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• **Haier US Appliance Solutions, Inc.**
Wilmington, DE 19801 (US)

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(72) Inventors:
• **BRIGGS, Peter Allen Crenshaw**
Wilmington, Delaware 19801 (US)
• **CONNOR, Austin B.**
Wilmington, Delaware 19801 (US)
• **BROWN, Justin Tyler**
Wilmington, Delaware 19801 (US)
• **JUNGE, Brent Alden**
Wilmington, Delaware 19801 (US)

(71) Applicants:
• **Qingdao Haier Refrigerator Co., Ltd**
Qingdao, Shandong 266101 (CN)
• **Haier Smart Home Co., Ltd.**
Qingdao, Shandong 266101 (CN)

(74) Representative: **Lavoix**
Bayerstraße 83
80335 München (DE)

(54) **EVAPORATOR ASSEMBLY FOR ICE-MAKING APPARATUS**

(57) An ice making assembly includes an ice mold defining a mold cavity and a refrigeration loop having an evaporator assembly in thermal communication with the ice mold. A compressor is operably coupled to the refrigeration loop for circulating a flow of refrigerant through the refrigerant loop to cool the evaporator assembly and the ice mold. The evaporator assembly includes a primary

evaporator tube and a thermal enhancement structure, such as internal tubes and/or copper foam, placed therein to increase the refrigerant side surface area. The primary evaporator tube is deformed into a non-circular cross sectional shape and soldered or brazed onto a top wall of the ice mold.

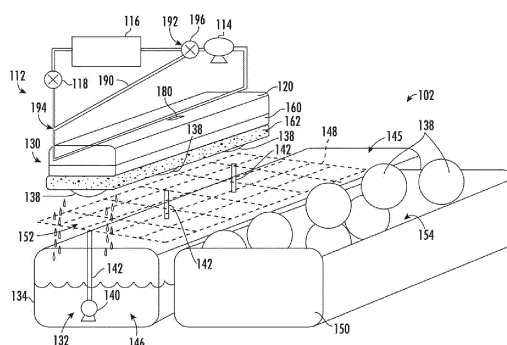


FIG. 3

Description

FIELD OF THE INVENTION

[0001] The present subject matter relates generally to ice making appliances, and more particularly to evaporator assemblies for cooling an ice mold of an ice making appliance.

BACKGROUND OF THE INVENTION

[0002] In domestic and commercial applications, ice is often formed as solid cubes, such as crescent cubes or generally rectangular blocks. The shape of such cubes is often dictated by the container holder water during a freezing process. For instance, an ice maker can receive liquid water, and such liquid water can freeze within the ice maker to form ice cubes. In particular, certain ice makers include a freezing mold that defines a plurality of cavities. The plurality of cavities can be filled with liquid water, and such liquid water can freeze within the plurality of cavities to form solid ice cubes. Typical solid cubes or blocks may be relatively small in order to accommodate a large number of uses, such as temporary cold storage and rapid cooling of liquids in a wide range of sizes.

[0003] Although the typical solid cubes or blocks may be useful in a variety of circumstances, there are certain conditions in which distinct or unique ice shapes may be desirable. As an example, it has been found that relatively large ice cubes or spheres (e.g., larger than two inches in diameter) will melt slower than typical ice sizes/shapes. Slow melting of ice may be especially desirable in certain liquors or cocktails. Moreover, such cubes or spheres may provide a unique or upscale impression for the user.

[0004] In recent years, ice making appliances have been developed for forming relatively large ice billets in a manner that avoids trapping impurities and gases within the billet. These appliances also use precise temperature control to avoid a dull or cloudy finish that may form on the exterior surfaces of an ice billet (e.g., during rapid freezing of the ice cube). In addition, in order to ensure that a shaped or final ice cube or sphere is substantially clear, many systems form solid ice billets that are substantially bigger (e.g., 50% larger in mass or volume) than a desired final ice cube or sphere. Along with being generally inefficient, this may significantly increase the amount of time and energy required to melt or shape an initial ice billet into a final cube or sphere.

[0005] Conventional ice making assemblies for forming large billets of ice often experience issues keeping the ice mold cool enough to freeze through the thickness of the large ice billet, particularly toward the bottom of the ice billet or at regions farthest away from the evaporator. Accordingly, further improvements in the field of ice making would be desirable. In particular, an evaporator assembly that quickly and efficiently cools an ice mold of an ice making assembly would be particularly beneficial.

BRIEF DESCRIPTION OF THE INVENTION

[0006] Aspects and advantages of the invention will be set forth in part in the following description, or may be obvious from the description, or may be learned through practice of the invention.

[0007] In one exemplary aspect of the present disclosure, an ice making assembly is provided including an ice mold defining a mold cavity and an evaporator assembly in thermal communication with the ice mold. The evaporator assembly includes a primary evaporator tube placed in direct contact with the ice mold and a thermal enhancement structure positioned within the primary evaporator tube.

[0008] In another exemplary aspect of the present disclosure, a method of forming an ice making assembly is provided. The method includes positioning a thermal enhancement structure inside a primary evaporator tube, pressing the primary evaporator tube into a non-circular shape to increase the thermal contact between the thermal enhancement structure and the primary evaporator tube, and attaching the primary evaporator tube onto an ice mold that defines a mold cavity.

[0009] These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures.

FIG. 1 provides a side plan view of an ice making appliance according to exemplary embodiments of the present disclosure.

FIG. 2 provides a schematic view of an ice making assembly according to exemplary embodiments of the present disclosure.

FIG. 3 provides a simplified perspective view of an ice making assembly according to exemplary embodiments of the present disclosure.

FIG. 4 provides a cross-sectional, schematic view of the exemplary ice making assembly of FIG. 3.

FIG. 5 provides a cross-sectional, schematic view of a portion of the exemplary ice making assembly of FIG. 3 during an ice forming operation.

FIG. 6 provides a bottom perspective view of an ice mold and an evaporator assembly according to an exemplary embodiment of the present subject matter.

FIG. 7 provides a top perspective view of the exem-

play ice mold and evaporator assembly of FIG. 6 according to an exemplary embodiment of the present subject matter.

FIG. 8 provides a cross sectional view of a primary evaporator tube of the exemplary evaporator assembly of FIG. 6 according to an exemplary embodiment of the present subject matter.

FIG. 9 provides a cross sectional view of a primary evaporator tube of the exemplary evaporator assembly of FIG. 6 according to another exemplary embodiment of the present subject matter.

FIG. 10 illustrates a method for forming an evaporator assembly for an ice making assembly according to an exemplary embodiment of the present subject matter.

[0011] Repeat use of reference characters in the present specification and drawings is intended to represent the same or analogous features or elements of the present invention.

DETAILED DESCRIPTION

[0012] Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0013] As used herein, the terms "first," "second," and "third" may be used interchangeably to distinguish one component from another and are not intended to signify location or importance of the individual components. The terms "upstream" and "downstream" refer to the relative flow direction with respect to fluid flow in a fluid pathway. For example, "upstream" refers to the flow direction from which the fluid flows, and "downstream" refers to the flow direction to which the fluid flows. The terms "includes" and "including" are intended to be inclusive in a manner similar to the term "comprising." Similarly, the term "or" is generally intended to be inclusive (i.e., "A or B" is intended to mean "A or B or both").

[0014] Approximating language, as used herein throughout the specification and claims, is applied to modify any quantitative representation that could permissibly vary without resulting in a change in the basic function to which it is related. Accordingly, a value modified by a term or terms, such as "about," "approximately," and "substantially," are not to be limited to the precise value specified. In at least some instances, the approximating

language may correspond to the precision of an instrument for measuring the value. For example, the approximating language may refer to being within a 10 percent margin.

[0015] Turning now to the figures, FIG. 1 provides a side plan view of an ice making appliance 100, including an ice making assembly 102. FIG. 2 provides a schematic view of ice making assembly 102. FIG. 3 provides a simplified perspective view of ice making assembly 102. Generally, ice making appliance 100 includes a cabinet 104 (e.g., insulated housing) and defines a mutually orthogonal vertical direction V, lateral direction, and transverse direction. The lateral direction and transverse direction may be generally understood to be horizontal directions H.

