control members are dimensioned so that a portion of each of the first and second passive temperature-control members is positioned directly over opposing peripheral edges of the product box.
- 10 22. The system as claimed in claim 18 wherein the at least one passive temperature-control member further comprises third and fourth passive temperature-control members, wherein the third and fourth passive temperature-control members are identical to the first passive temperature-control member, the system further comprising a second positioning device, the second positioning device being identical to the first positioning device, and wherein the second positioning device comprises a second dividing bar positioned between the third passive temperature-control member and the fourth passive temperature-control member.
- 15 23. A system suitable for storing and/or transporting temperature-sensitive materials, the system comprising:
- 20 (a) an insulated container, the insulated container comprising a cavity;
- 25 (b) a product box, the product box being removably disposed within the cavity of the insulated container, the product box being designed to hold the temperature-sensitive materials;
- 30 (c) a plurality of passive temperature-control members removably disposed within the cavity of the insulated container, the plurality of passive temperature-control members being identical to one another and comprising a first passive temperature-control member and a second passive temperature-control member,

wherein the first and second passive temperature-control members are seated directly on top of the product box; and

(d) a positioning device removably disposed within the cavity of the insulated container, wherein the positioning device comprises a dividing bar positioned between the first passive temperature-control member and the second passive temperature-control.

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24. The system as claimed in claim 23 wherein the insulated container, the product box, and the positioning device are made exclusively of one or more materials selected from the group consisting of natural wood fiber and/or plant fiber materials and wherein each of the passive temperature-control members comprises a paper-based refrigerant container and a freezable refrigerant comprising water.

25. The system as claimed in claim 24 wherein the freezable refrigerant consists of water.

26. The system as claimed in claim 25 wherein the water is at least partially frozen.

27. The system as claimed in claim 24 wherein the product box, the positioning device, and the first and second passive temperature-control members are dimensioned so that a portion of each of the first and second passive temperature-control members is positioned directly over opposing peripheral edges of the product box.

28. A method for storing and/or transporting a payload of temperature-sensitive materials, the system comprising:

(a) providing a thermal shipping system, the thermal shipping system comprising

- (i) an insulated container, the insulated container comprising a cavity, and
- (ii) at least one passive temperature-control member removably disposed within the cavity of the insulated container, the at least one passive temperature-control member comprising a first passive temperature-control member, the first passive temperature-control member comprising a refrigerant container and a freezable refrigerant, the refrigerant container having an openable gabled end, the freezable refrigerant being disposed within the refrigerant container;

(b) positioning a payload of temperature-sensitive materials within the insulated container;

(c) storing and/or transporting the payload within the insulated container;

- (d) then, removing the payload from the insulated container; and
- (e) opening the openable gabled end of the refrigerant container and emptying the freezable refrigerant from the refrigerant container.

29. The method as claimed in claim 28 wherein the freezable refrigerant consists of water.

5 30. The method as claimed in claim 28 wherein the freezable refrigerant is at least partially frozen during steps (c) and (e).

31. The method as claimed in claim 28 wherein the insulated container is made exclusively of one or more materials selected from the group consisting of natural wood fiber and/or plant fiber materials and wherein the refrigerant container is a paper-based refrigerant container.

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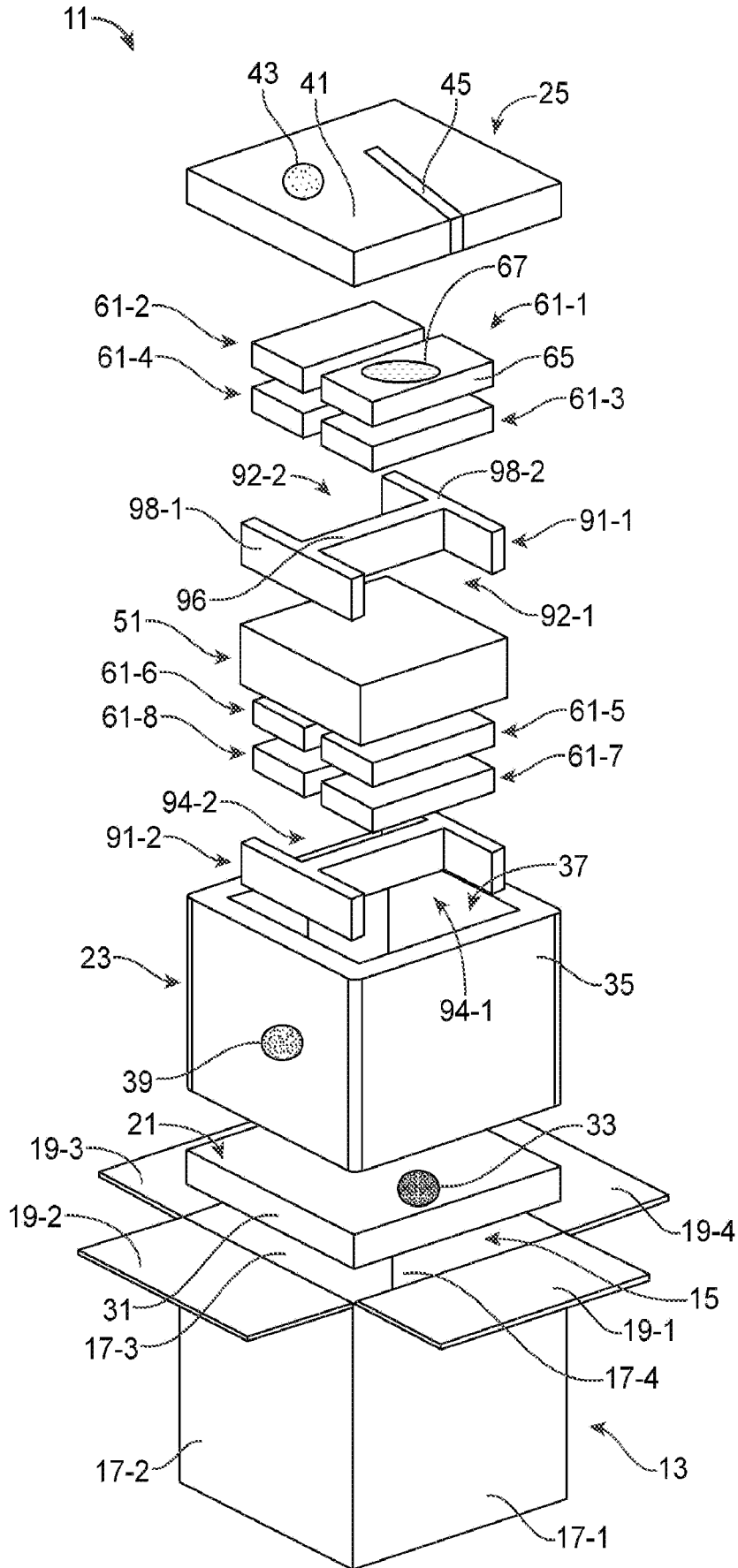


FIG. 1

SUBSTITUTE SHEET (RULE 26)

