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(54) **SYSTEMS AND METHODS FOR MODULAR REFRIGERATION**

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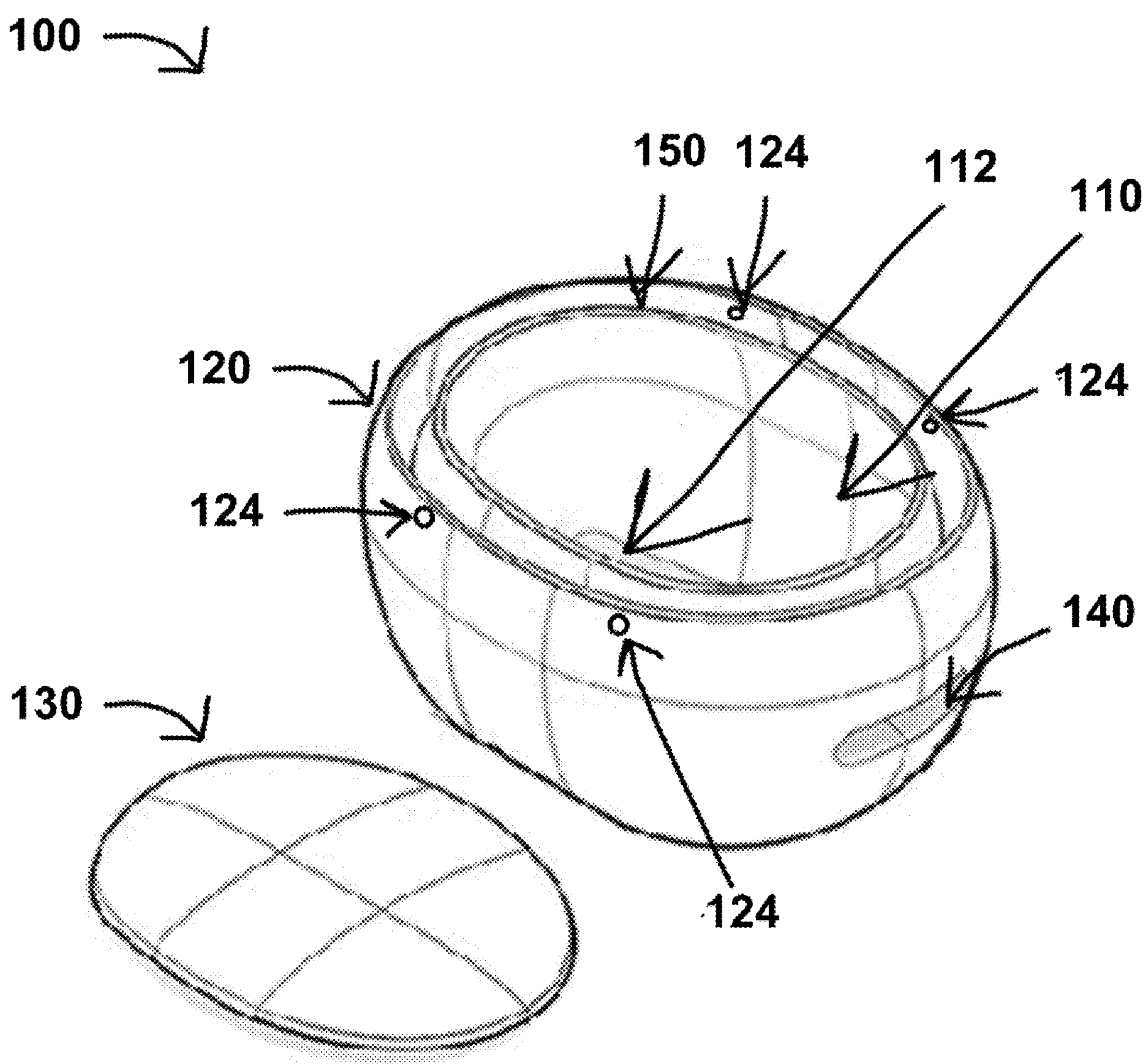
CPC ***F25D 16/00*** (2013.01); ***F25B 21/02*** (2013.01); ***F25D 1/02*** (2013.01); ***F25D 11/003*** (2013.01); *F25D 2323/00* (2013.01); *F25D 2400/14* (2013.01)

(57) **ABSTRACT**

A modular refrigeration system comprising one or more structural components configured to store food, wherein the one or more structural components comprise: an internal compartment configured to store the food; an outer vessel configured to hold the inner compartment; and a cavity formed by the internal compartment and the outer vessel and configured to hold an absorbent material, wherein the outer vessel, the internal compartment, and the absorbent material maintain the food in the internal compartment within a first predetermined temperature range.