[0016] As shown, cabinet 104 defines one or more chilled chambers, such as a freezer chamber 106. In certain embodiments, such as those illustrated by FIG. 1, ice making appliance 100 is understood to be formed as, or as part of, a stand-alone freezer appliance. It is recognized, however, that additional or alternative embodiments may be provided within the context of other refrigeration appliances. For instance, the benefits of the present disclosure may apply to any type or style of a refrigerator appliance that includes a freezer chamber (e.g., a top mount refrigerator appliance, a bottom mount refrigerator appliance, a side-by-side style refrigerator appliance, etc.). Consequently, the description set forth herein is for illustrative purposes only and is not intended to be limiting in any aspect to any particular chamber configuration.

[0017] Ice making appliance 100 generally includes an ice making assembly 102 on or within freezer chamber 106. In some embodiments, ice making appliance 100 includes a door 105 that is rotatably attached to cabinet 104 (e.g., at a top portion thereof). As would be understood, door 105 may selectively cover an opening defined by cabinet 104. For instance, door 105 may rotate on cabinet 104 between an open position (not pictured) permitting access to freezer chamber 106 and a closed position (FIG. 2) restricting access to freezer chamber 106.

[0018] A user interface panel 108 is provided for controlling the mode of operation. For example, user interface panel 108 may include a plurality of user inputs (not labeled), such as a touchscreen or button interface, for selecting a desired mode of operation. Operation of ice making appliance 100 can be regulated by a controller 110 that is operatively coupled to user interface panel 108 or various other components, as will be described below. User interface panel 108 provides selections for user manipulation of the operation of ice making appliance 100 such as (e.g., selections regarding chamber temperature, ice making speed, or other various options). In response to user manipulation of user interface panel 108, or one or more sensor signals, controller 110 may operate various components of the ice making appliance 100 or ice making assembly 102.

[0019] Controller 110 may include a memory (e.g.,

non-transitive memory) and one or more microprocessors, CPUs or the like, such as general or special purpose microprocessors operable to execute programming instructions or micro-control code associated with operation of ice making appliance 100. The memory may represent random access memory such as DRAM, or read only memory such as ROM or FLASH. In one embodiment, the processor executes programming instructions stored in memory. The memory may be a separate component from the processor or may be included onboard within the processor. Alternatively, controller 110 may be constructed without using a microprocessor (e.g., using a combination of discrete analog or digital logic circuitry; such as switches, amplifiers, integrators, comparators, flip-flops, AND gates, and the like; to perform control functionality instead of relying upon software).

[0020] Controller 110 may be positioned in a variety of locations throughout ice making appliance 100. In optional embodiments, controller 110 is located within the user interface panel 108. In other embodiments, the controller 110 may be positioned at any suitable location within ice making appliance 100, such as for example within cabinet 104. Input/output ("I/O") signals may be routed between controller 110 and various operational components of ice making appliance 100. For example, user interface panel 108 may be in communication with controller 110 via one or more signal lines or shared communication busses.

[0021] As illustrated, controller 110 may be in communication with the various components of ice making assembly 102 and may control operation of the various components. For example, various valves, switches, etc. may be actuatable based on commands from the controller 110. As discussed, user interface panel 108 may additionally be in communication with the controller 110. Thus, the various operations may occur based on user input or automatically through controller 110 instruction.

[0022] Generally, as shown in FIGS. 3 and 4, ice making appliance 100 includes a sealed refrigeration system 112 for executing a vapor compression cycle for cooling water within ice making appliance 100 (e.g., within freezer chamber 106). Sealed refrigeration system 112 includes a compressor 114, a condenser 116, an expansion device 118, and an evaporator 120 connected in fluid series and charged with a refrigerant. As will be understood by those skilled in the art, sealed refrigeration system 112 may include additional components (e.g., one or more directional flow valves or an additional evaporator, compressor, expansion device, or condenser). Moreover, at least one component (e.g., evaporator 120) is provided in thermal communication (e.g., conductive thermal communication) with an ice mold or mold assembly 130 (FIG. 3) to cool mold assembly 130, such as during ice making operations. Optionally, evaporator 120 is mounted within freezer chamber 106, as generally illustrated in FIG. 1.

[0023] Within sealed refrigeration system 112, gaseous refrigerant flows into compressor 114, which oper-

ates to increase the pressure of the refrigerant. This compression of the refrigerant raises its temperature, which is lowered by passing the gaseous refrigerant through condenser 116. Within condenser 116, heat exchange with ambient air takes place so as to cool the refrigerant and cause the refrigerant to condense to a liquid state.

[0024] Expansion device 118 (e.g., a mechanical valve, capillary tube, electronic expansion valve, or other restriction device) receives liquid refrigerant from condenser 116. From expansion device 118, the liquid refrigerant enters evaporator 120. Upon exiting expansion device 118 and entering evaporator 120, the liquid refrigerant drops in pressure and vaporizes. Due to the pressure drop and phase change of the refrigerant, evaporator 120 is cool relative to freezer chamber 106. As such, cooled water and ice or air is produced and refrigerates ice making appliance 100 or freezer chamber 106. Thus, evaporator 120 is a heat exchanger which transfers heat from water or air in thermal communication with evaporator 120 to refrigerant flowing through evaporator 120.

[0025] Optionally, as described in more detail below, one or more directional valves may be provided (e.g., between compressor 114 and condenser 116) to selectively redirect refrigerant through a bypass line connecting the directional valve or valves to a point in the fluid circuit downstream from the expansion device 118 and upstream from the evaporator 120. In other words, the one or more directional valves may permit refrigerant to selectively bypass the condenser 116 and expansion device 120.

[0026] In additional or alternative embodiments, ice making appliance 100 further includes a valve 122 for regulating a flow of liquid water to ice making assembly 102. For example, valve 122 may be selectively adjustable between an open configuration and a closed configuration. In the open configuration, valve 122 permits a flow of liquid water to ice making assembly 102 (e.g., to a water dispenser 132 or a water basin 134 of ice making assembly 102). Conversely, in the closed configuration, valve 122 hinders the flow of liquid water to ice making assembly 102.

[0027] In certain embodiments, ice making appliance 100 also includes a discrete chamber cooling system 124 (e.g., separate from sealed refrigeration system 112) to generally draw heat from within freezer chamber 106. For example, discrete chamber cooling system 124 may include a corresponding sealed refrigeration circuit (e.g., including a unique compressor, condenser, evaporator, and expansion device) or air handler (e.g., axial fan, centrifugal fan, etc.) configured to motivate a flow of chilled air within freezer chamber 106.

[0028] Turning now to FIGS. 3 and 4, FIG. 4 provides a cross-sectional, schematic view of ice making assembly 102. As shown, ice making assembly 102 includes a mold assembly 130 that defines a mold cavity 136 within which an ice billet 138 may be formed. Optionally, a plurality of mold cavities 136 may be defined by mold assembly 130 and spaced apart from each other (e.g., per-

pendicular to the vertical direction V). One or more portions of sealed refrigeration system 112 may be in thermal communication with mold assembly 130. In particular, evaporator 120 may be placed on or in contact (e.g., conductive contact) with a portion of mold assembly 130. During use, evaporator 120 may selectively draw heat from mold cavity 136, as will be further described below. Moreover, a water dispenser 132 positioned below mold assembly 130 may selectively direct the flow of water into mold cavity 136. Generally, water dispenser 132 includes a water pump 140 and at least one nozzle 142 directed (e.g., vertically) toward mold cavity 136. In embodiments wherein multiple discrete mold cavities 136 are defined by mold assembly 130, water dispenser 132 may include a plurality of nozzles 142 or fluid pumps vertically aligned with the plurality mold cavities 136. For instance, each mold cavity 136 may be vertically aligned with a discrete nozzle 142.

[0029] In some embodiments, a water basin 134 is positioned below the ice mold (e.g., directly beneath mold cavity 136 along the vertical direction V). Water basin 134 includes a solid nonpermeable body and may define a vertical opening 145 and interior volume 146 in fluid communication with mold cavity 136. When assembled, fluids, such as excess water falling from mold cavity 136, may pass into interior volume 146 of water basin 134 through vertical opening 145. In certain embodiments, one or more portions of water dispenser 132 are positioned within water basin 134 (e.g., within interior volume 146). As an example, water pump 140 may be mounted within water basin 134 in fluid communication with interior volume 146. Thus, water pump 140 may selectively draw water from interior volume 146 (e.g., to be dispensed by spray nozzle 142). Nozzle 142 may extend (e.g., vertically) from water pump 140 through interior volume 146.