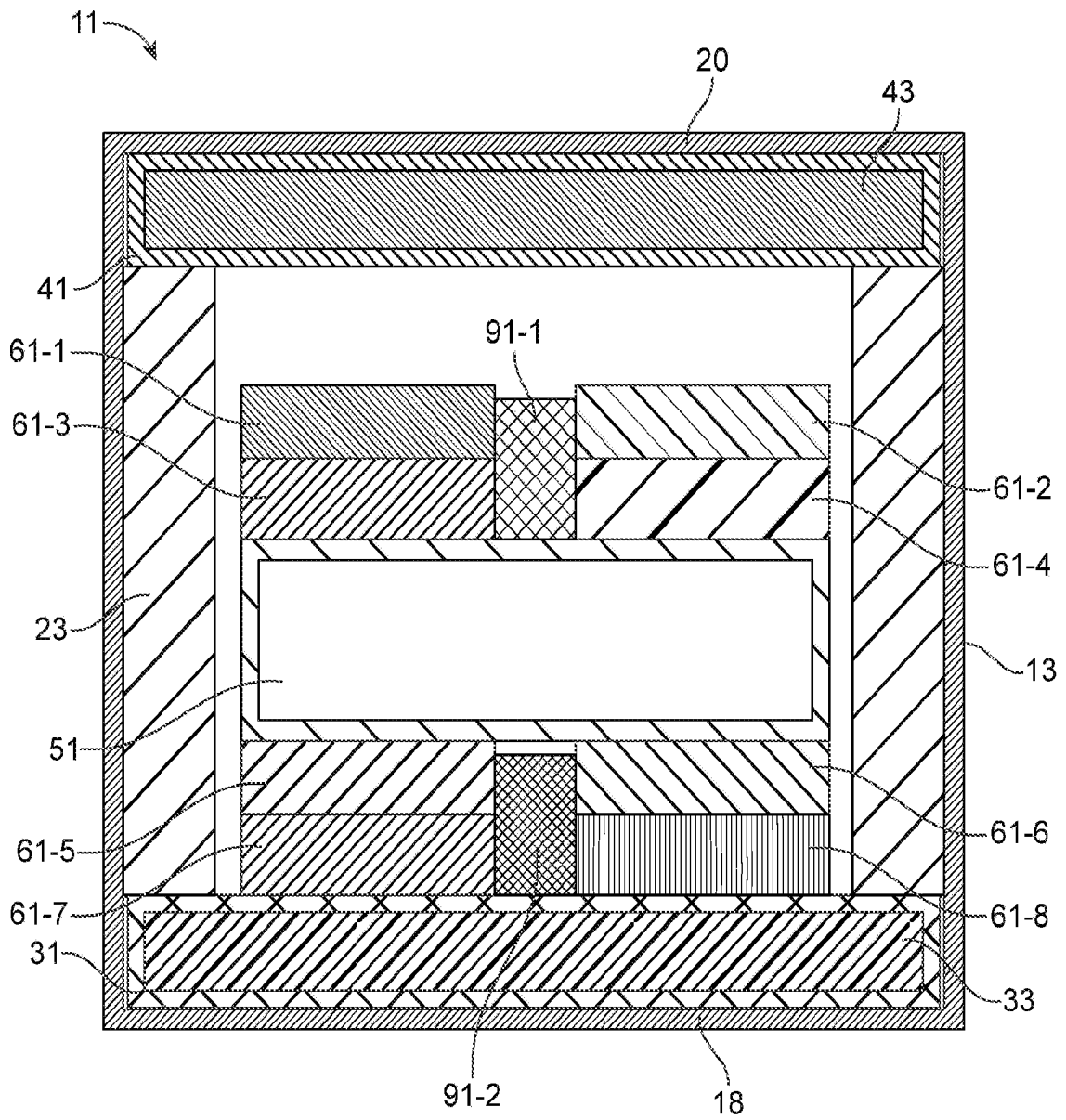


FIG. 2A

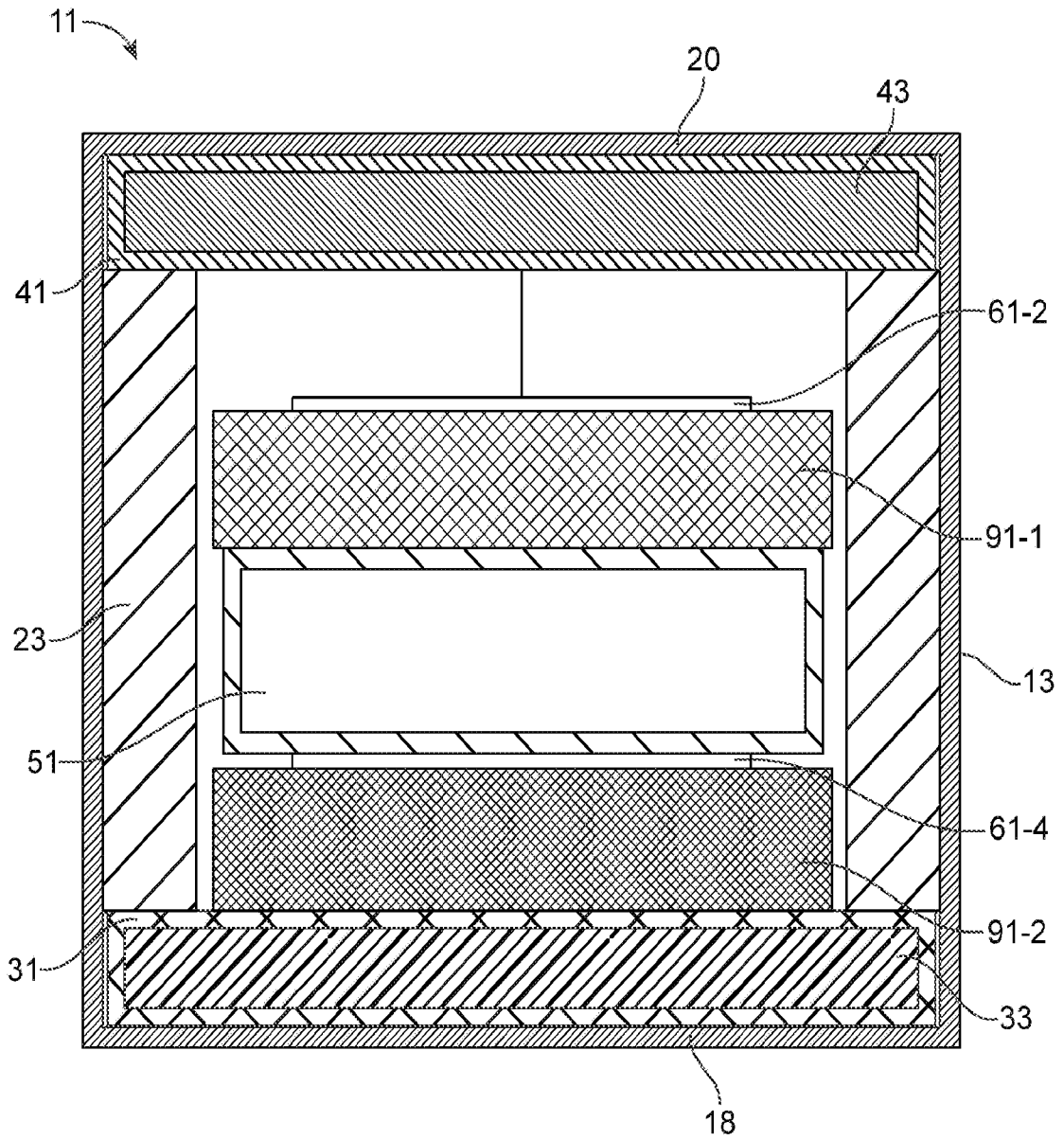