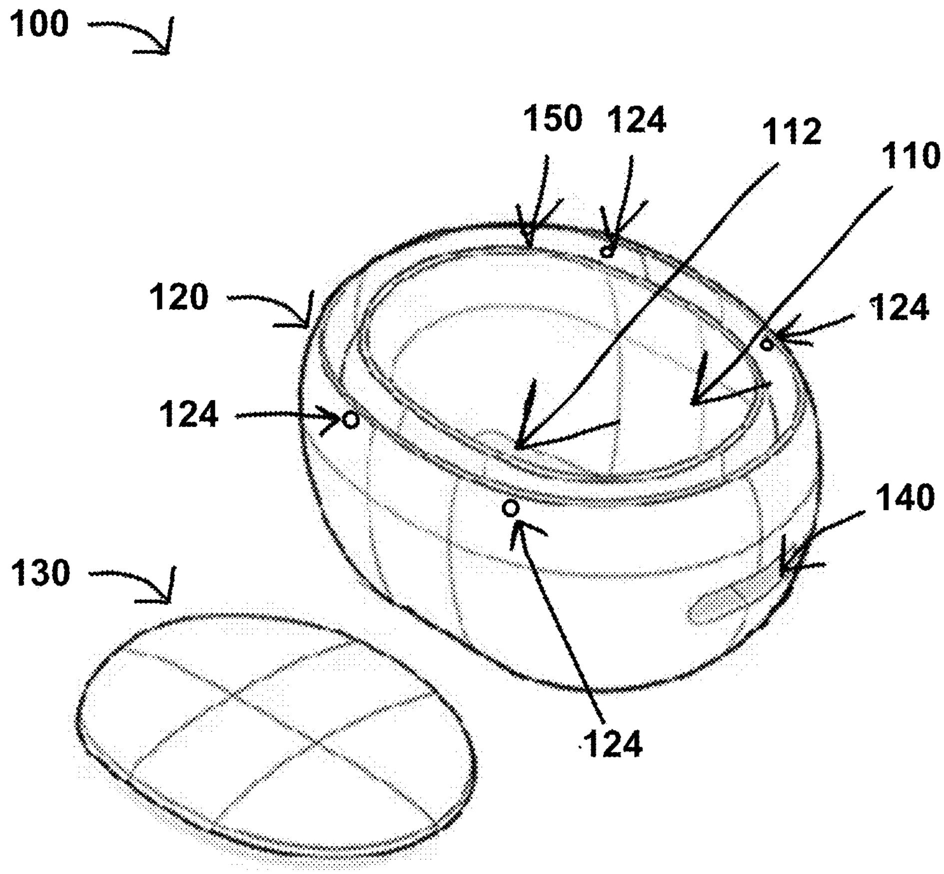


FIG. 1

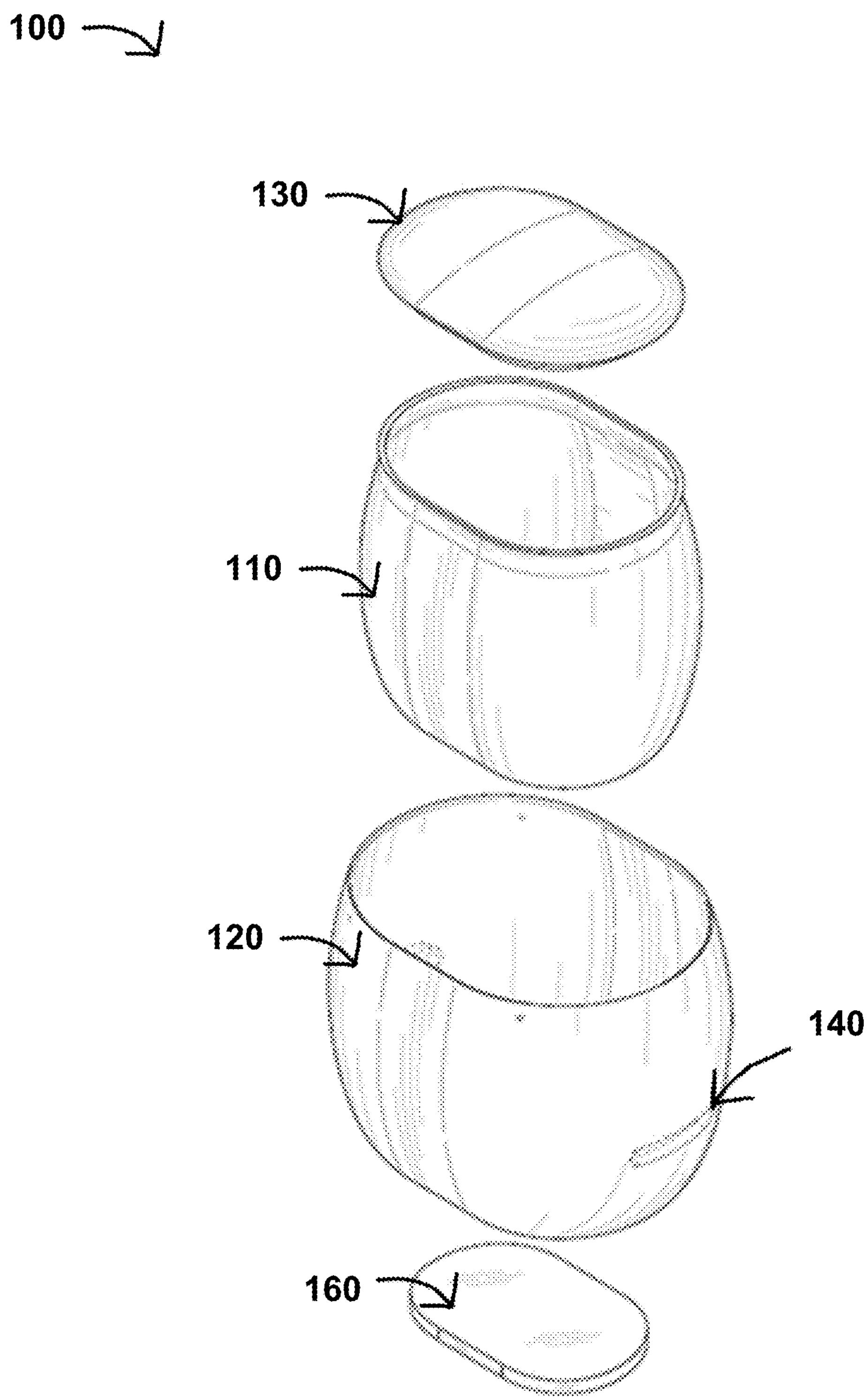


FIG. 2

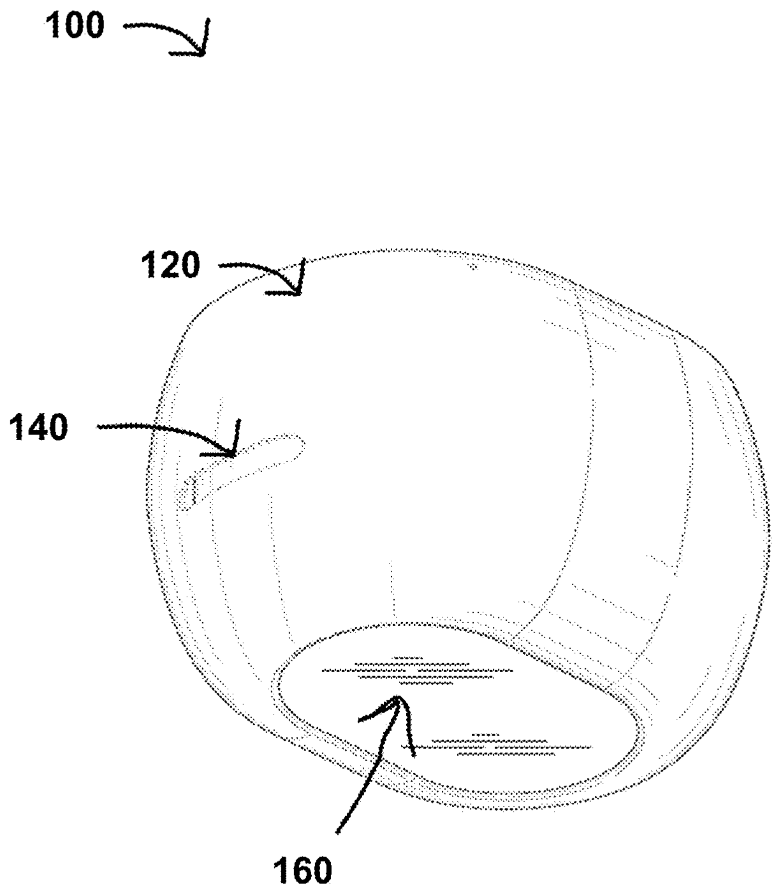


FIG. 3

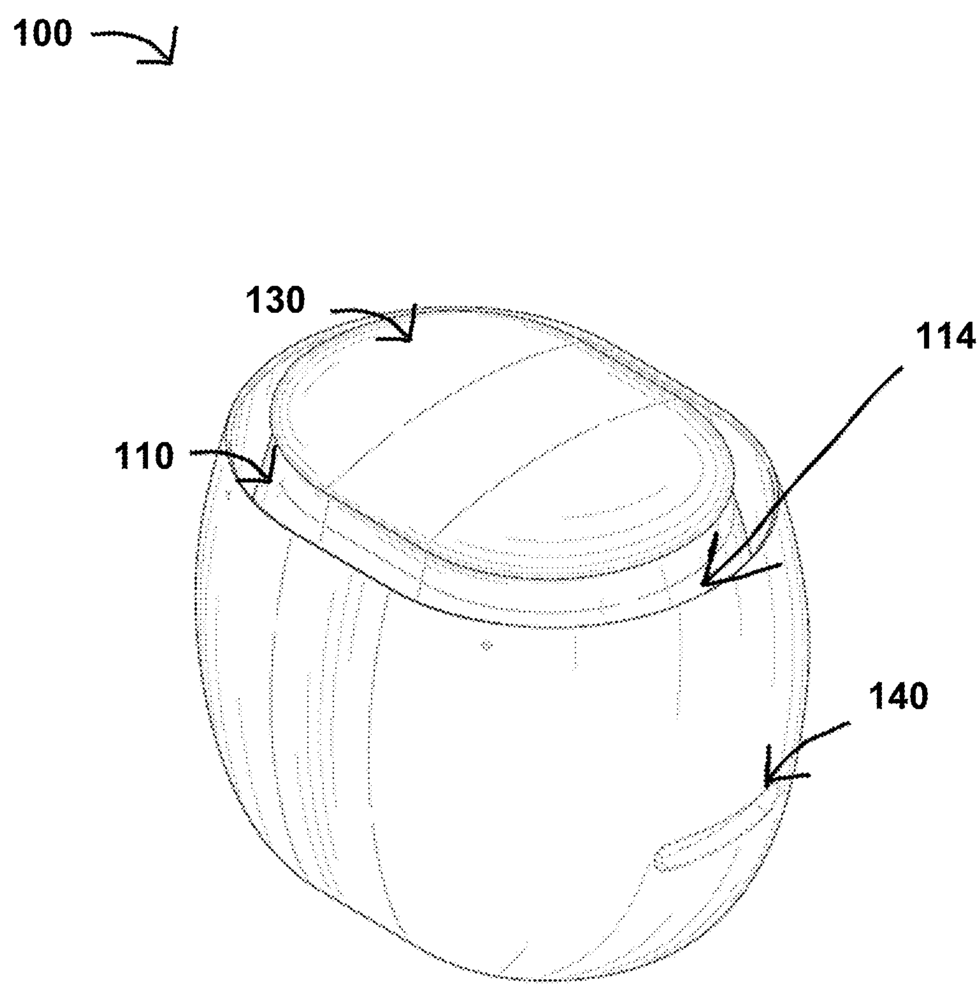


FIG. 4

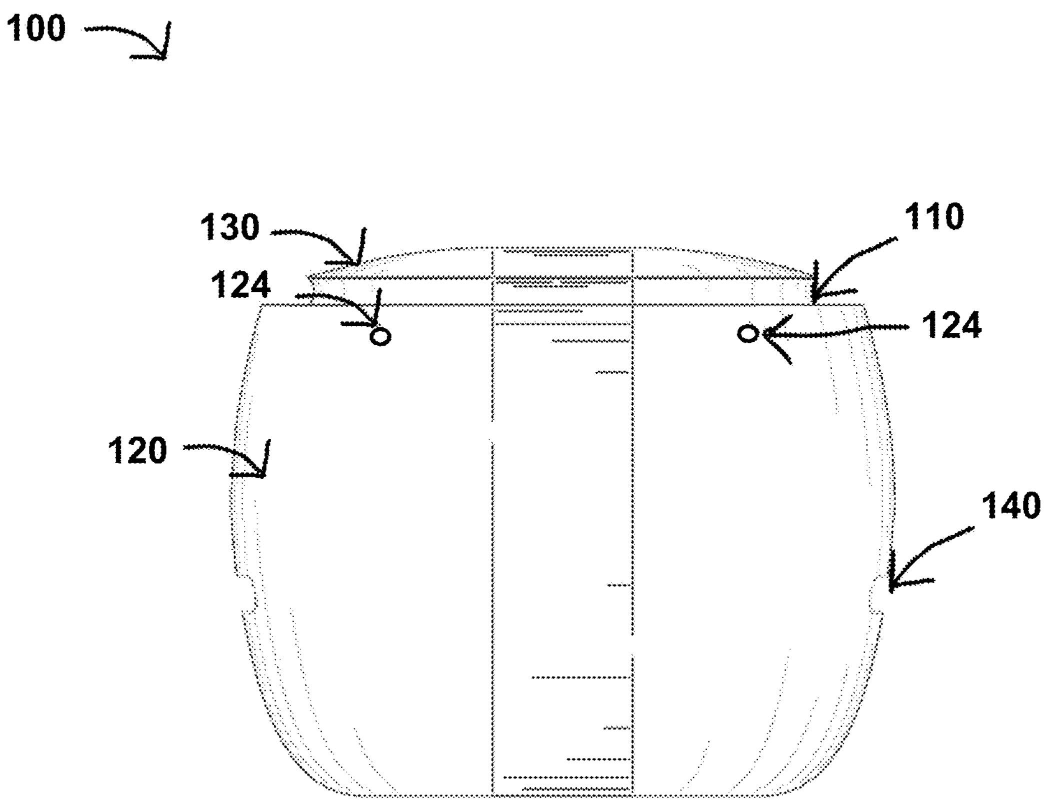


FIG. 5

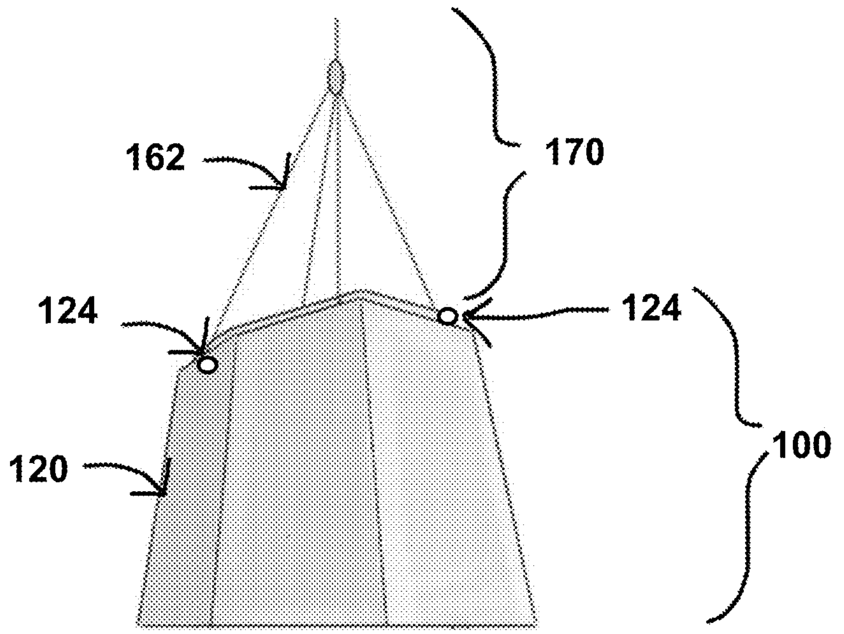


FIG. 6A

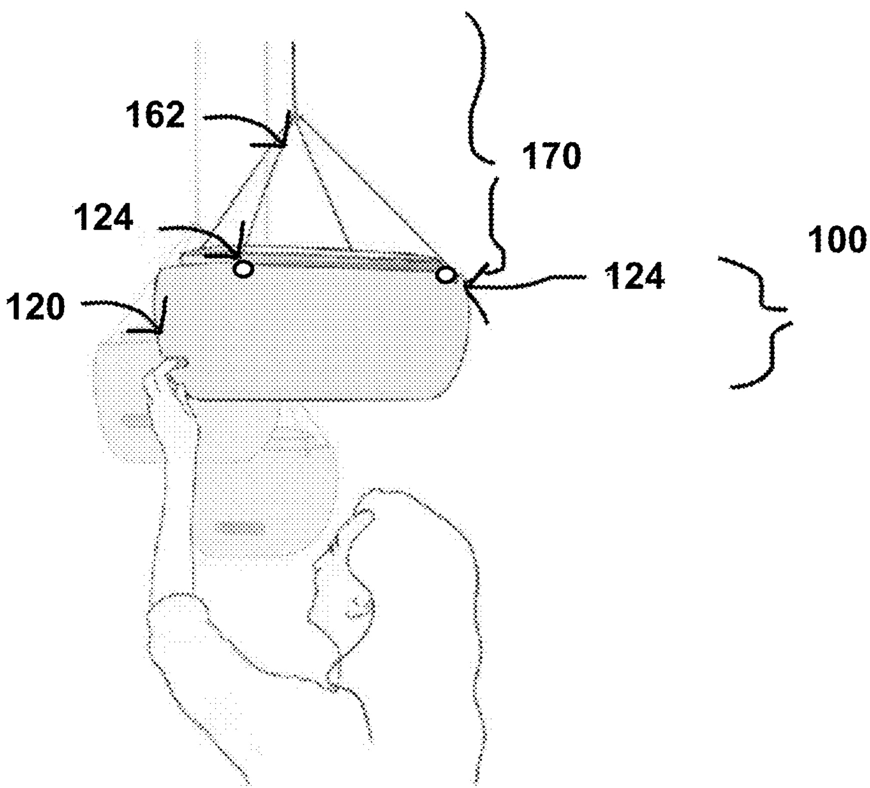


FIG. 6B

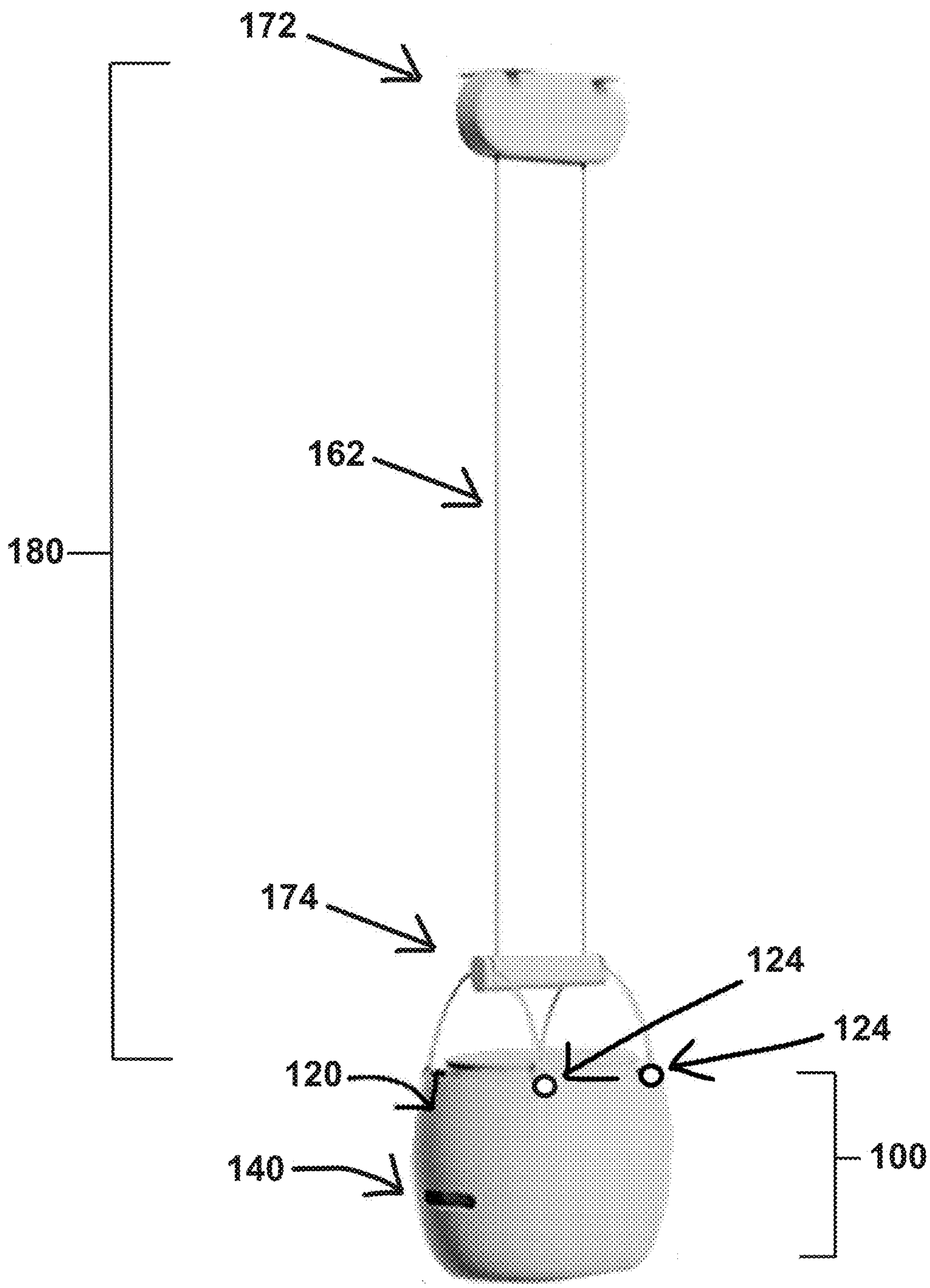


FIG. 6C

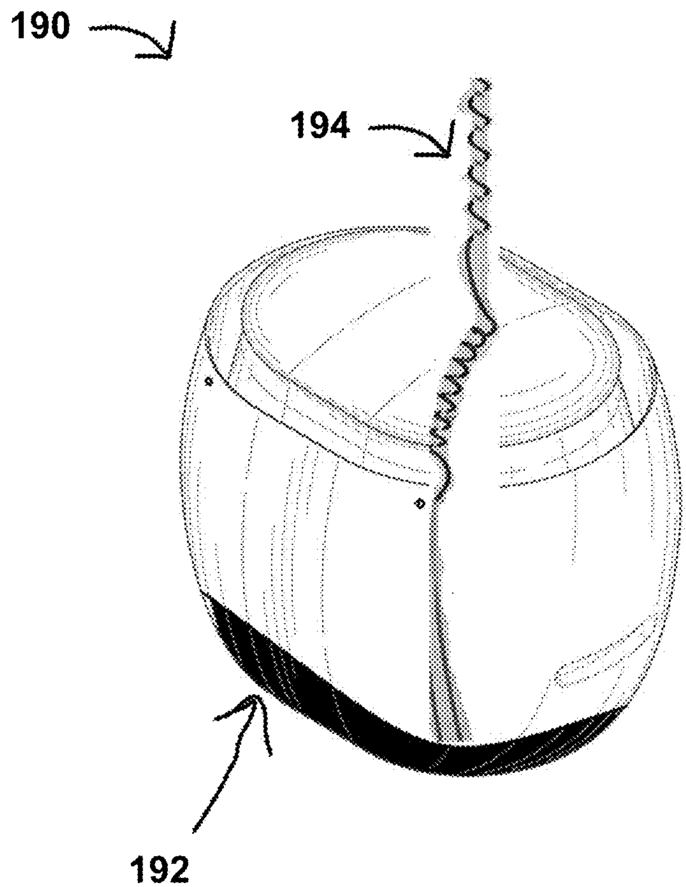


FIG. 7

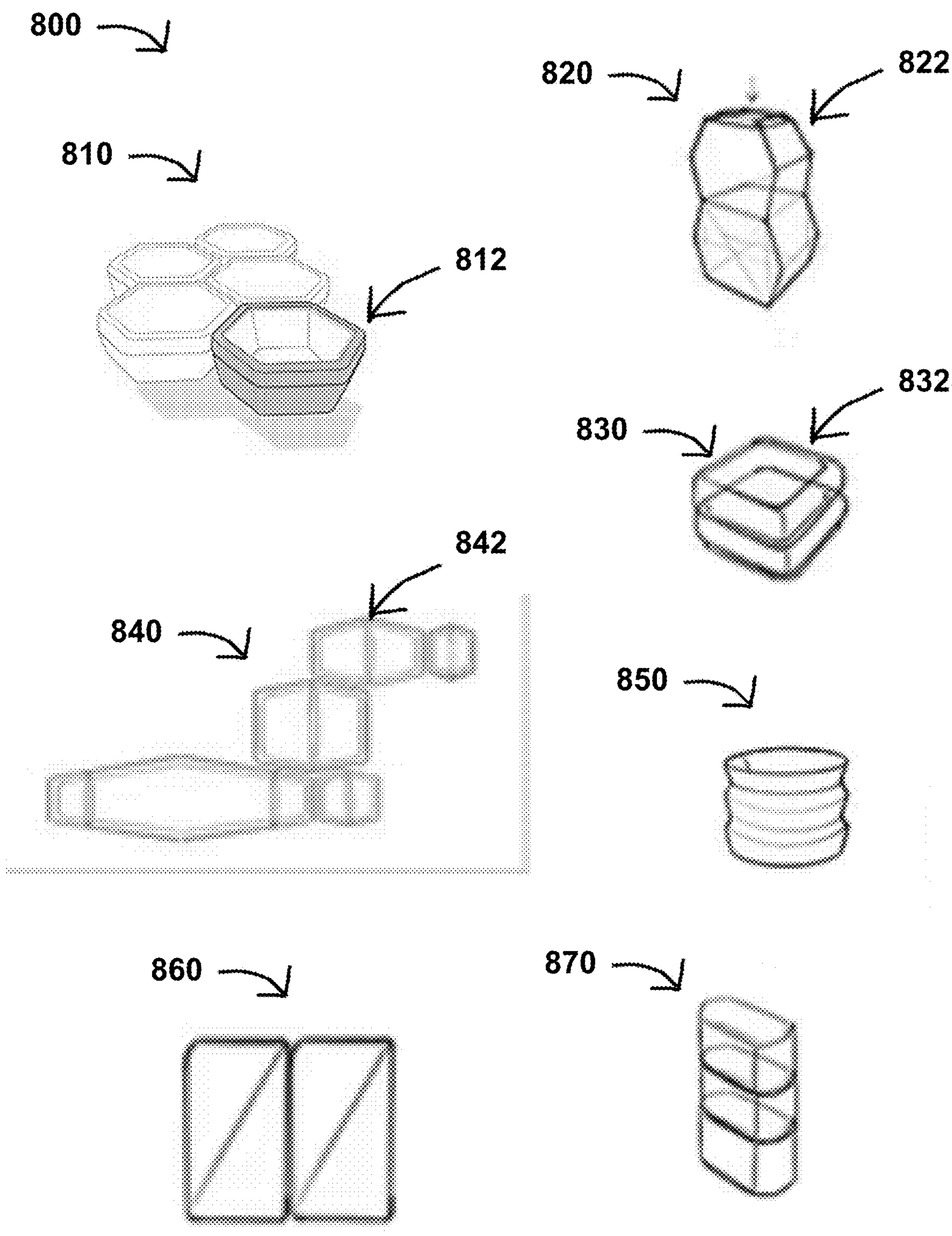


FIG. 8

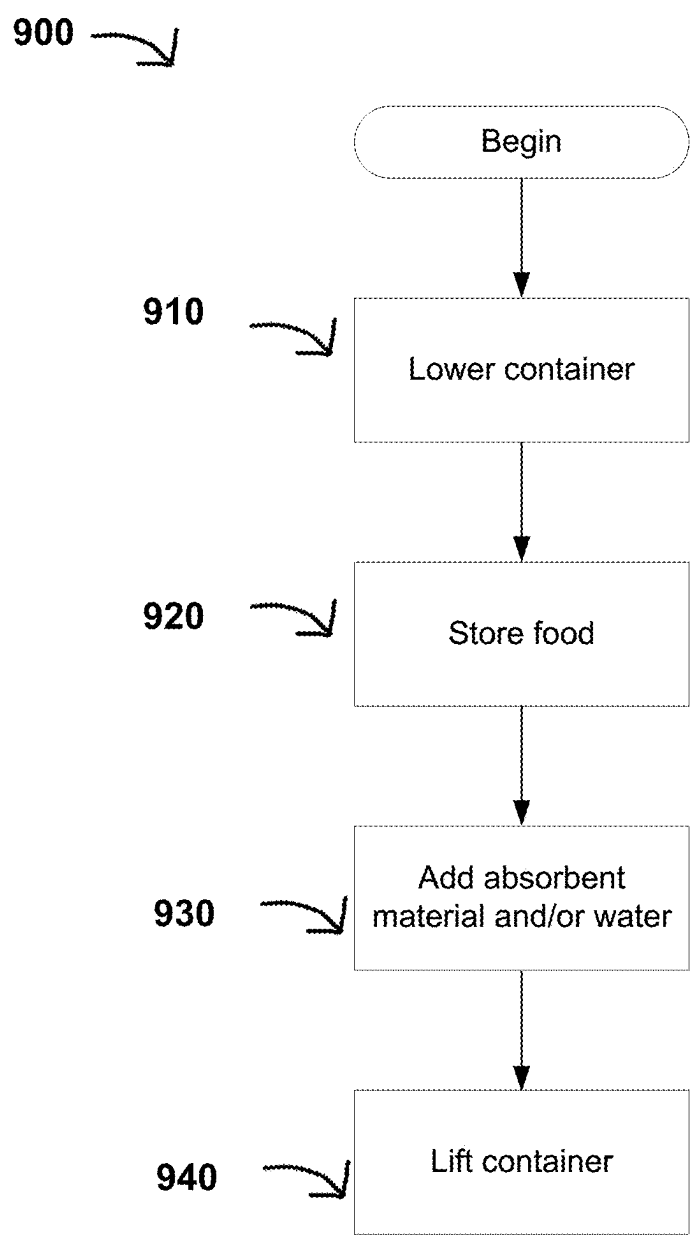

900
Begin
910
Lower container
920
Store food
930
Add absorbent material and/or water
940
Lift container

FIG. 9

SYSTEMS AND METHODS FOR MODULAR REFRIGERATION

FIELD OF DISCLOSURE

[0001] The present disclosure relates to modular refrigeration systems for the storage and preservation of perishable foods, focusing on energy efficiency, sustainability, and scalable designs. More specifically, the disclosure incorporates passive and active cooling methods and is built using natural, recyclable, and eco-friendly materials to reduce the environmental footprint of traditional refrigeration systems.

BACKGROUND

[0002] Conventional refrigeration systems rely on energy-intensive cooling methods and toxic refrigerants (e.g., HFCs, CFCs, HCFCs). These systems contribute to significant carbon emissions, energy waste, and ozone depletion. Additionally, food waste is a pressing global issue, with produce such as fruit and vegetables making up a large part of global food waste. Traditional refrigeration contributes to this problem due to inefficiency and reliance on harmful refrigerants.