[0030] In optional embodiments, a guide ramp 148 is positioned between mold assembly 130 and water basin 134 along the vertical direction V. For example, guide ramp 148 may include a ramp surface that extends at a negative angle (e.g., relative to a horizontal direction) from a location beneath mold cavity 136 to another location spaced apart from water basin 134 (e.g., horizontally). In some such embodiments, guide ramp 148 extends to or terminates above an ice bin 150. Additionally or alternatively, guide ramp 148 may define a perforated portion 152 that is, for example, vertically aligned between mold cavity 136 and nozzle 142 or between mold cavity 136 and interior volume 146. One or more apertures are generally defined through guide ramp 148 at perforated portion 152. Fluids, such as water, may thus generally pass through perforated portion 152 of guide ramp 148 (e.g., along the vertical direction between mold cavity 136 and interior volume 146).

[0031] As shown, ice bin 150 generally defines a storage volume 154 and may be positioned below mold assembly 130 and mold cavity 136. Ice billets 138 formed within mold cavity 136 may be expelled from mold assembly 130 and subsequently stored within storage vol-

ume 154 of ice bin 150 (e.g., within freezer chamber 106). In some such embodiments, ice bin 150 is positioned within freezer chamber 106 and horizontally spaced apart from water basin 134, water dispenser 132, or mold assembly 130. Guide ramp 148 may span the horizontal distance between mold assembly 130 and ice bin 150. As ice billets 138 descend or fall from mold cavity 136, the ice billets 138 may thus be motivated (e.g., by gravity) toward ice bin 150.

[0032] Turning now generally to FIGS. 4 and 5, exemplary ice forming operations of ice making assembly 102 will be described. As shown, mold assembly 130 is formed from discrete conductive ice mold 160 and insulation jacket 162. Generally, insulation jacket 162 extends downward from (e.g., directly from) conductive ice mold 160. For instance, insulation jacket 162 may be fixed to conductive ice mold 160 through one or more suitable adhesives or attachment fasteners (e.g., bolts, latches, mated prongs-channels, etc.) positioned or formed between conductive ice mold 160 and insulation jacket 162.

[0033] Together, conductive ice mold 160 and insulation jacket 162 may define mold cavity 136. For instance, conductive ice mold 160 may define an upper portion 136A of mold cavity 136 while insulation jacket 162 defines a lower portion 136B of mold cavity 136. Upper portion 136A of mold cavity 136 may extend between a non-permeable top end 164 and an open bottom end 166. Additionally or alternatively, upper portion 136A of mold cavity 136 may be curved (e.g., hemispherical) in open fluid communication with lower portion 136B of mold cavity 136. Lower portion 136B of mold cavity 136 may be a vertically open passage that is aligned (e.g., in the vertical direction V) with upper portion 136A of mold cavity 136. Thus, mold cavity 136 may extend along the vertical direction between a mold opening 168 at a bottom portion or bottom surface 170 of insulation jacket 162 to top end 164 within conductive ice mold 160. In some such embodiments, mold cavity 136 defines a constant diameter or horizontal width from lower portion 136B to upper portion 136A. When assembled, fluids, such as water may pass to upper portion 136A of mold cavity 136 through lower portion 136B of mold cavity 136 (e.g., after flowing through the bottom opening defined by insulation jacket 162).

[0034] Conductive ice mold 160 and insulation jacket 162 are formed, at least in part, from two different materials. Conductive ice mold 160 is generally formed from a thermally conductive material (e.g., metal, such as copper, aluminum, or stainless steel, including alloys thereof) while insulation jacket 162 is generally formed from a thermally insulating material (e.g., insulating polymer, such as a synthetic silicone configured for use within sub-freezing temperatures without significant deterioration). According to alternative embodiments, insulation jacket 162 may be formed using polyethylene terephthalate (PET) plastic or any other suitable material. In some embodiments, conductive ice mold 160 is formed from ma-

terial having a greater amount of water surface adhesion than the material from which insulation jacket 162 is formed. Water freezing within mold cavity 136 may be prevented from extending horizontally along bottom surface 170 of insulation jacket 162.

[0035] Advantageously, an ice billet within mold cavity 136 may be prevented from mushrooming beyond the bounds of mold cavity 136. Moreover, if multiple mold cavities 136 are defined within mold assembly 130, ice making assembly 102 may advantageously prevent a connecting layer of ice from being formed along the bottom surface 170 of insulation jacket 162 between the separate mold cavities 136 (and ice billets therein). Further advantageously, the present embodiments may ensure an even heat distribution across an ice billet within mold cavity 136. Cracking of the ice billet or formation of a concave dimple at the bottom of the ice billet may thus be prevented.

[0036] In some embodiments, the unique materials of conductive ice mold 160 and insulation jacket 162 each extend to the surfaces defining upper portion 136A and lower portion 136B of mold cavity 136. In particular, a material having a relatively high water adhesion may define the bounds of upper portion 136A of mold cavity 136 while a material having a relatively low water adhesion defines the bounds of lower portion 136B of mold cavity 136. For instance, the surface of insulation jacket 162 defining the bounds of lower portion 136B of mold cavity 136 may be formed from an insulating polymer (e.g., silicone). The surface of conductive mold cavity 136 defining the bounds of upper portion 136A of mold cavity 136 may be formed from a thermally conductive metal (e.g., aluminum or copper). In some such embodiments, the thermally conductive metal of conductive ice mold 160 may extend along (e.g., the entirety of) of upper portion 136A.

[0037] Although an exemplary mold assembly 130 is described above, it should be appreciated that variations and modifications may be made to mold assembly 130 while remaining within the scope of the present subject matter. For example, the size, number, position, and geometry of mold cavities 136 may vary. In addition, according to alternative embodiments, an insulation film may extend along and define the bounds of upper portion 136A of mold cavity 136, e.g., may extend along an inner surface of conductive ice mold 160 at upper portion 136A of mold cavity 136. Indeed, aspects of the present subject matter may be modified and implemented in a different ice making apparatus or process while remaining within the scope of the present subject matter.

[0038] In some embodiments, one or more sensors are mounted on or within ice mold 160. As an example, a temperature sensor 180 may be mounted adjacent to ice mold 160. Temperature sensor 180 may be electrically coupled to controller 110 and configured to detect the temperature within ice mold 160. Temperature sensor 180 may be formed as any suitable temperature detecting device, such as a thermocouple, thermistor, etc. Al-

though temperature sensor 180 is illustrated as being mounted to ice mold 160, it should be appreciated that according to alternative embodiments, temperature sensor may be positioned at any other suitable location for providing data indicative of the temperature of the ice mold 160. For example, temperature sensor 180 may alternatively be mounted to a coil of evaporator 120 or at any other suitable location within ice making appliance 100.

[0039] As shown, controller 110 may be in communication (e.g., electrical communication) with one or more portions of ice making assembly 102. In some embodiments, controller 110 is in communication with one or more fluid pumps (e.g., water pump 140), compressor 114, flow regulating valves, etc. Controller 110 may be configured to initiate discrete ice making operations and ice release operations. For instance, controller 110 may alternate the fluid source spray to mold cavity 136 and a release or ice harvest process, which will be described in more detail below.

[0040] During ice making operations, controller 110 may initiate or direct water dispenser 132 to motivate an ice-building spray (e.g., as indicated at arrows 184) through nozzle 142 and into mold cavity 136 (e.g., through mold opening 168). Controller 110 may further direct sealed refrigeration system 112 (e.g., at compressor 114) (FIG. 3) to motivate refrigerant through evaporator 120 and draw heat from within mold cavity 136. As the water from the ice-building spray 184 strikes mold assembly 130 within mold cavity 136, a portion of the water may freeze in progressive layers from top end 164 to bottom end 166. Excess water (e.g., water within mold cavity 136 that does not freeze upon contact with mold assembly 130 or the frozen volume herein) and impurities within the ice-building spray 184 may fall from mold cavity 136 and, for example, to water basin 134.