FIG. 2B

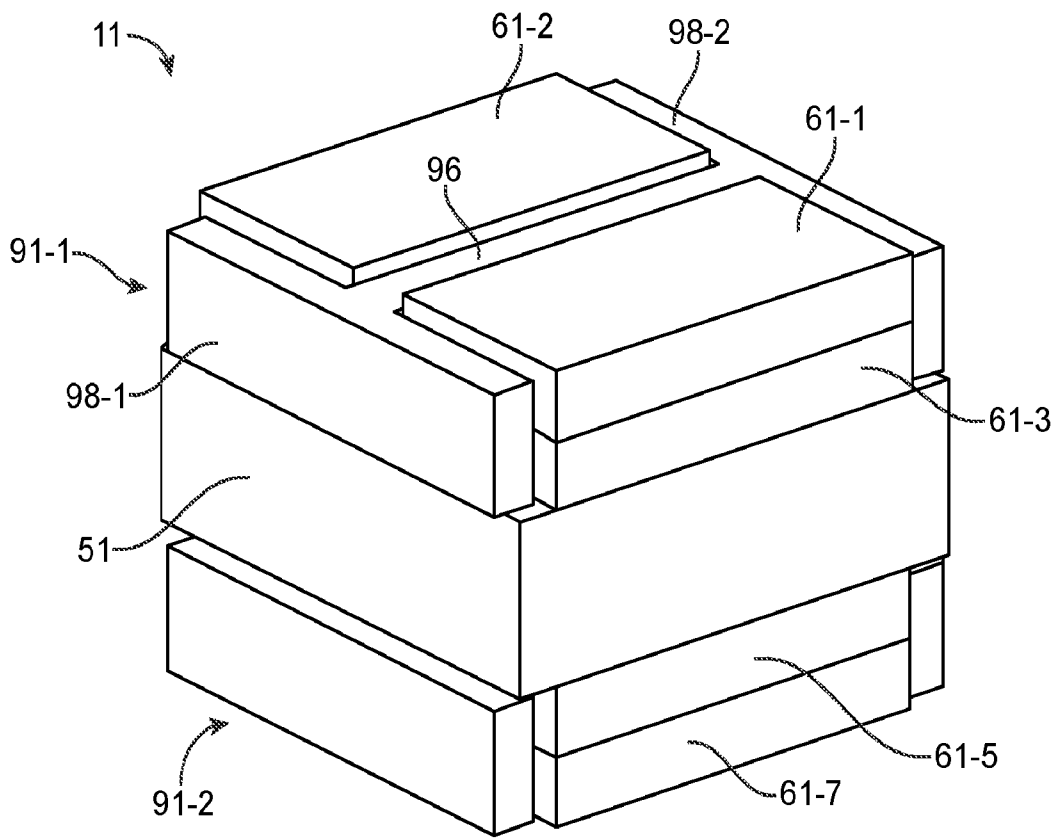
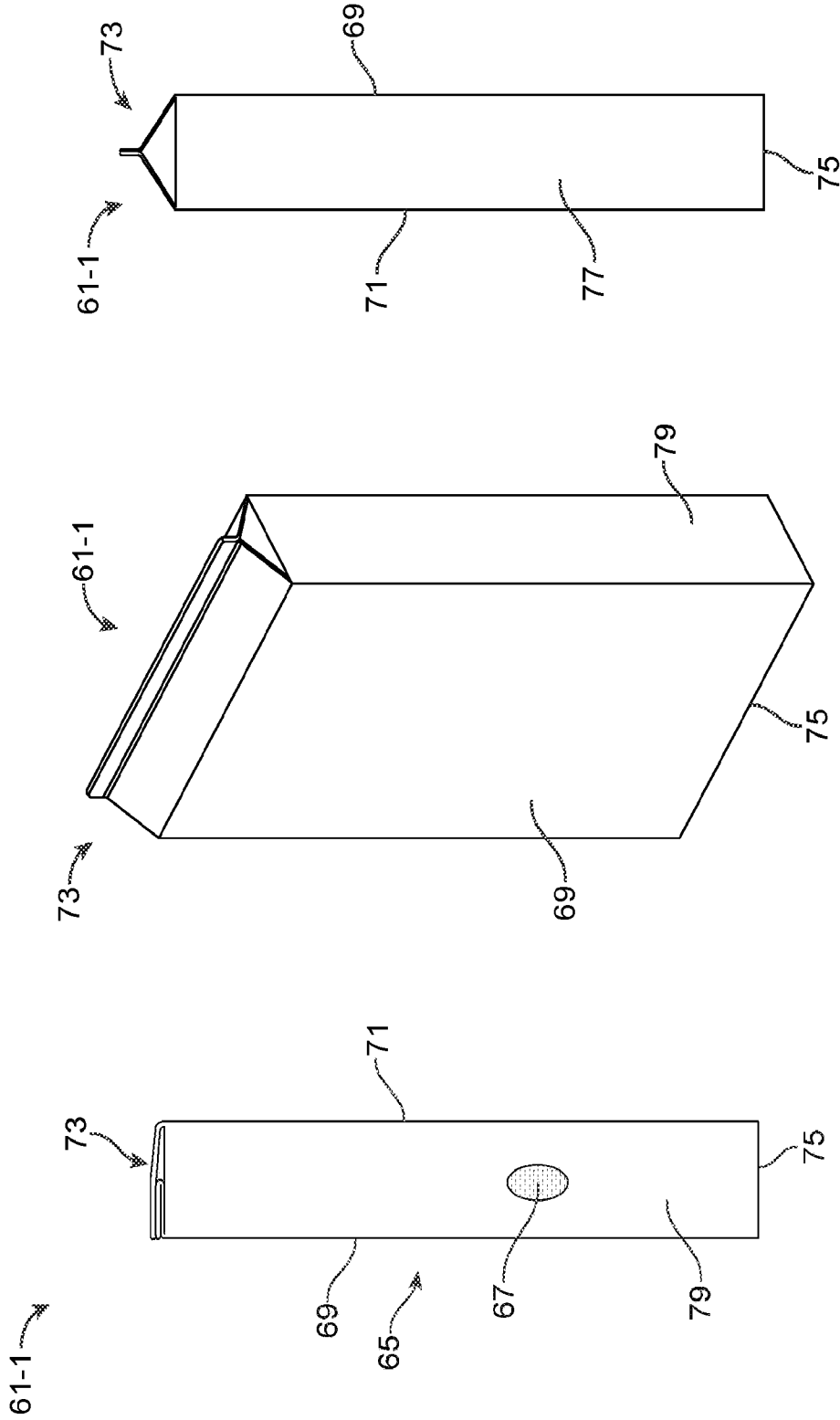