[0003] Given the growing demand for energy-efficient solutions, there is a need for refrigeration systems that address food preservation and environmental concerns. The present disclosure provides modular refrigeration systems that reduce refrigerant use, and incorporate sustainable, recyclable materials, offering an energy-efficient and environmentally friendly alternative to conventional refrigeration systems.

SUMMARY

[0004] These and other features and advantages of the disclosure will be more fully understood from the following detailed description of the disclosure taken together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] These and other features, aspects, and advantages of the present disclosure will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0006] FIG. **1** illustrates a first top perspective view of an exemplary modular refrigeration system **100**, in accordance with aspects of this disclosure.

[0007] FIG. **2** illustrates a top perspective exploded view of the exemplary modular refrigeration system of FIG. **1**.

[0008] FIG. **3** illustrates a bottom perspective view of the exemplary modular refrigeration system of FIG. **1**.

[0009] FIG. **4** illustrates a second top perspective view of the exemplary modular refrigeration system of FIG. **1**.

[0010] FIG. **5** illustrates a side view of the exemplary modular refrigeration system of FIG. **1**.

[0011] FIG. **6**A illustrates a first hanging mechanism **170** for use with a modular refrigeration system such as described with regards to FIG. **1**.

[0012] FIG. **6**B illustrates the first hanging mechanism **170** for a third exemplary modular refrigeration system such as described with regards to FIG. **1**.

[0013] FIG. **6**C illustrates a second hanging mechanism **180** for a third exemplary modular refrigeration system such as described with regards to FIG. **1**.

