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(54) **ICE MAKING MACHINE AND ICE CUBE EVAPORATOR**

EISERZEUGUNGSMASCHINE UND EISWÜRFELVERDAMPFER

MACHINE DE FABRICATION DE GLACE ET ÉVAPORATEUR À GLAÇONS

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Description

Background of the Invention

[0001] The present invention relates to an evaporator, an ice making machine incorporating the evaporator, and a process for making the evaporator.

[0002] KR 2015 0124222 A relates to a flat cold-water tank with an ice-making unit arranged in between two cases of the flat cold-water tank. The ice-making unit comprises a meander-shaped refrigerant pipe and ice generated on an outer circumferential surface of the refrigerant pipe. The refrigerant pipe comprises a first linear portion, a second linear portion and multiple protruding portions. The refrigerant pipe further comprises a refrigerant pipe inlet and a refrigerant pipe outlet. A water cooling channel is provided with a portion of its outer circumferential surface being formed by the outer circumferential surface of the ice-making unit. The water cooling channel comprises a water cooling channel inlet and a water cooling channel outlet. One of the cases comprises recessed portions, in which the refrigerant pipe is arranged. The other one of the cases also comprises recessed portions for providing space for the generated ice of the ice-making unit. The ice-making unit is cooling drinking water flowing in the cooling channels.

[0003] US 2015/375349A1 relates to a heat exchanger tube with ribs on an inner surface of the heat exchanger tube.

[0004] US 4,580,410 A relates to an ice product making machine comprising an ice-making mold with a meandering refrigerant pipe mounted on the back surface of the ice-making mold and water spray tube with water outlet apertures arranged on top of the ice-making mold.

[0005] Vertically extending ice-making recesses are defined between adjacent ribs on the ice-making mold. A number of formations are formed in each ice-making recess as one with the ice-making mold and are vertically spaced apart from one another. The formations may be formed as ribs, beads or bosses. When water is supplied from the spray tube to the ice-making recesses it is gradually frozen by means of chilled refrigerant supplied into the refrigerant pipe. Thereby, approximately semi-cylindrical ice products are formed between the formations, which are removed from the ice-making recesses by hot gas supplied into the refrigerant pipe.

[0006] US 4412429 discloses an ice making system with an evaporator comprising a front and a rear plate each having protrusions facing each other and defining cavities.

[0007] Automatic ice making machines are well known and are typically found in food and drink service establishments, hotels, motels, sports arenas, and various other places where large quantities of ice are needed on a continuous basis. Some automatic ice making machines produce flaked ice while others produce ice shaped in a variety of configurations, which are commonly referred to as cubes or nuggets.

[0008] Automatic ice making machines generally include a refrigeration system having a compressor, a condenser, an evaporator, and an expansion valve. A series of individual ice forming sites are formed on the evaporator and water is supplied to those sites by a water supply system by, for example, trickling or spraying water onto the ice forming site. The run-off of the water is usually recirculated within the water supply. The trickling or spraying methods of supplying water are normally preferred because the methods produce clear ice while the static filled pockets method generally produces white or opaque ice.

[0009] Automatic ice making machines are normally controlled as a function of the amount of ice in an ice bin of the ice making machine. When the supply of ice in the ice bin is insufficient, automatic controls cycle the ice making machine through ice production and ice harvest to supplement the supply of ice in the storage portion. In the ice production mode, the refrigeration system operates in a normal manner such that expanding refrigerant in the evaporator removes heat from the series of ice forming sites, freezing the water to form an outwardly growing layer of ice. When the ice thickness reaches a predetermined condition or a specified time period has elapsed, the ice making machine switches to harvest mode.

[0010] Typically the harvest mode involves a valve change which directs hot refrigerant gasses to the evaporator. The ice forming locations are heated by the hot refrigerant gasses until the ice in contact with the evaporator begins to thaw. Once the ice falls from the evaporator, it is collected by an appropriate ice bin. When more ice is required, the refrigerant system is switched back to the production mode and the cycle begins again. These cycles continue until there is sufficient ice in the ice bin.