FIG. 3



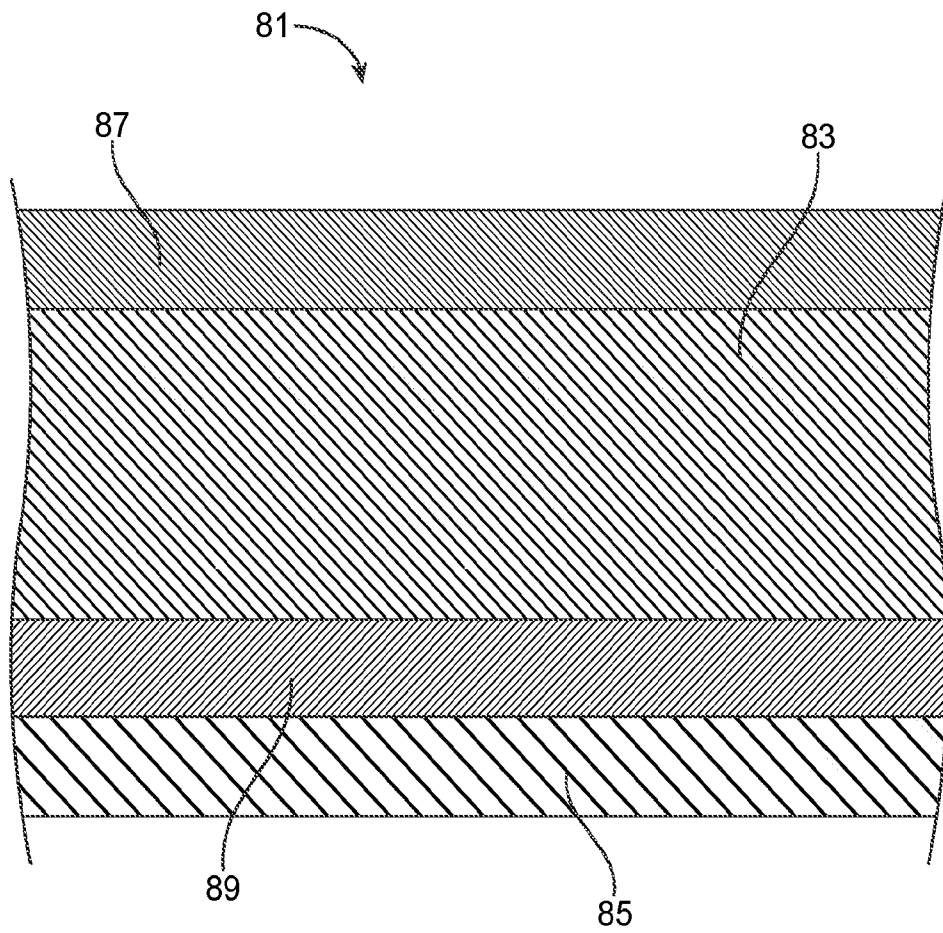


FIG. 6

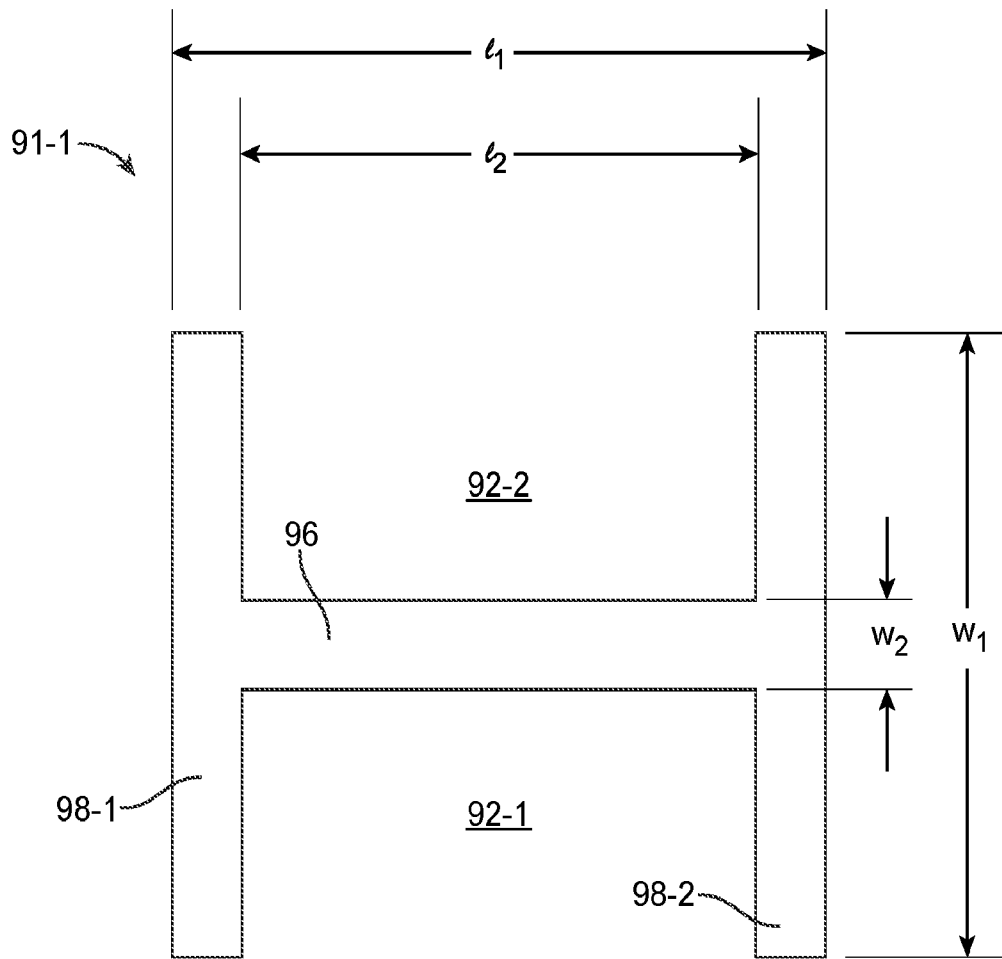


FIG. 7

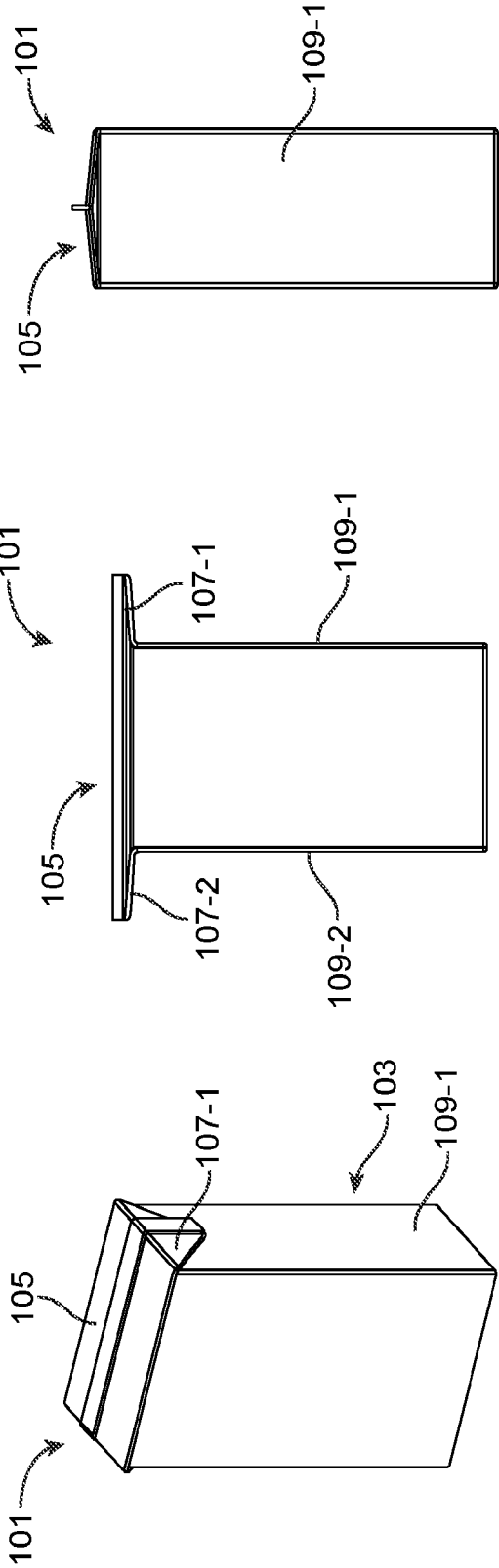