[0014] FIG. **7** illustrates exemplary refrigeration mechanisms of the exemplary modular refrigeration system such as described with regards to FIG. **1**.

[0015] FIG. **8** illustrates exemplary configurations using modular refrigeration systems.

[0016] FIG. **9** illustrates a flow chart with exemplary steps of how the modular refrigeration system of FIG. **1** may be utilized.

[0017] Although the system of FIGS. **1-9** is illustrated with one or more particular shapes, materials, colors, and/or arrangement of included components, one of ordinary skill in the art would appreciate that different shapes, materials, colors, and/or arrangement of components is considered within the scope of the present disclosure.

[0018] The figures are not necessarily to scale. Where appropriate, similar or identical reference numbers are used to refer to similar or identical components.

DETAILED DESCRIPTION

[0019] The present disclosure generally describes systems and methods for a modular refrigeration system, and more particularly, to systems and methods for modular refrigeration for food preservation, including energy efficient and sustainable passive and active cooling mechanisms.

[0020] An example system comprising modular refrigeration for storing and keeping food cool, wherein one or more structural components are configured for cooling and storing the food. For instance, one or more characteristics of the one or more structural components are configured to cool based on a shape, a selected material, and/or arrangement of the one or more structural components relative to another structural component or an arrangement of one or more structural components. Additionally, other cooling elements may be included in order to store the food at certain temperatures and/or ranges of temperatures.