[0041] Once ice billets 138 are formed within mold cavity 136, an ice release or harvest process may be performed in accordance with embodiments of the present subject matter. Specifically, referring again to FIG. 3, sealed system 112 may further include a bypass conduit 190 that is fluidly coupled to refrigeration loop or sealed system 112 for routing a portion of the flow of refrigerant around condenser 116. In this manner, by selectively regulating the amount of relatively hot refrigerant flow that exits compressor 114 and bypasses condenser 116, the temperature of the flow of refrigerant passing into evaporator 120 may be precisely regulated.

[0042] Specifically, according to the illustrated embodiment, bypass conduit 190 extends from a first junction 192 to a second junction 194 within sealed system 112. First junction 192 is located between compressor 114 and condenser 116, e.g., downstream of compressor 114 and upstream of condenser 116. By contrast, second junction 194 is located between condenser 116 and evaporator 120, e.g., downstream of condenser 116 and upstream of evaporator 120. Moreover, according to the illustrated embodiment, second junction 194 is also lo-

cated downstream of expansion device 118, although second junction 194 could alternatively be positioned upstream of expansion device 118. When plumbed in this manner, bypass conduit 190 provides a pathway through which a portion of the flow of refrigerant may pass directly from compressor 114 to a location immediately upstream of evaporator 120 to increase the temperature of evaporator 120.

[0043] Notably, if substantially all of the flow of refrigerant were diverted from compressor 114 through bypass conduit 190 when ice mold 160 is still very cold (e.g., below 10°F or 20°F), the thermal shock experienced by ice billets 138 due to the sudden increase in evaporator temperature might cause ice billets 138 to crack. Therefore, controller 110 may implement methods for slowly regulating or precisely controlling the evaporator temperature to achieve the desired mold temperature profile and harvest release time to prevent the ice billets 138 from cracking.

[0044] In this regard, for example, bypass conduit 190 may be fluidly coupled to sealed system 112 using a flow regulating device 196. Specifically, flow regulating device 196 may be used to couple bypass conduit 190 to sealed system 112 at first junction 192. In general, flow regulating device 196 may be any device suitable for regulating a flow rate of refrigerant through bypass conduit 190. For example, according to an exemplary embodiment of the present subject matter, flow regulating device 196 is an electronic expansion device which may selectively divert a portion of the flow of refrigerant exiting compressor 114 into bypass conduit 190. According to still another embodiment, flow regulating device 196 may be a servomotor-controlled valve for regulating the flow of refrigerant through bypass conduit 190. According to still other embodiments, flow regulating device 196 may be a three-way valve mounted at first junction 192 or a solenoid-controlled valve operably coupled along bypass conduit 190.

[0045] According to exemplary embodiments of the present subject matter, controller 110 may initiate an ice release or harvest process to discharge ice billets 138 from mold cavities 136. Specifically, for example, controller 110 may first halt or prevent the ice-building spray 184 by de-energizing water pump 140. Next, controller 110 may regulate the operation of sealed system 112 to slowly increase a temperature of evaporator 120 and ice mold 160. Specifically, by increasing the temperature of evaporator 120, the mold temperature of ice mold 160 is also increased, thereby facilitating partial melting or release of ice billets 138 from mold cavities.

[0046] According to exemplary embodiments, controller 110 may be operably coupled to flow regulating device 196 for regulating a flow rate of the flow of refrigerant through bypass conduit 190. Specifically, according to an exemplary embodiment, controller 110 may be configured for obtaining a mold temperature of the mold body using temperature sensor 180. Although the term "mold temperature" is used herein, it should be appreciated that

temperature sensor 180 may measure any suitable temperature within the ice making appliance 100 that is indicative of mold temperature and may be used to facilitate improved harvest of ice billets 138.

[0047] Controller 110 may further regulate the flow regulating device 196 to control the flow of refrigerant based in part on the measured mold temperature. For example, according to an exemplary embodiment, flow regulating device 196 may be regulated such that a rate of change of the mold temperature does not exceed a predetermined threshold rate. For example, this predetermined threshold rate may be any suitable rate of temperature change beyond which thermal cracking of ice billets 138 may occur. For example, according to an exemplary embodiment, the predetermined threshold rate may be approximately 1°F per minute, about 2°F per minute, about 3°F per minute, or higher. According to exemplary embodiments, the predetermined threshold rate may be less than 10°F per minute, less than 5°F per minute, less than 2°F per minute, or lower. In this manner, flow regulating device 196 may regulate the rate of temperature change of ice billets 138, thereby preventing thermal cracking.

[0048] In general, the sealed system 112 and methods of operation described herein are intended to regulate a temperature change of ice billets 138 to prevent thermal cracking. However, although specific control algorithms and system configurations are described, it should be appreciated that according to alternative embodiments variations and modifications may be made to such systems and methods while remaining within the scope of the present subject matter. For example, the exact plumbing of bypass conduit 190 may vary, the type or position of flow regulating device 196 may change, and different control methods may be used while remaining within scope of the present subject matter. In addition, depending on the size and shape of ice billets 138, the predetermined threshold rate and predetermined temperature threshold may be adjusted to prevent that particular set of ice billets 138 from cracking, or to otherwise facilitate an improved harvest procedure.

[0049] Referring now specifically to FIGS. 6 and 7, an exemplary ice mold 200 and evaporator assembly 202 that may be used with ice making appliance 100 will be described according to exemplary embodiments of the present subject matter. Specifically, for example, ice mold 200 may be used as mold assembly 130 and evaporator assembly 202 may be used as evaporator 120 of sealed cooling system 112. Although ice mold 200 and evaporator assembly 202 are described herein with respect to ice making appliance 100, it should be appreciated that ice mold 200 and evaporator assembly 202 may be used in any other suitable ice making application or appliance.

[0050] As shown, ice mold 200 generally includes a top wall 210 and a plurality of sidewalls 212 that are cantilevered from top wall 210 and extend downward from top wall 210. More specifically, according to the illustrated embodiment, ice mold 200 includes eight sidewalls 212

that include an angled portion 214 that extends away from top wall 210 and a vertical portion 216 that extends down from angled portion 214 substantially along the vertical direction. In this manner, the top wall 210 and the plurality of sidewalls 212 form a mold cavity 218 having an octagonal cross-section when viewed in a horizontal plane. In addition, each of the plurality of sidewalls 212 may be separated by a gap 220 that extends substantially along the vertical direction. In this manner, the plurality of sidewalls 212 may move relative to each other and act as spring fingers to permit some flexing of ice mold 200 during ice formation. Notably, this flexibility of ice mold 200 facilitates improved ice formation and reduces the likelihood of cracking.

[0051] In general, ice mold 200 may be formed from any suitable material and in any suitable manner that provides sufficient thermal conductivity to transfer heat to evaporator assembly 202 to facilitate the ice making process. According to an exemplary embodiment, ice mold 200 is formed from a single sheet of copper. In this regard, for example, a flat sheet of copper having a constant thickness may be machined to define top wall 210 and sidewalls 212. Sidewalls 212 may be subsequently bent to form the desired shape of mold cavity 218, e.g., such as the octagonal or gem shape described above. In this manner, top wall 210 and sidewalls 212 may be formed to have an identical thickness without requiring complex and costly machining processes.

[0052] According exemplary embodiments of the present subject matter, evaporator assembly 202 is mounted in direct contact with the top wall 210 of ice mold 200. In addition, evaporator assembly 202 may not be in direct contact with sidewalls 212. This may be desirable, for example, to prevent restricting the movement of sidewalls 212, e.g., to reduce to the likelihood of ice cracking. Notably, when evaporator assembly 202 is mounted only on top wall 210, the conductive path to each of the plurality of sidewalls 212 is through the joint or connection where sidewalls 212 meet top wall 210. Thus, it may be desirable to make a sidewall width 222 as large as possible to provide improved thermal conductivity. For example, the sidewall width 222 may be between about 0.5 and 1.5 inches, between about 0.7 and 1 inches, or about 0.8 inches. Such a sidewall width 222 facilitates the conduction of thermal energy to the bottom ends of each of the plurality of sidewalls 212.