FIG. 8

FIG. 9A

FIG. 9B

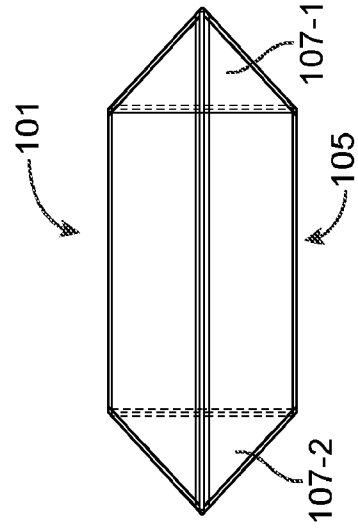


FIG. 9C

FIG. 9D

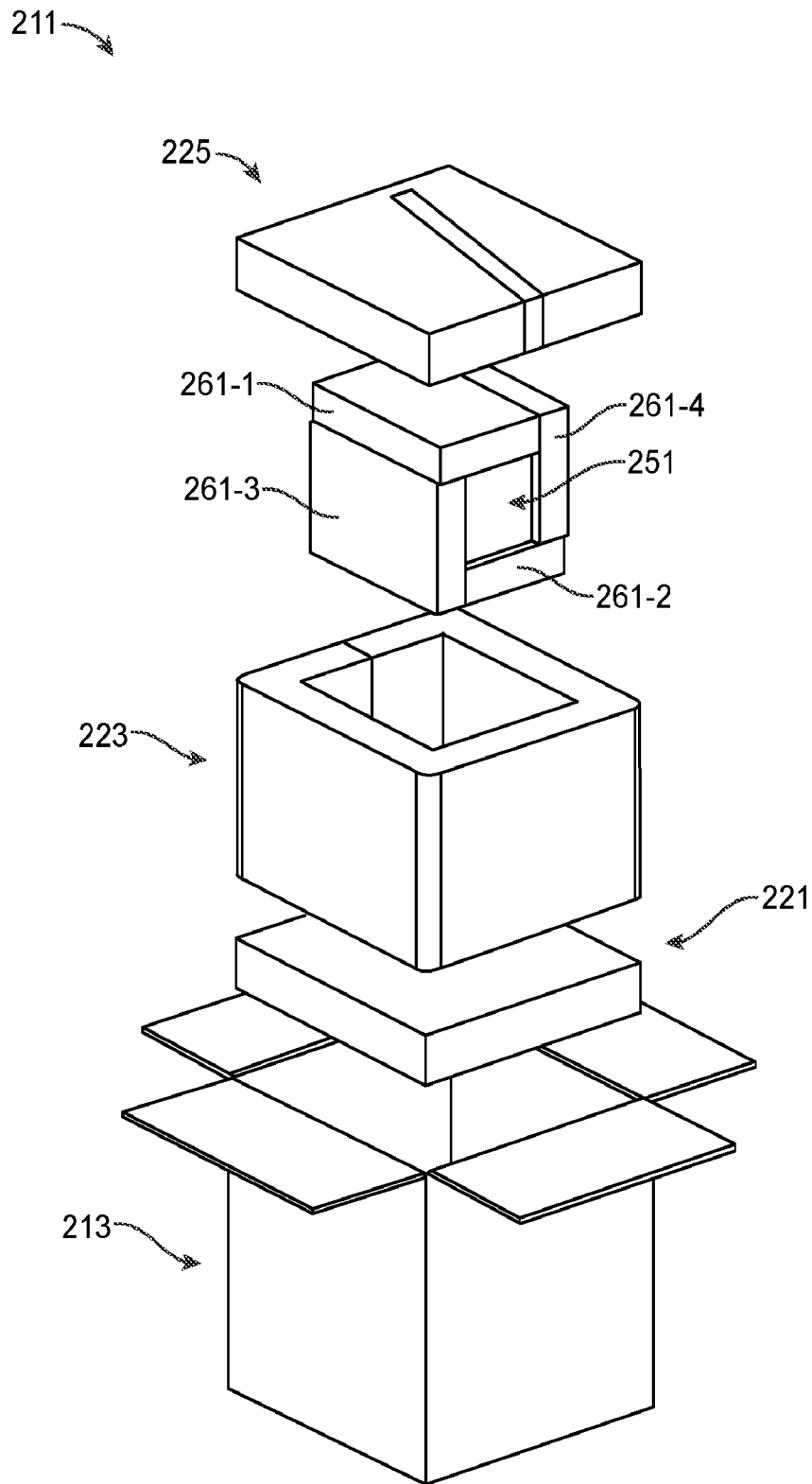