[0021] Aspects of the present disclosure provides a modular and customizable design. The refrigeration system is made up of individual, interchangeable structural components that can be configured in various ways to meet specific storage needs. The system can be easily expanded, reduced, or rearranged based on space and food storage requirements, making it adaptable for both home and commercial use.

[0022] Disclosed example refrigeration systems provide advanced cooling technologies by integrating both passive cooling, such as evaporative cooling (e.g., Zeer pot), and active cooling via thermoelectric (Peltier) devices, offering optimal storage conditions for different perishable foods. In some aspects, evaporative cooling provides a sustainable method of cooling stored food using a combination of wet cloths, absorbent materials, and outer/inner pot configurations. Additional aspects of the present disclosure actively cool food by using electric current to transfer heat, reducing energy use compared to conventional refrigeration systems and without utilizing harmful refrigerants.

[0023] In some aspects, disclosed components of the disclosed example refrigeration systems are made from natural, recyclable, and biodegradable materials. This reduces environmental impact by eliminating the need for harmful refrigerants and reducing the carbon footprint of traditional refrigeration methods. Disclosed example refrigeration systems feature temperature and humidity regulation for different types of food. Temperature ranges may be maintained from 32° F. to 40° F. for most vegetables, and above 40° F. for other produce. Humidity may also be adjusted for optimal food preservation, with higher humidity for root vegetables and lower humidity for other produce.

[0024] Disclosed modular refrigeration systems include one or more structural components configured to store food, wherein the one or more structural components include an internal compartment configured to store the food, an outer vessel configured to hold the internal compartment, and a cavity formed by the internal compartment and the outer vessel and configured to hold an absorbent material, wherein the outer vessel, the internal compartment, and the absorbent material maintain the food in the internal compartment within a first predetermined temperature range.

[0025] In some aspects, the disclosed modular refrigeration systems include a thermoelectric cooler, wherein the internal compartment, the outer vessel, the absorbent material, and the thermoelectric cooler maintain the food in the internal compartment within a second predetermined temperature range. In some aspects, the thermoelectric cooler is a Peltier device. In some aspects, the first predetermined temperature range is above 40° F. In some aspects, the second predetermined temperature range is approximately 32° F. to 40° F.

[0026] In some aspects, the one or more structural components are made from natural, recyclable, or biodegradable materials. In some aspects, the internal compartment comprises a bottom portion and the outer vessel include a base portion, and wherein the bottom portion and the base portion are transparent and configured to allow the food in the internal compartment to be visible. In some aspects, the modular refrigeration systems include humidity control features to regulate moisture levels appropriate for different types of food. In some aspects, the modular refrigeration systems eliminate use of refrigerants.