[0053] In addition, to improve the thermal contact between evaporator assembly 202 and ice mold 200, it may be desirable to make top wall relatively large. Therefore, according to exemplary embodiments, top wall 210 may define a top width 224 and mold cavity 218 may define a max width 226. According to exemplary embodiments, top width 224 is greater than about 50% of max width 226. According to still other embodiments, top width 224 may be greater than about 60%, greater than about 70%, greater than about 80%, or greater, of max width 226. In addition, or alternatively, top width 224 may be less than 90%, less than 70%, less than 60%, less than 50%, or

less, of max width 226. It should be appreciated that other suitable sizes, geometries, and configurations of ice mold 200 are possible and within the scope of the present subject matter. In addition, although only two ice molds 200 are illustrated in FIGS. 6 and 7, it should be appreciated that alternative embodiments may include any other suitable number and configuration of ice molds 200.

[0054] Referring still to FIGS. 6 and 7, evaporator assembly 202 may generally include a primary evaporator tube 230 and a thermal enhancement structure 232 which is positioned within primary evaporator tube 230. According to an exemplary embodiment, primary evaporator tube may be a copper pipe having a circular cross section. The diameter of primary evaporator tube 230 may be between about 0.1 and 3 inches, between about 0.2 and 2 inches, between about 0.3 and 1 inches, between about 0.4 and 0.8 inches, or about 0.5 inches. However, it should be appreciated that primary evaporator tube 230 may be any other suitable size, shape, length, and material.

[0055] As used herein, "thermal enhancement structure" is generally intended to refer to any suitable material, structure, or features within interior of primary evaporator tube 230 which are intended to increase the refrigerant side surface area within primary evaporator tube 230. For example, as best shown in FIG. 8, thermal enhancement structure 232 may be a plurality of internal tubes 240 that are stacked within primary evaporator tube 230. In general, these internal tubes 240 may be copper pipes that have a smaller diameter than primary evaporator tube 230. Internal tubes 240 may be stacked in primary evaporator tube 230 and extend approximately the same length as primary evaporator tube 230.

[0056] According to an exemplary embodiment, the thermal enhancement structure 232 includes greater than 5 tubes, greater than 10 tubes, greater than 15 tubes, greater than 20 tubes, or more. In addition, or alternatively, thermal enhancement structure 232 may include fewer than 50 tubes, fewer than 25 tubes, fewer than 10 tubes, or fewer. The diameter of each internal tube 240 may be between about 0.01 and 0.5 inches, between about 0.04 and 0.2 inches, between about 0.06 and 0.1 inches, or about 0.08 inches. In addition, it should be appreciated that internal tubes 240 may have different sizes, lengths, or cross sectional shapes, e.g., in order to efficiently and completely fill primary evaporator tube 230.

[0057] Alternatively, as shown in FIG. 10, thermal enhancement structure 232 may include a copper foam or mesh structure 242. Alternatively, thermal enhancement structure 232 may be a porous thermally conductive material, a honeycomb structure, a lattice structure, or any other suitable thermally conductive material that extends from the internal walls of primary evaporator tube 230 through the center of primary evaporator tube 230 to increase the refrigerant side surface area. It should be appreciated that any other suitable thermal enhancement structure 232 may be used while remaining within the

scope of the present subject matter.

[0058] As shown generally in FIGS. 6 and 7, after thermal enhancement structure 232 is positioned within primary evaporator tube 230, primary evaporator tube 230 may be pressed or otherwise formed into a flattened or noncircular cross sectional shape. In this manner, primary evaporator tube 230 may be placed in direct contact with the top wall 210 of ice mold 200 and may have improved thermal contact with the top wall 210. In addition, the larger contact surface area between the top wall 210 and primary evaporator tube 230 facilitates a simplified brazing or soldering process to join primary evaporator tube 230 with top wall 210. In addition, pressing primary evaporator tube 230 into a noncircular cross section improves the thermal contact between internal tubes 240, e.g., to increase the refrigerant side surface area of evaporator assembly 200. Once formed, according to an exemplary embodiment, evaporator assembly 202 may be used with sealed cooling system 112. In this manner, for example, compressor 114 may urge a flow of refrigerant through condenser 116, expansion device 118, and evaporator assembly 202, as described above.

[0059] Now that the construction of ice making appliance 100 and evaporator assembly 202 have been described according to exemplary embodiments, an exemplary method 300 of forming an evaporator assembly will be described. Although the discussion below refers to the exemplary method 300 of forming evaporator assembly 202, one skilled in the art will appreciate that the exemplary method 300 is applicable to the operation of a variety of other evaporator configurations and methods of formation.

[0060] Referring now to FIG. 10, method 300 includes, at step 310, positioning a thermal enhancement structure inside a primary evaporator tube. In this regard, as explained above, thermal enhancement structure 230 may be copper internal tubes 240 or copper foam 242. For example, 15 internal tubes having an outer diameter of 0.8 inches may be positioned within primary evaporator tube 230, which may be a copper tube having a diameter of 0.5 inches.

[0061] After the thermal enhancement structure is in place, step 320 includes pressing the primary evaporator tube into a non-circular shape to increase the thermal contact between the thermal enhancement structure and the primary evaporator tube. In this regard, for example, the primary evaporator tube 230 may be pressed or compressed to deform the primary evaporator tube 230 and create improved thermal contact between each of the internal tubes 240 and the primary evaporator tube 230, as shown for example by dotted lines in FIGS. 8 and 9. The primary evaporator tube 230 may then be installed into a sealed refrigeration system, such as sealed cooling system 112 as evaporator 120.

[0062] Step 330 includes attaching the primary evaporator tube onto an ice mold that defines a mold cavity. In this regard, for example, deformed primary evaporator tube 230 may be soldered, brazed, or otherwise attached

to top wall 210 of ice mold 200. In this manner, when sealed cooling system 112 is circulating refrigerant, primary evaporator tube 230 absorbs thermal energy from the ice mold 200 and transfers it to the refrigerant. The thermal enhancement structure 232 enables more efficient transfer of thermal energy from the ice mold 200 to the refrigerant.

[0063] FIG. 10 depicts steps performed in a particular order for purposes of illustration and discussion. Those of ordinary skill in the art, using the disclosures provided herein, will understand that the steps of any of the methods discussed herein can be adapted, rearranged, expanded, omitted, or modified in various ways without deviating from the scope of the present disclosure. Moreover, although aspects of method 300 are explained using ice making appliance 100 and evaporator assembly 202 as an example, it should be appreciated that these methods may be applied to the operation of any evaporator assembly or an ice making appliance having any other suitable configuration.

[0064] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they include structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

Claims

1. An ice making assembly comprising:

an ice mold defining a mold cavity;
an evaporator assembly in thermal communication with the ice mold, the evaporator assembly comprising:

a primary evaporator tube placed in direct contact with the ice mold; and
a thermal enhancement structure positioned within the primary evaporator tube.

2. The ice making assembly of claim 1, wherein the ice mold comprises:

a top wall; and
a plurality of sidewalls cantilevered from the top wall and extending downward from the top wall.

3. The ice making assembly of claim 2, wherein the evaporator assembly is in direct contact with the top

wall of the ice mold.

4. The ice making assembly of claim 2, wherein the top wall and the plurality of sidewalls are formed from a single sheet of copper and have a constant thickness. 5
5. The ice making assembly of claim 2, wherein the top wall defines a top width and the mold cavity defines a max width, the top width being greater than 50 percent of the max width. 10
6. The ice making assembly of claim 2, wherein each of the plurality of sidewalls are separated by a gap to permit flexing relative to each other. 15
7. The ice making assembly of claim 2, wherein the plurality of sidewalls comprise eight sidewalls forming a mold cavity having an octagonal cross section. 20
8. The ice making assembly of claim 1, wherein the ice making assembly comprises a plurality of ice molds, the evaporator assembly being placed in thermal communication with each of the plurality of ice molds. 25
9. The ice making assembly of claim 1, wherein the thermal enhancement structure comprises copper foam.
10. The ice making assembly of claim 1, wherein the thermal enhancement structure comprises a plurality of internal tubes. 30
11. The ice making assembly of claim 1, wherein the primary evaporator tube is formed into a non-circular cross section. 35
12. The ice making assembly of claim 10, wherein the plurality of tubes comprise greater than 10 tubes. 40
13. The ice making assembly of claim 10, wherein the plurality of tubes comprises about 15 tubes.
14. The ice making assembly of claim 1, wherein the primary evaporator tube is a half-inch copper tube. 45
15. The ice making assembly of claim 1, further comprising:
 - a refrigeration loop comprising a condenser and an expansion device in serial flow communication with each other and with the evaporator assembly; and
 - a compressor operably coupled to the refrigeration loop and being configured for circulating a flow of refrigerant through the refrigerant loop. 50
16. A method of forming an ice making assembly, com-

prising:

- positioning a thermal enhancement structure inside a primary evaporator tube;
 - pressing the primary evaporator tube into a non-circular shape to increase the thermal contact between the thermal enhancement structure and the primary evaporator tube;
 - attaching the primary evaporator tube onto an ice mold that defines a mold cavity.
17. The method of claim 16, wherein the primary evaporator tube is brazed or soldered onto a top wall of the ice mold.
 18. The method of claim 16, wherein the ice mold comprises:
 - a top wall; and
 - a plurality of sidewalls cantilevered from the top wall and extending downward from the top wall.
 19. The method of claim 18, wherein each of the plurality of sidewalls are separated by a gap to permit flexing relative to each other.
 20. The method of claim 16, wherein the thermal enhancement structure comprises copper foam or a plurality of internal tubes.