FIG. 10

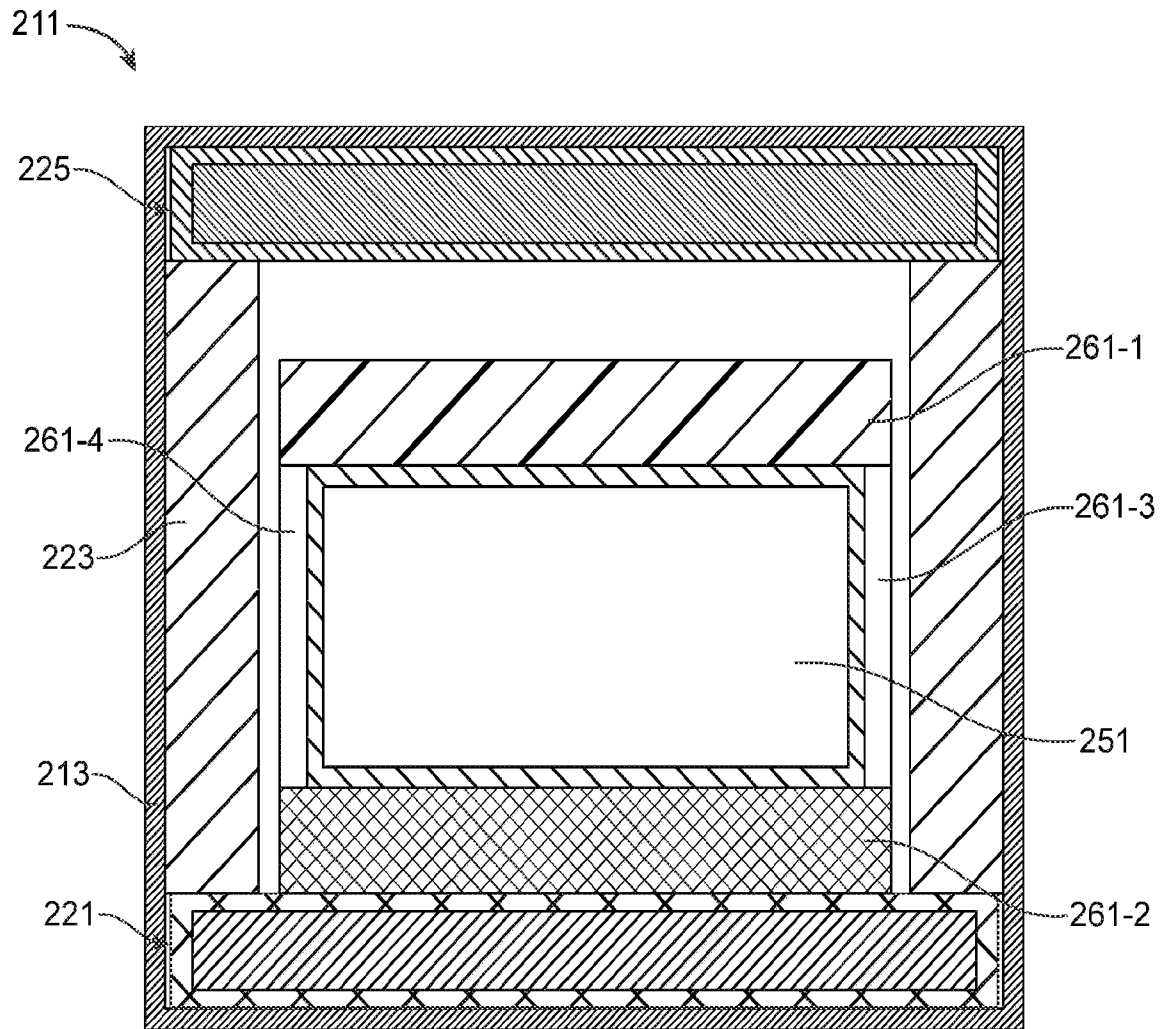


FIG. 11A

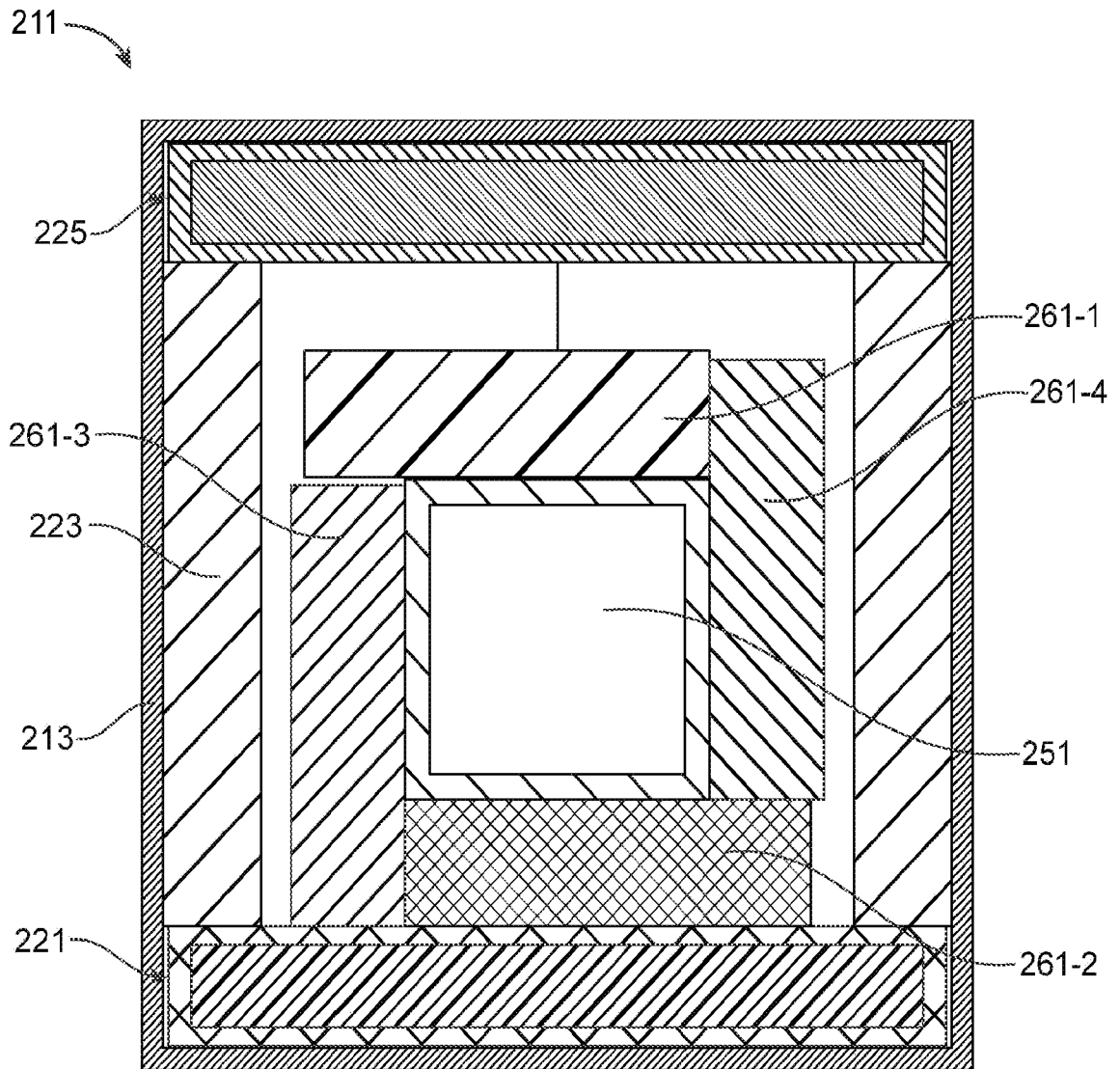


FIG. 11B

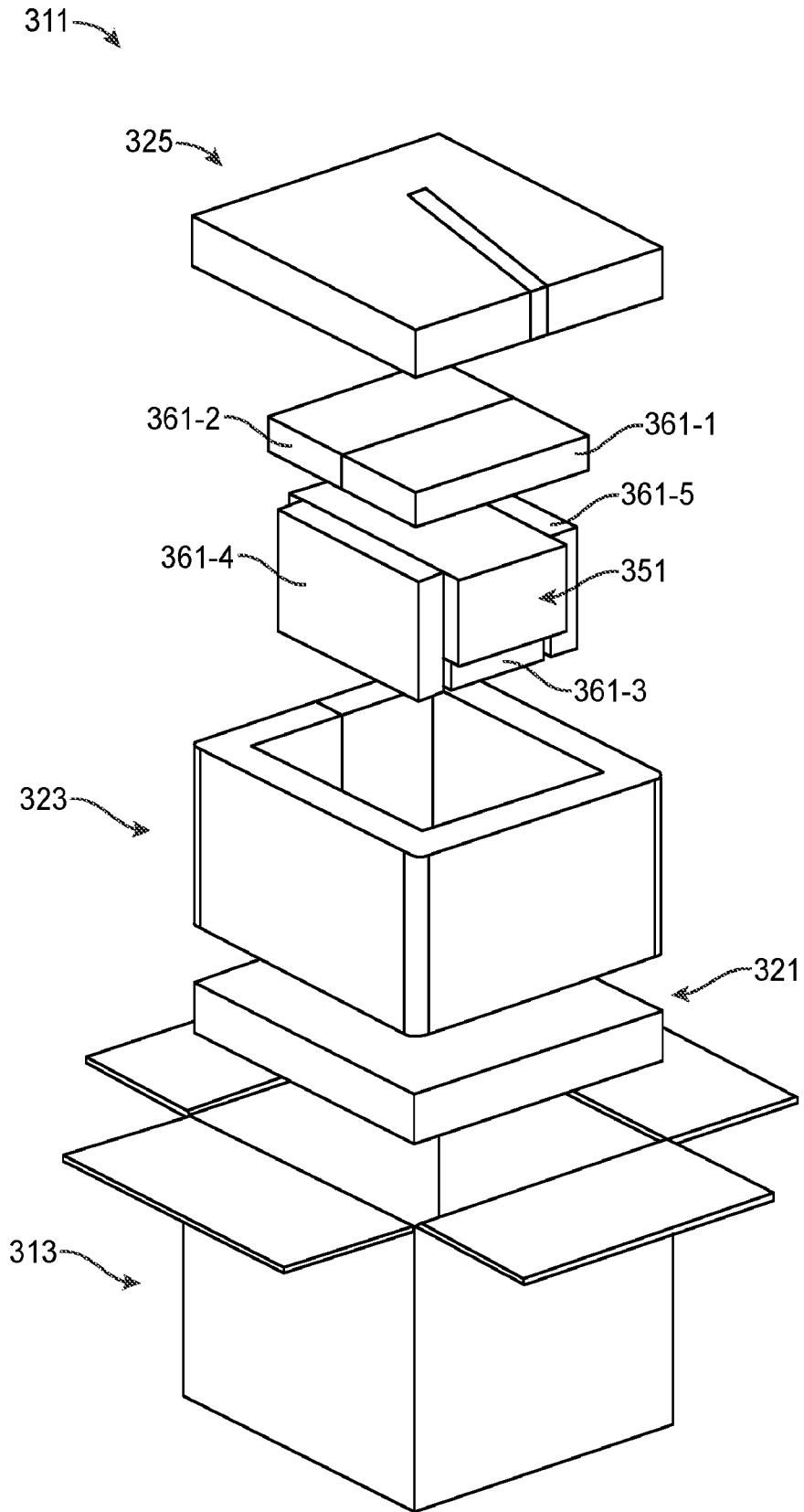