[0027] In some example modular refrigeration systems, the modular refrigeration system is configured to be arranged with a second modular refrigeration system. In some aspects, the arrangement is stacking of the modular refrigeration system with the second modular refrigeration system.

[0028] In some aspects, the modular refrigeration systems include a hanging mechanism attached to the outer vessel, wherein the hanging mechanism is configured to suspend the modular refrigeration system. In some aspects, the modular refrigeration systems include a lifting mechanism configured to lift and lower the modular refrigeration system in order to suspend the modular refrigeration system. In some aspects, the outer vessel of disclosed modular refrigeration systems includes a gripping mechanism for handling the modular refrigeration systems.

[0029] As used herein, the terms "first" and "second" may be used to enumerate different components or elements of the same type, and do not necessarily imply any particular order.

[0030] As used herein, the words "exemplary" and "example" mean "serving as an example, instance, or illustration." The examples described herein are not limiting, but rather are exemplary only. It should be understood that the described examples are not necessarily to be construed as preferred or advantageous over other examples. Moreover, the terms "examples of the invention," "examples," or "invention" do not require that all examples of the invention include the discussed feature, advantage, or mode of operation.

[0031] As utilized herein, "and/or" means any one or more of the items in the list joined by "and/or". As an example, "x and/or y" means any element of the three-element set {(x), (y), (x, y)}. In other words, "x and/or y" means "one or both of x and y". As another example, "x, y, and/or z" means any element of the seven-element set {(x), (y), (z), (x, y), (x, z), (y, z), (x, y, z)}. In other words, "x, y and/or z" means "one or more of x, y and z". As utilized herein, the term "exemplary" means serving as a non-limiting example, instance, or illustration. As utilized herein, the terms "e.g.," and "for example" set off lists of one or more non-limiting examples, instances, or illustrations. As utilized herein, circuitry is "operable" to perform a function whenever the circuitry comprises the necessary hardware and code (if any is necessary) to perform the function, regardless of whether performance of the function is disabled or not enabled (e.g., by a user-configurable setting, factory trim, etc.).

[0032] FIG. **1** illustrates a first top perspective view of an exemplary modular refrigeration system **100**, in accordance with aspects of this disclosure. FIG. **2** illustrates a top perspective exploded view of the exemplary modular refrigeration system of FIG.

[0033] **1**. The modular refrigeration system **100** may store produce, such as fruits and vegetables, and includes an internal compartment **110** and an outer vessel **120**. The modular refrigeration system **100** may also include a cover **130** and one or more handles or gripping mechanisms **140**.

[0034] The internal compartment **110** and outer vessel **120** may be a container, vessel, canister, pot, box, receptacle, etc. Although the internal compartment **110** and outer vessel **120** are illustrated as elliptical or oblong, the internal compartment **110** and outer vessel **120** may be circular, rectangular, square, triangular, cylindrical, cubical, polygonal, or any other shaped container. The internal compartment **110** and outer vessel **120** may be made from natural materials like clay, biodegradable plastics, wood, and/or other materials with similar thermal properties and environmental sustainability. In some examples, the internal compartment **110** may be made of natural clay, and the outer vessel **120** may be made of fired clay. In some examples, the internal compartment **110** and/or the outer vessel **120** are made of one or more of the above materials. The internal compartment **110** is used to store produce or perishables, such as fruit and vegetables but may also be used to store other types of food or consumables.

[0035] In some examples, the internal compartment **110** may include a bottom **112** that is constructed of a transparent material, such as glass, biodegradable plastic, etc., as non-limiting examples. In some examples, the cover **130** may also be made from natural materials like clay, biodegradable plastics, wood, or other similar materials. The gripping mechanism **140** may be an opening as shown, or may be a handle, knob, or other similar mechanism on the outer vessel **120** that may be used to grasp the modular refrigeration system **100**.

[0036] The modular refrigeration system **100** may be hung, placed on a surface, etc. The modular refrigeration system **100** may be stackable, arranged with other modular refrigeration systems, etc. In some examples, the outer vessel **120** includes openings **124** that may be used to hang the modular refrigeration system **120** using metal wire, nylon, rope, string, fishing line, etc., as non-limiting examples. In some examples, the outer vessel **120** may include four openings **124**; however, fewer or more openings may be used, depending on the gauge of the wire and the weight of the modular refrigeration system **100**. The outer vessel **120** and internal compartment **110** form a cavity **150** which may be filled with an absorbent material, such as sand, soil, gravel, sawdust, perlite, sponges, fabric, rice husks, straw, vermiculite, or other similar clean, non-toxic material with similar water absorption and evaporation properties. The absorbent material may be filled with water for evaporative cooling of the food.

[0037] FIG. **3** illustrates a bottom perspective view of the exemplary modular refrigeration system **100** of FIG. **1**. Similar to the bottom **112** of the internal compartment **110**, the base **160** of the outer vessel **120** may be constructed of a transparent material, such as glass, biodegradable plastic, etc., as non-limiting examples. In some other examples, the base **160** of the outer vessel is not transparent and may be made of a same material as the outer vessel **160**.

[0038] FIG. **4** illustrates a second top perspective view of the exemplary modular refrigeration system of FIG. **1** with the cover **130** secured in place. FIG. **5** illustrates a side view of the exemplary modular refrigeration system of FIG. **1** with the cover secured in place. The cover **130** may be constructed to fit over the internal compartment **110**. In some examples, the cover **130** aligns with the internal compartment **110** and a lip on an underside of the cover (not shown) fits within the internal compartment **110** so that the lip abuts an inside of the internal compartment **110**. Additionally or alternatively, the cover **130** may include an edge that extends past one or more sidewalls **114** of the internal compartment **110**. As illustrated in FIG. **5**, the internal compartment **110** may be higher relative to the outer vessel **120** when placed within the outer vessel **120**.

[0039] FIG. **6**A illustrates a first hanging mechanism **170** for a modular refrigeration system, such as described in FIG. **1**. FIG. **6**B illustrates the first hanging mechanism **170** for an exemplary modular refrigeration system, such as described in FIG. **1**. FIG. **6**C illustrates a second hanging mechanism **180** for an exemplary modular refrigeration system, such as described in FIG. **1**. In some examples, the modular refrigeration system **100** is hung in an area, such as a pantry, kitchen, etc. The outer vessel **120** may include openings **124** as described above, through which wire **162** or another similar material may be inserted to suspend the modular refrigeration system **100** from a ceiling, cabinet, etc. A lifting mechanism **172** may be fastened to the ceiling and may allow the wire **162** to be pulled through in order to lower or lift the modular refrigeration system **100**. In some examples, the lifting mechanism **172** may be a pulley system and/or a retractable cable reel with a butterfly anchor, toggle bolt, or other similar attaching and/or locking device that allows the modular refrigeration system to be lifted, lowered, and suspended in place at a desired height. Although a lifting mechanism is not shown in FIGS. **6**A and **6**B, a lifting mechanism may also be used in conjunction with the first hanging mechanism.