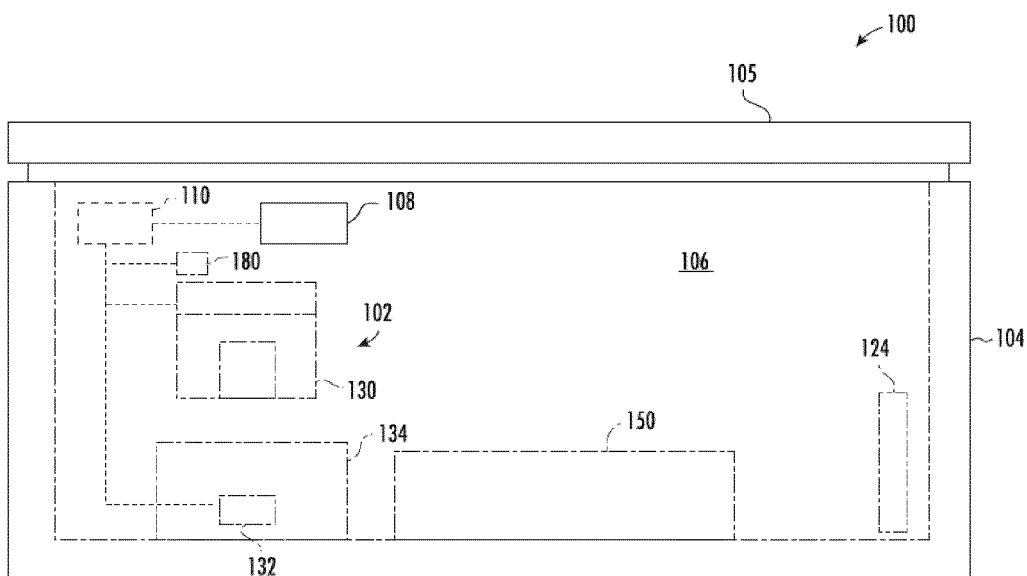


FIG. 1

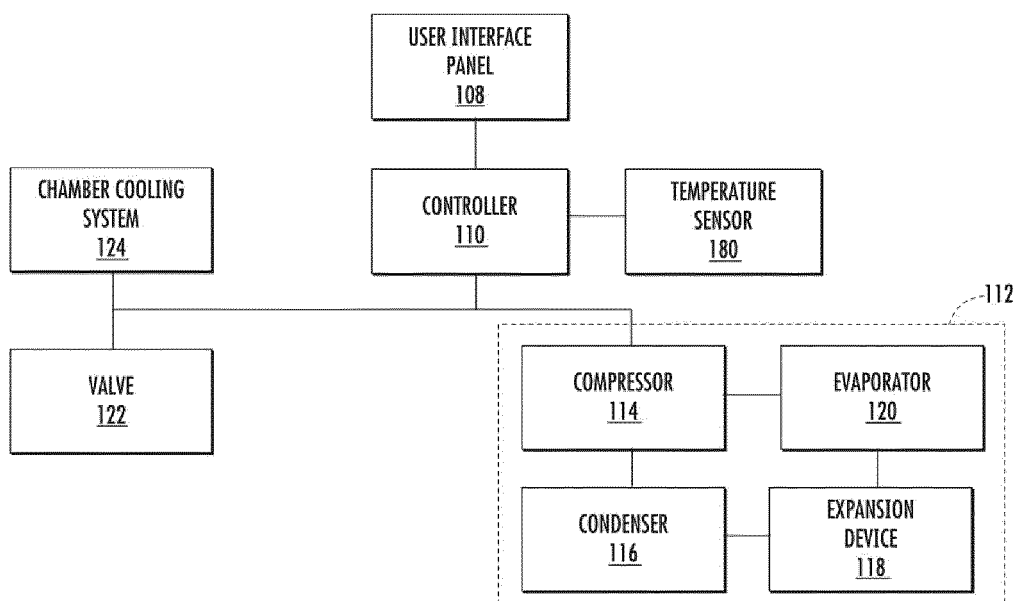


FIG. 2

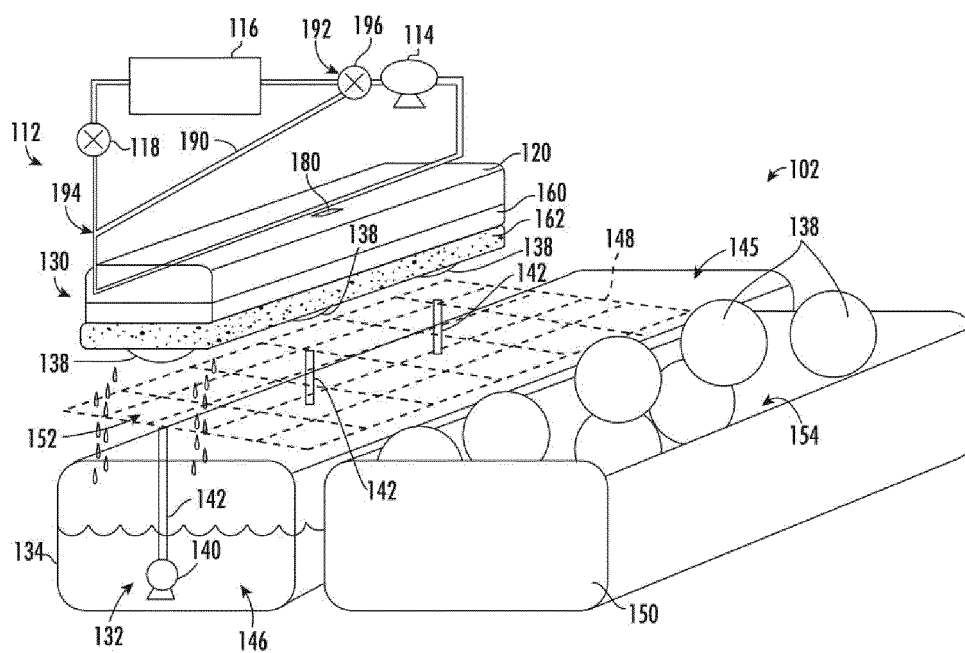


FIG. 3

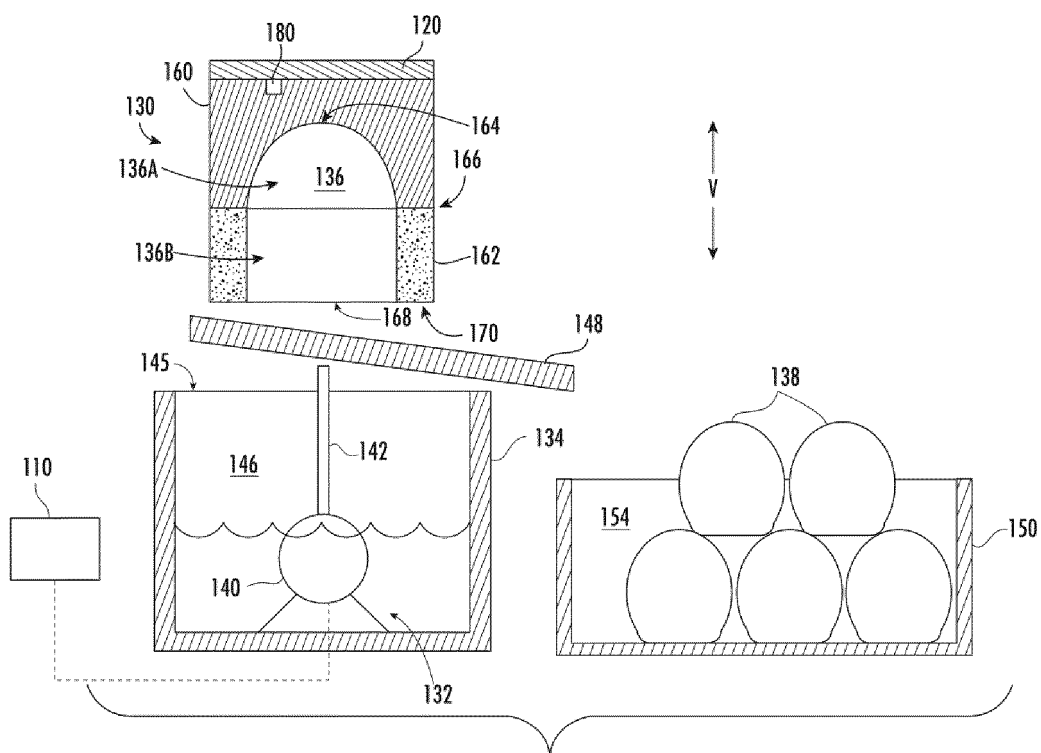


FIG. 4

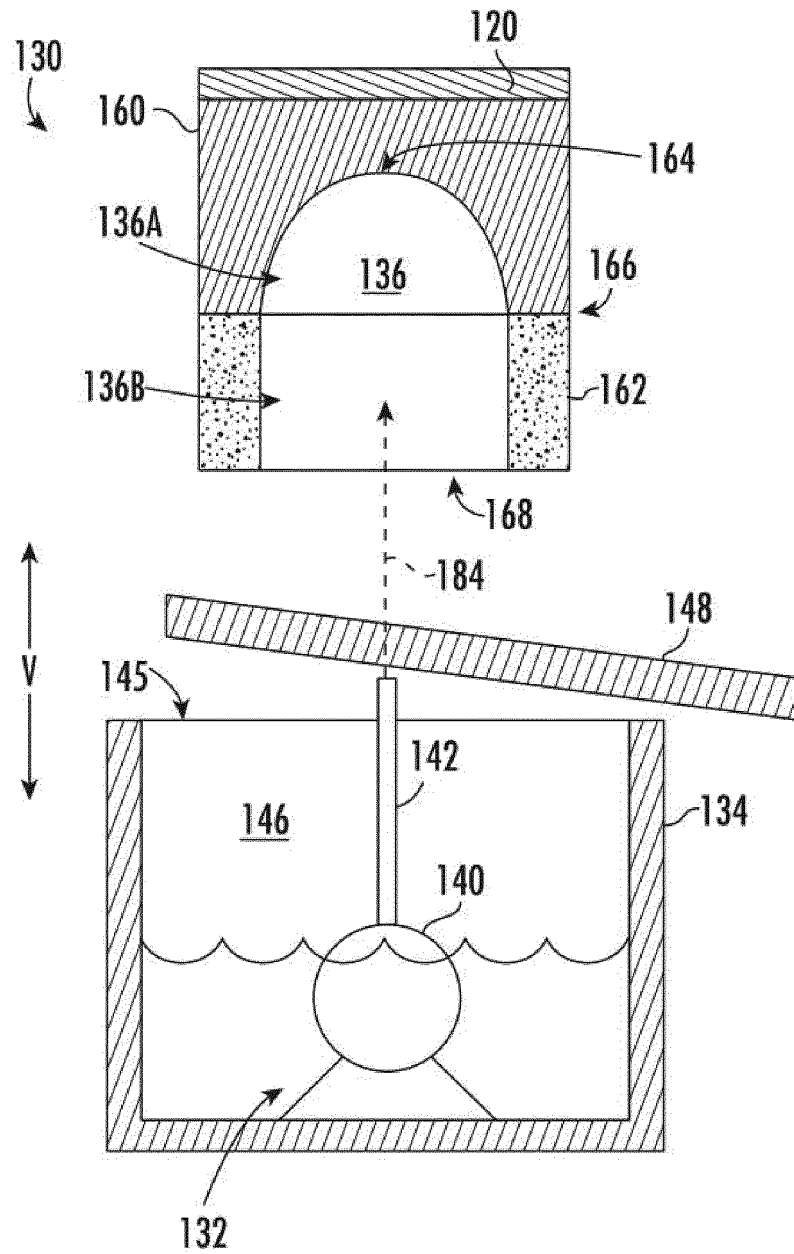


FIG. 5

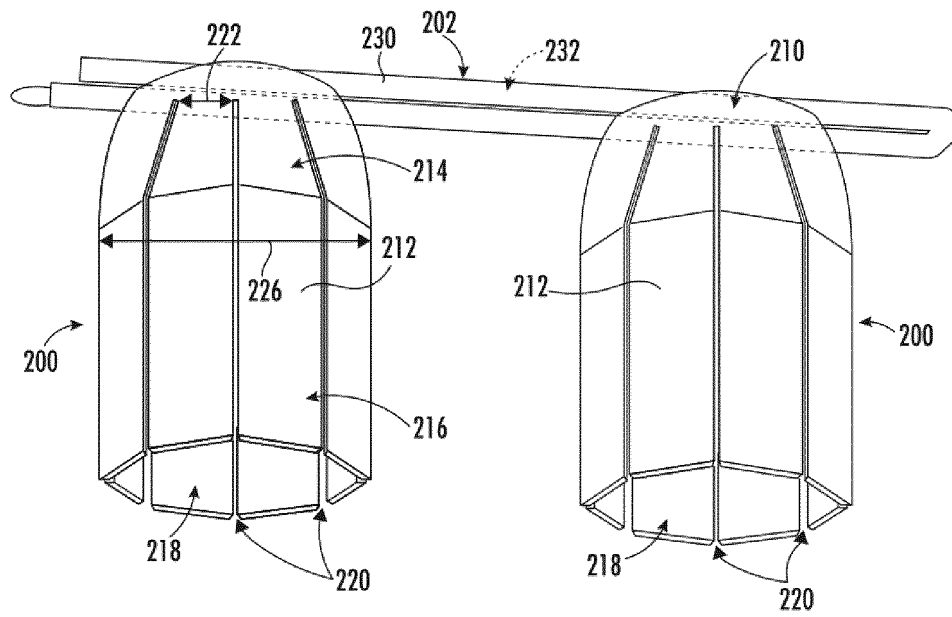


FIG. 6

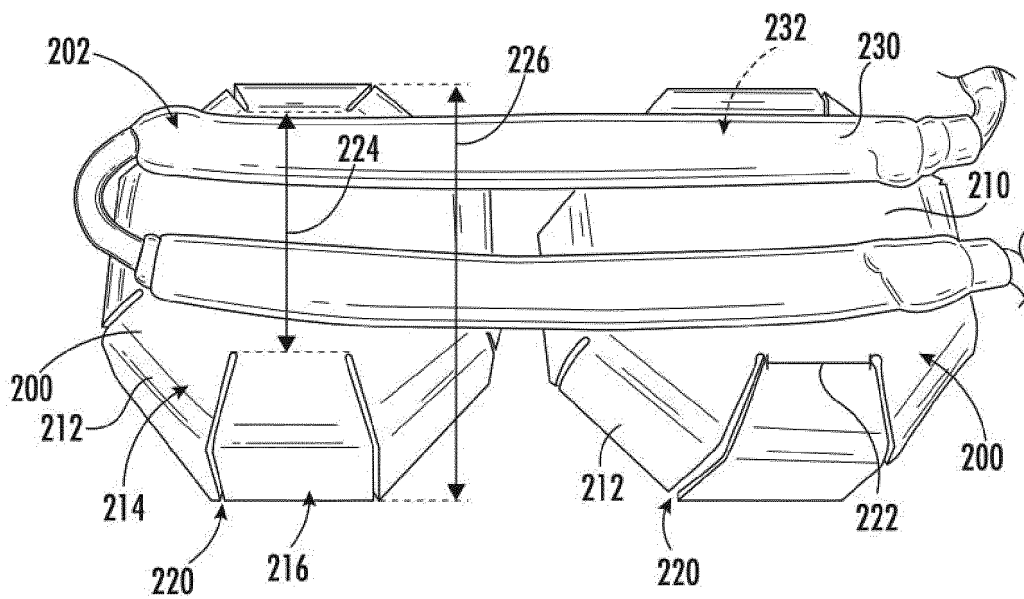


FIG. 7

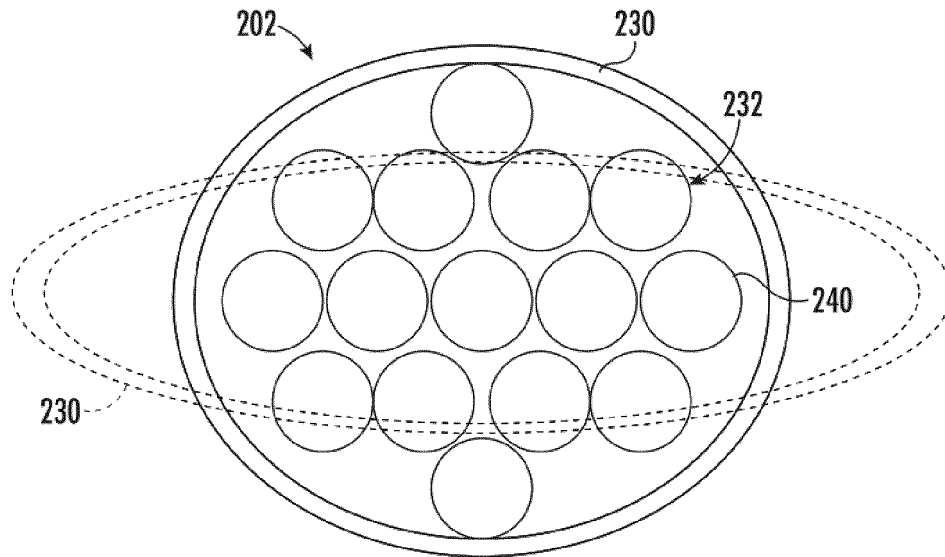


FIG. 8

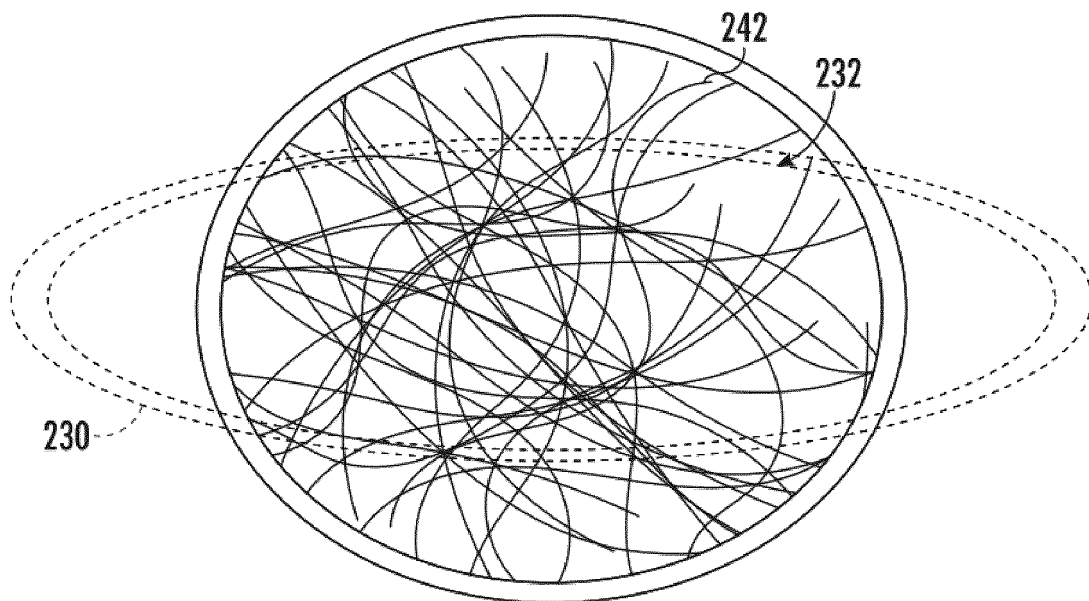


FIG. 9

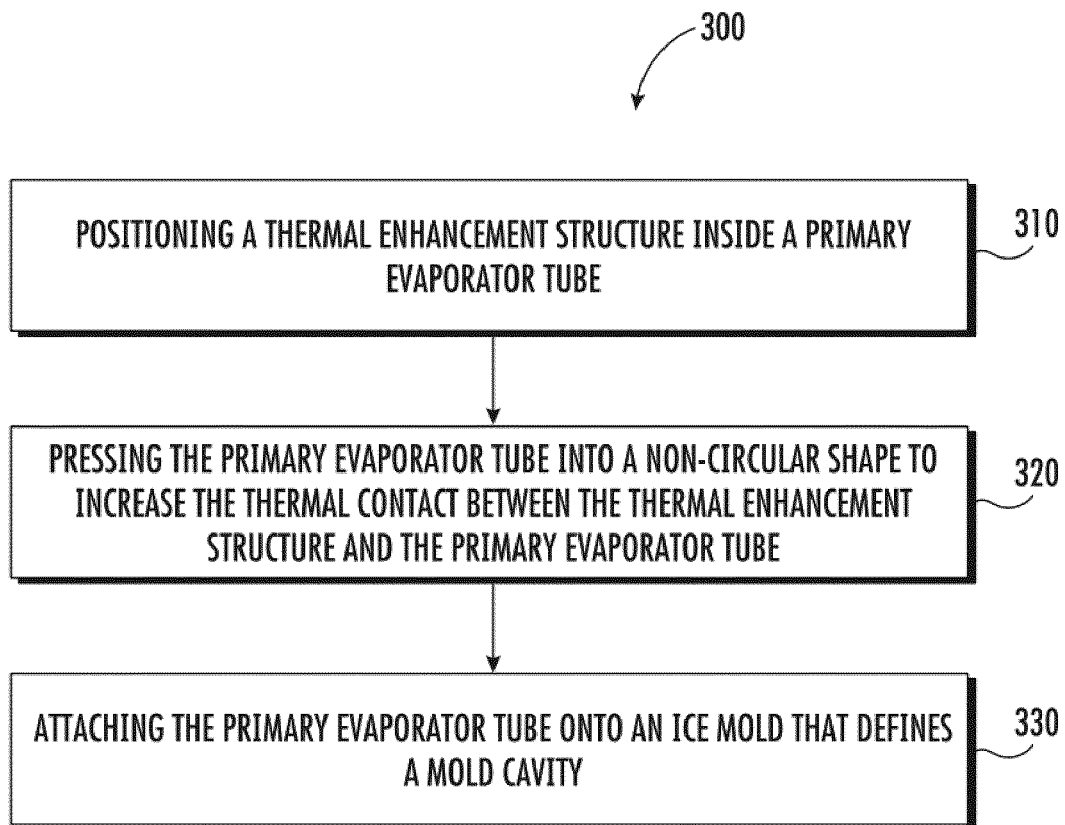


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/113703

A. CLASSIFICATION OF SUBJECT MATTER

F25C 1/04(2018.01)i; F25B 39/00(2006.01)i; F28F 1/40(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25C1/-;F25B39;/F28F1/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

SIPOABS, DWPI, CNABS, CNTXT, PATENTICS, 海尔, 制冰, 热交换管, 换热管, 传热管, 蒸发器管, 泡沫金属, 金属泡沫, 喷射, 热增强, 增强换热, 内部管, 内管, 内芯, 管中管, heat w exchange+, pipe+, spray+, metal w foam+, inner w tube+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	CN 1036824 A (THEO WESSA) 01 November 1989 (1989-11-01) entire document	1-20
A	CN 1880889 A (LG ELECTRONICS (TIANJIN) ELECTRICAL APPLIANCES CO., LTD.) 20 December 2006 (2006-12-20) entire document	1-20

☐ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

26 November 2020

Date of mailing of the international search report

08 December 2020

Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/
CN)
No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing
100088
China

Authorized officer

Facsimile No. (86-10)62019451

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2020/113703

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