FIG. 12

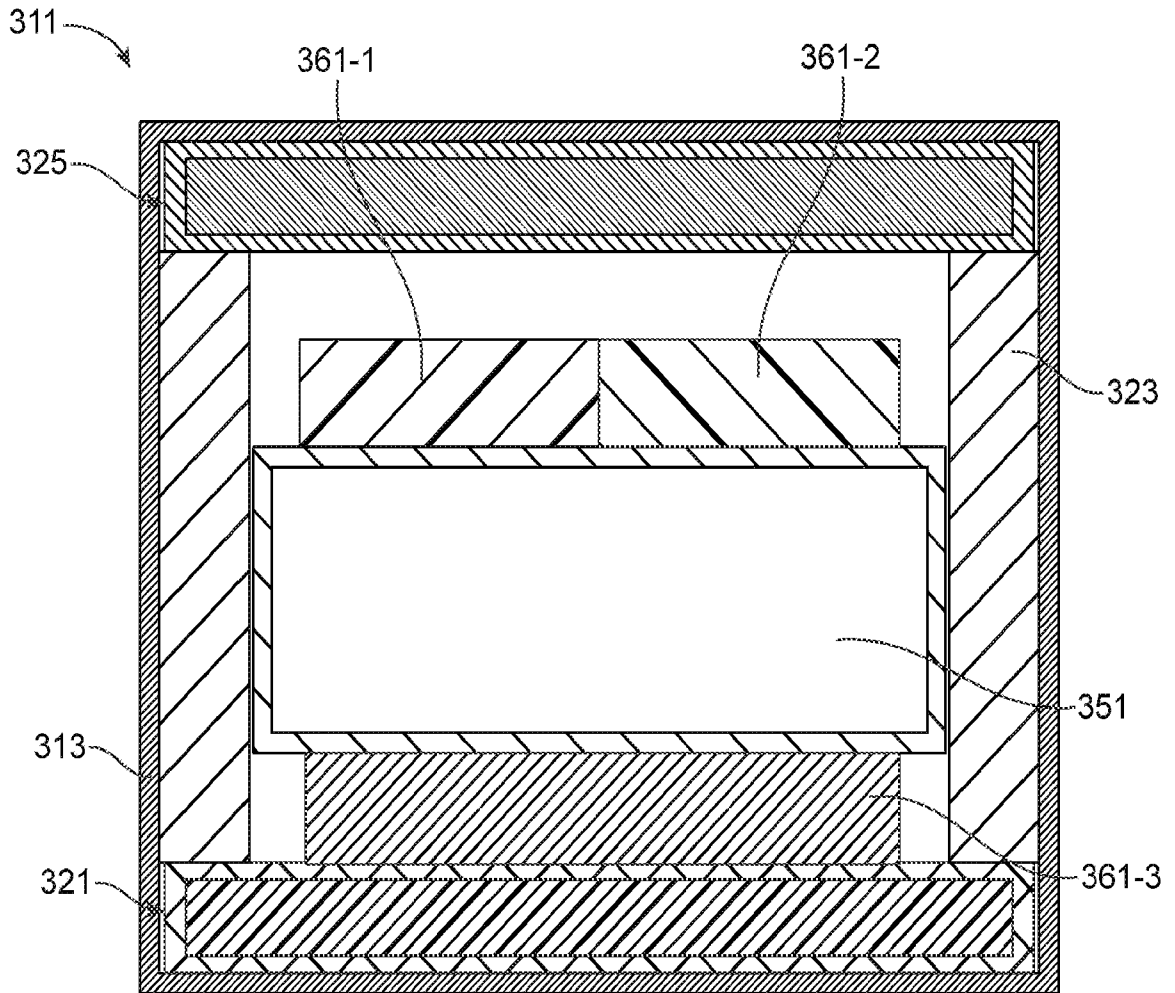


FIG. 13A

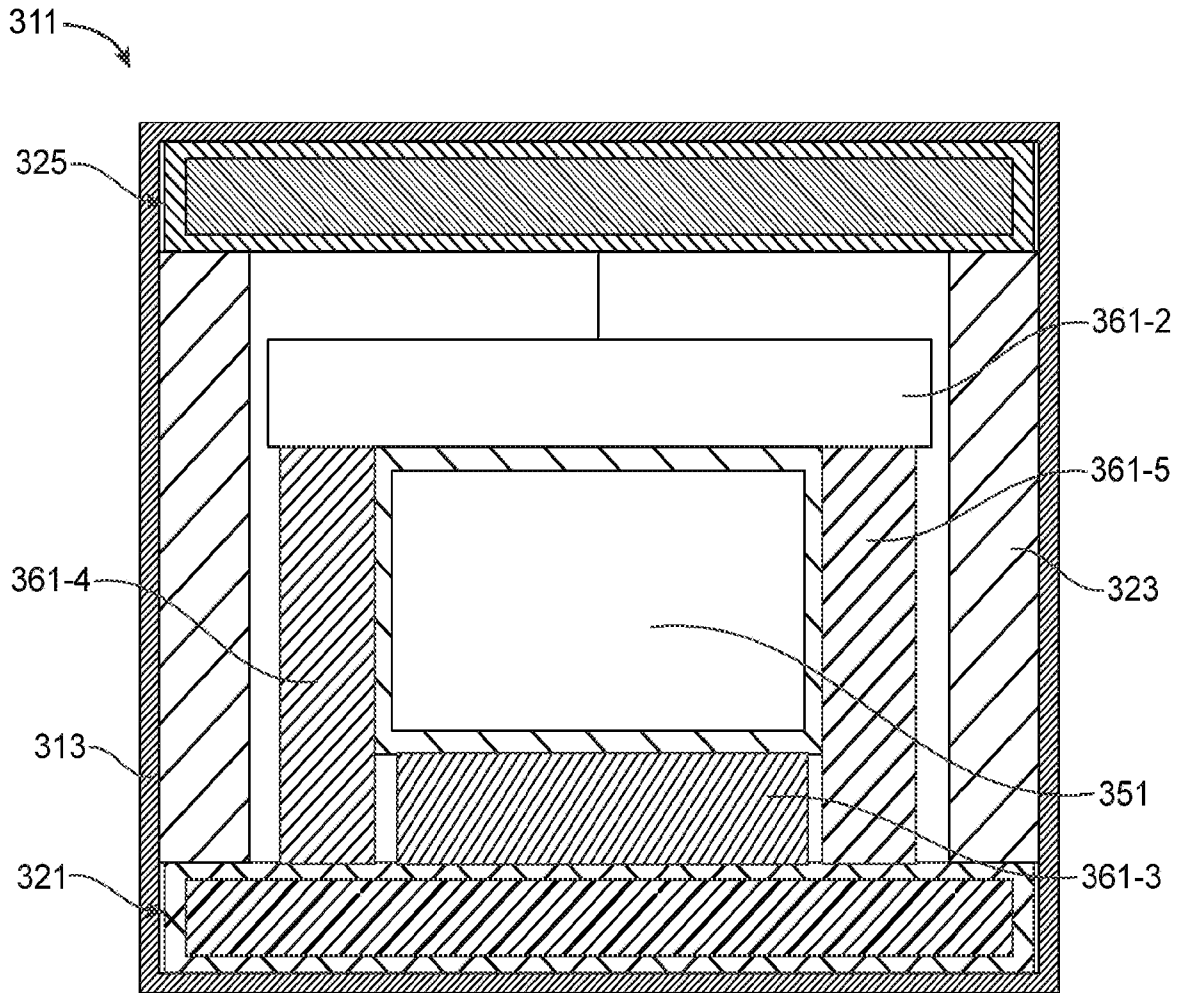


FIG. 13B