[0040] In some examples, the modular refrigeration system **100** may include a handle **174**, rod, or other similar mechanism, which may be attached to the wire **162** from the pulley in order to help balance the modular refrigeration system **100** while the modular refrigeration system **100** is suspended. The modular refrigeration system **100** may be lifted to a height desired in order to be able to view the contents of the inner compartment **110**.

[0041] FIG. **7** illustrates exemplary refrigeration mechanisms of the exemplary modular refrigeration system of FIG. **1**. The modular refrigeration system **100** may include refrigeration mechanisms that include active cooling and/or passive cooling. For example, the modular refrigeration system **100** includes a passive cooling using the internal compartment **110**, the cavity **150**, and the outer vessel which form a passive cooling refrigeration mechanism as described above in FIG. **1**. In some examples, the modular refrigeration system **100** may also include an active cooling mechanism **190**. For example, the active cooling mechanism **190** may include a thermoelectric cooler **192**, such as a Peltier or other similar device to provide active cooling of produce. In some examples, the active cooling mechanism may include wiring **194** which may be low voltage wiring from the thermoelectric cooler **192** to a power source. In some examples, alternative power sources, such as a battery, wireless power, or other power source may be provided. In some examples, a switch (not shown) may be used to power on the thermoelectric cooler **192**.

[0042] The modular refrigeration system **100** may be configured to keep the perishable foods within a certain temperature range. For example, vegetables that must be kept between 32 and 40 degrees may be placed in a modular refrigeration system **100** that includes the thermoelectric cooler **192** plus evaporative cooling. Vegetables that should be kept above 40 degrees may be placed in a modular refrigeration system **100** that does not include a thermoelectric cooler **192** or with the thermoelectric cooler **192** turned off. In some examples, vegetables or fruits that require higher humidity may be placed in the container with a wet cloth, towel, or other similar material. In some examples, the internal compartment **110** may include one or more sensors, such as a temperature sensor, humidity sensor, or other types of sensors that may provide a visual indication of the temperature and/or humidity levels within the internal compartment **110**. In some other examples, the one or more sensors may provide information wirelessly to a user device such as a tablet, phone, computer, etc. In some examples, the information may be used to regulate the thermoelectric cooler by powering on/off the thermoelectric cooler based on the information.

[0043] FIG. **8** illustrates exemplary configurations **800** using modular refrigeration systems **100**, such as those described in FIG. **1**. The modular refrigeration system **100** can be easily expanded, reduced, or rearranged based on space and food storage requirements, making it adaptable for both home and commercial use. For example, a first modular configuration **810** may be made up of hexagonal modular refrigeration systems **812** which may be arranged relative to each other. Each hexagonal modular refrigeration system **812** may hold perishable foods, and each hexagonal modular refrigeration system **812** may be configured to keep the perishable foods within a certain temperature range as described above with regards to FIG. **7**.

[0044] The second and third modular configurations **820**, **830** show different modular refrigeration systems **822**, **832**, respectively, which may be stacked when placed on a flat surface. The modular refrigeration systems **822**, **832**, may hold perishable foods and may conveniently be stacked on top of each other in order to save space and to be customized based on the needs of the user.

[0045] The fourth modular configuration **840** is a top-down view of various modular refrigeration systems **842**

which are polygons and differ in size relative to each other. The modular refrigeration systems **842** may be arranged relative to each other and may each hold different perishable foods. The fifth, sixth, and seventh modular configurations **850**, **860**, **870** show additional examples of possible configurations using modular refrigeration systems.

[0046] FIG. **9** illustrates a flow chart **900** with exemplary steps of how the modular refrigeration system of FIG. **1** may be utilized. At step **910**, the modular refrigeration system may be lowered using the lifting mechanism described in FIGS. **6**A-**6**C. At step **920**, food may be placed in the internal compartment **110**. The food may be covered with a towel, cloth, or other similar material. In some examples, the food may be covered with a wet towel, cloth, etc. The cover is subsequently placed. At step **930**, an absorbent material is placed in the cavity formed between the internal compartment and the outer vessel, or if the absorbent material has already been placed, water is added. At step **940**, the modular refrigeration system is lifted using the lifting mechanism and suspended to a desired height, such as, for example, a height where the contents of the modular refrigeration system **100** may be viewed. A thermoelectric cooler of the modular refrigeration system may be activated at any time.

[0047] While the present method and/or system has been described with reference to certain implementations, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present method and/or system. For example, block and/or components of disclosed examples may be combined, divided, re-arranged, and/or otherwise modified. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from its scope. Therefore, the present method and/or system are not limited to the particular implementations disclosed. Instead, the present method and/or system will include all implementations falling within the scope of the appended claims, both literally and under the doctrine of equivalents.

What is claimed is:

1. A modular refrigeration system comprising one or more structural components configured to store food, wherein the one or more structural components comprise:

an internal compartment configured to store the food;

an outer vessel configured to hold the internal compartment; and

a cavity formed by the internal compartment and the outer vessel and configured to hold an absorbent material, wherein the outer vessel, the internal compartment, and the absorbent material maintain the food in the internal compartment within a first predetermined temperature range.

2. The modular refrigeration system of claim **1**, further comprising a thermoelectric cooler, wherein the internal compartment, the outer vessel, the absorbent material, and the thermoelectric cooler maintain the food in the internal compartment within a second predetermined temperature range.

3. The modular refrigeration system of claim **2**, wherein the thermoelectric cooler is a Peltier device.

4. The modular refrigeration system of claim **3**, wherein the first predetermined temperature range is above 40° F.

5. The modular refrigeration system of claim **4**, wherein the second predetermined temperature range is approximately 32° F. to 40° F.

6. The modular refrigeration system of claim **1**, wherein the one or more structural components are made from natural, recyclable, or biodegradable materials.

7. The modular refrigeration system of claim **1**, wherein the internal compartment comprises a bottom portion and the outer vessel include a base portion, and wherein the bottom portion and the base portion are transparent and configured to allow the food in the internal compartment to be visible.

8. The modular refrigeration system of claim **1**, wherein the modular refrigeration system includes humidity control features to regulate moisture levels appropriate for different types of food.

9. The modular refrigeration system of claim **1**, wherein the modular refrigeration system eliminates use of refrigerants.

10. The modular refrigeration system of claim **1**, wherein the modular refrigeration system is configured to be arranged with a second modular refrigeration system.

11. The modular refrigeration system of claim **10**, wherein the arrangement is stacking of the modular refrigeration system with the second modular refrigeration system.

12. The modular refrigeration system of claim **1**, further comprising a hanging mechanism attached to the outer vessel, wherein the hanging mechanism is configured to suspend the modular refrigeration system.

13. The modular refrigeration system of claim **12**, further comprising a lifting mechanism configured to lift and lower the modular refrigeration system in order to suspend the modular refrigeration system.

14. The modular refrigeration system of claim **1**, wherein the outer vessel includes a gripping mechanism for handling the modular refrigeration system.

* * * * *