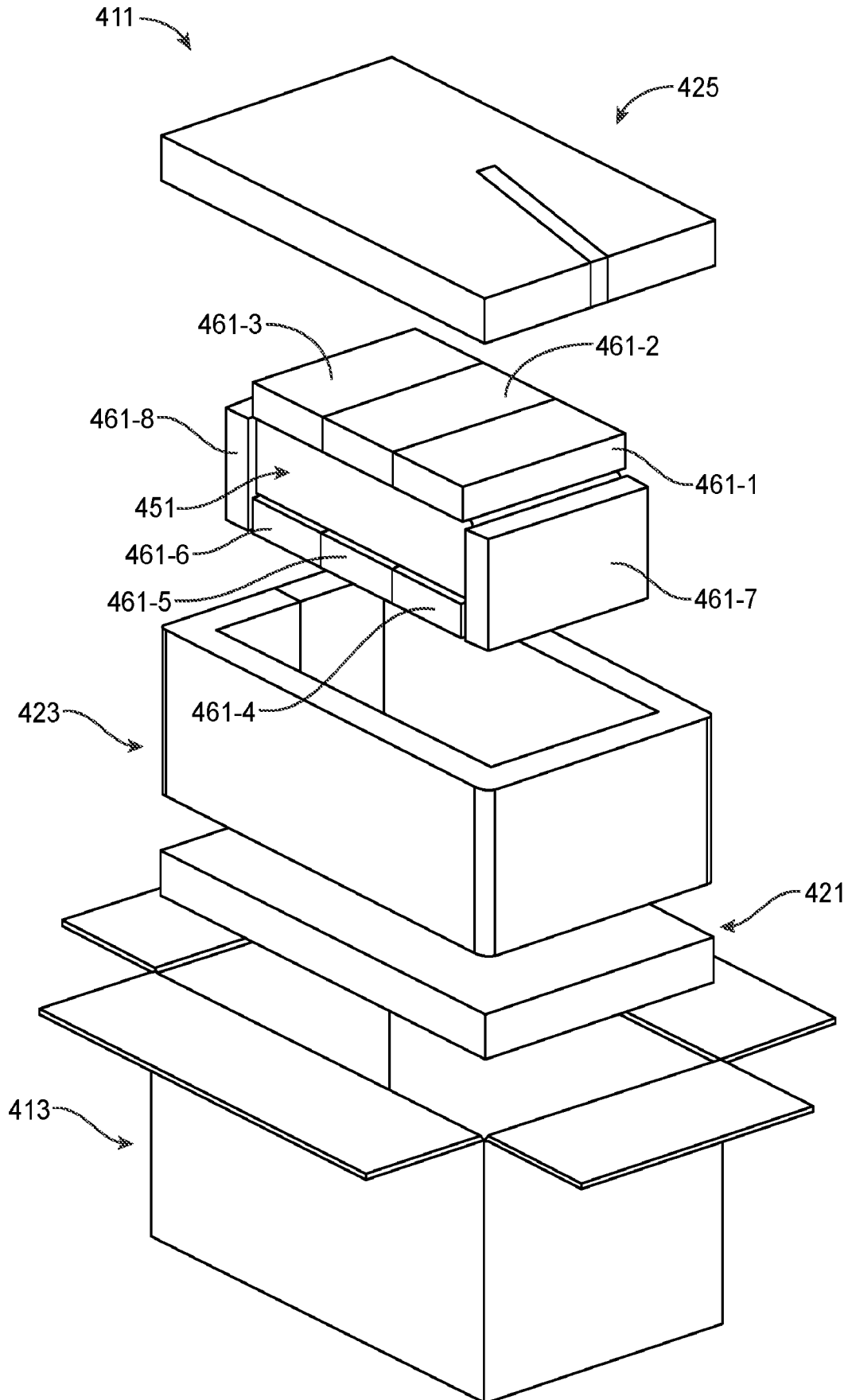


FIG. 14

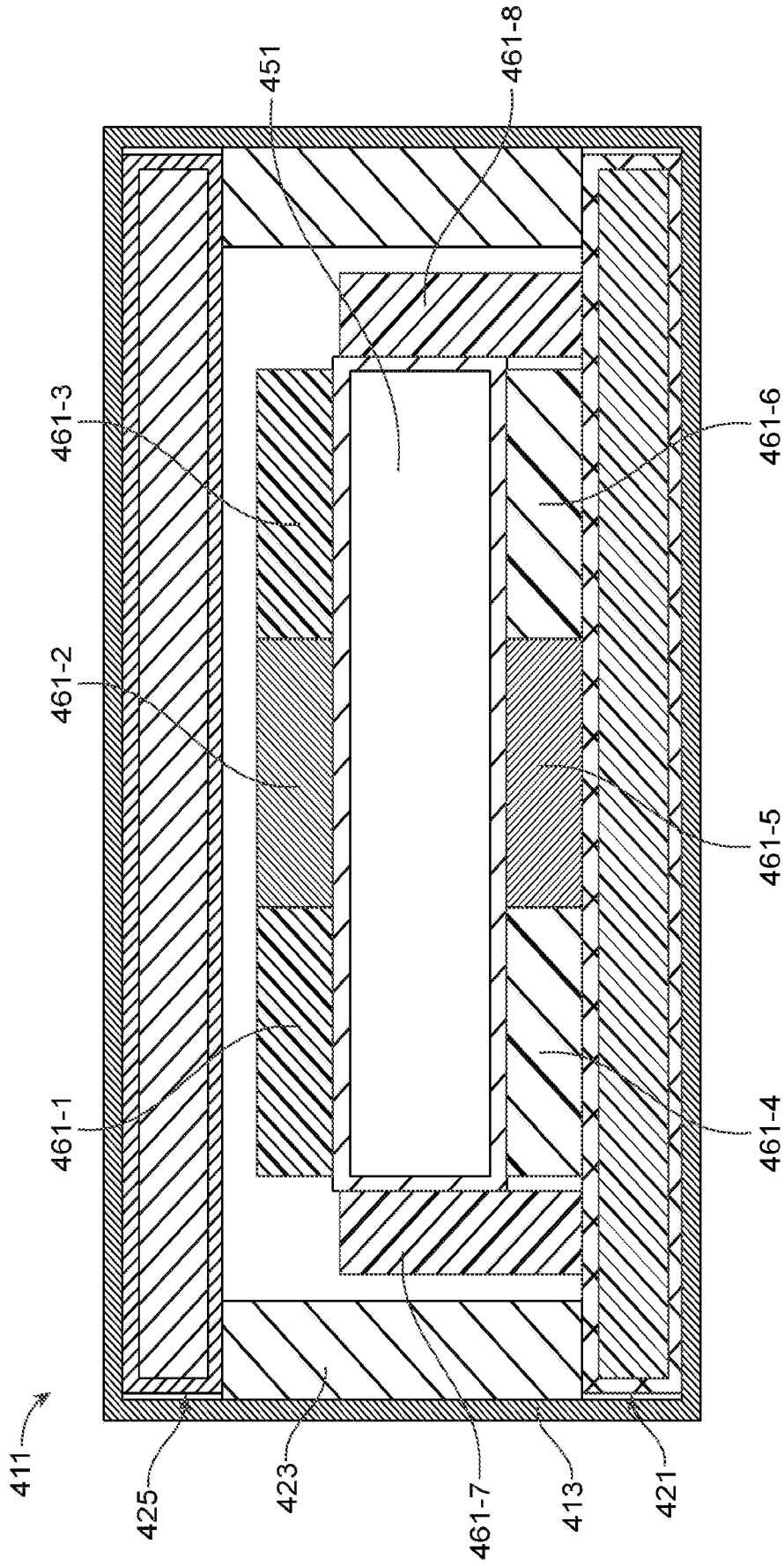


FIG. 15A

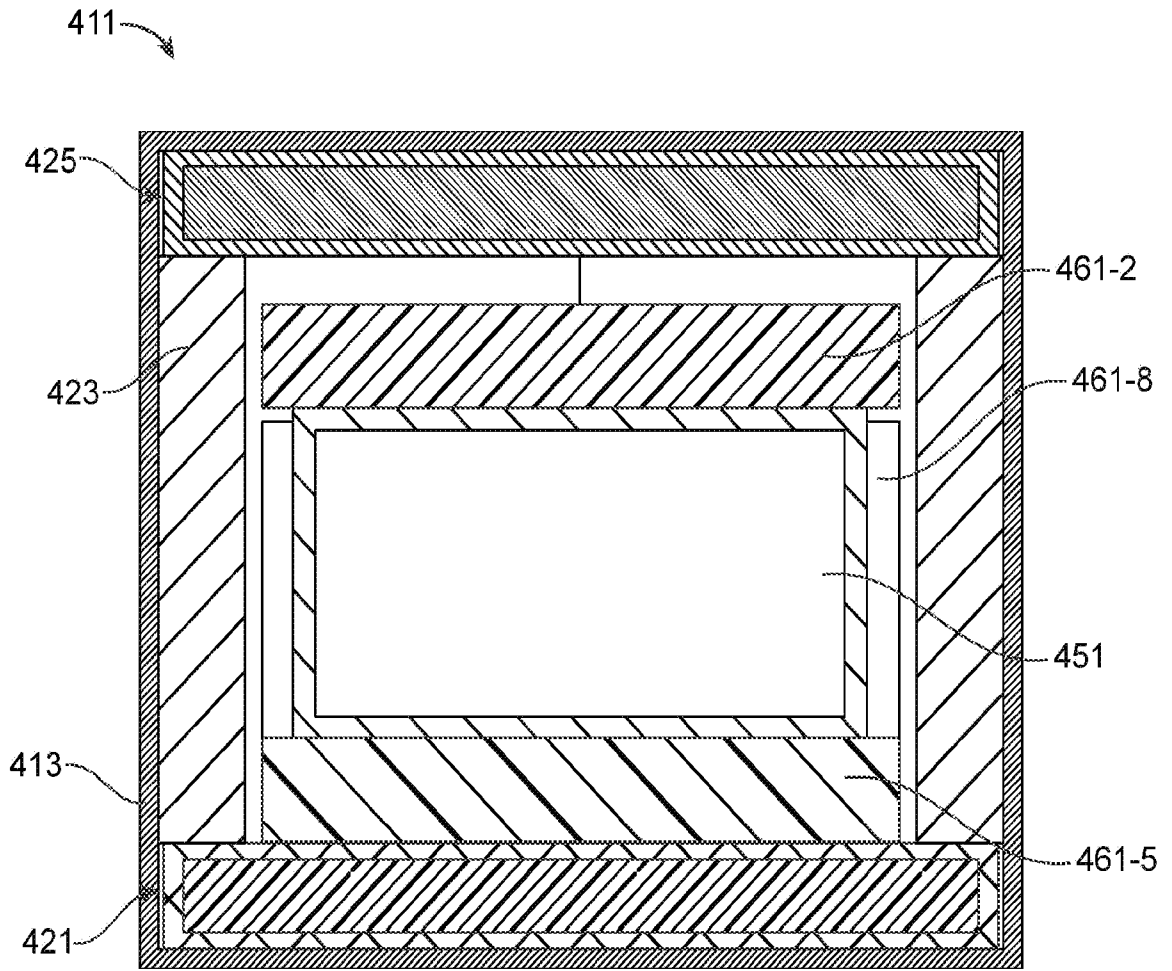


FIG. 15B