[0011] In accordance with one aspect of the invention defined in claim 1, an evaporator comprises a refrigerant conduit and front and rear plates sandwiching the refrigerant conduit. The front and rear plates have inner flat portions, each inner flat portion of the front plate facing, but being spaced from, a respective inner flat portion of the rear plate to define a respective spaced portion. A plurality of triangular fins divide the respective plates into a plurality of ice forming columns. The front and rear plates also include a set of first protrusions defined in the respective ice forming columns, each first protrusion on the front plate facing a respective first protrusion on the rear plate to define a respective active cavity. The refrigerant conduit extends through each of the active cavities. The front and rear plates further include a set of second protrusions defined in the respective ice forming columns, each second protrusion on the front plate facing a respective second protrusion on the rear plate to define a respective passive cavity. The refrigerant conduit does not extend through any of the passive cavities. The location of the active and passive cavities are interspersed and separated by respective inner flat portions so as to

define a plurality of ice forming sites in the ice forming columns of the respective plates.

[0012] In a preferred embodiment, the evaporator uses a single refrigerant conduit having a serpentine shape. However, a plurality of refrigerant conduits can be used. For example, a first refrigerant conduit can be used for the upper half of the evaporator and a second refrigerant conduit can be used for the lower half of the evaporator. In either case, a portion of at least one of the refrigerant conduits preferably extends through each of the active cavities.

[0013] The refrigerant conduit is preferably a pipe having grooves formed along its inner surface so as to increase the inner surface area of the pipe and thereby improve the heat transfer between the refrigerant flowing through the pipe and the ice forming surfaces of the protrusions defining the ice forming cavities. The inner grooves preferably run helically along the inner surface of the pipe.

[0014] Each active cavity is preferably surrounded by a pair of inactive cavities which are connected to the active cavity by respective spaced portions. The spacing between the inner flat faces defining the respective spaced portions, as measured along a line running perpendicular to the flat faces is preferably between 1 and 2 mm. This is important because if the flat portions abut one another it has been found that corrosion can occur.

[0015] It has also been found that spaces between the inner walls of the active cavities and the refrigerant conduit passing through them can lead to corrosion of the protrusions forming the active cavities. This can lead to holes being formed in the protrusions which can allow water to enter the active cavities. If that happens water can freeze and melt during the ice making and ice harvesting cycles and can deform the plate and/or the refrigerant conduit. This decreases the heat transfer between the refrigerant in the refrigerant conduit and the outer surfaces of the active cavities and eventually can block refrigerant from passing through the refrigerant conduit. In order to avoid this problem, it is preferred that the outer surfaces of the refrigerant are pressed against (abut) the inner surfaces of the protrusions except for the area where the spaced portions meet the active cavity.

[0016] In the preferred embodiment, each protrusion of the respective pair has an outer flat portion surrounded by a pair of curved portions extending from the outer flat portion to the respective pair of inner flat portions. The refrigerant conduit takes the same form.

[0017] In one embodiment, the front and rear plates are connected to one another by an appropriate fastener such as bolts or rivets which extend through elongated slots in the front and rear plates. Because the slots are elongated, and preferably formed at a 45 degree angle with respect to the plane in which the inner flat portions lie, the slots need not be perfectly located in order to ensure that they will overlap allowing for easier assembly of the evaporator.

[0018] Each of the front plate and the rear plate in-

cludes a plurality of fins, which divide each of the front plate and the rear plate into a plurality of ice forming columns each including a plurality of ice forming sites. The ice forming columns preferably run parallel to one another and perpendicular to the direction that the at least one refrigerant conduit passes through the active cavities.

[0019] In another aspect of the invention, an ice making system according to claim 19 is proposed.

[0020] The source of refrigerant can switch between a cooling cycle, in which cooling refrigerant is passed through the refrigerant conduit(s) and ice is formed, and a harvesting cycle, wherein a warming refrigerant is passed through the refrigerant conduit(s) and ice falls off of the ice forming sites and is harvested.

[0021] In at least one other aspect of the invention, a method according to claim 17 is proposed, according to which inter alia the front plate and the rear plate are formed, in part, by bending a flat plate to include the plurality of fins which divide the plate into a plurality of ice forming columns. Each ice forming column preferably includes a plurality of ice forming sites. To assist in this process, notches are formed on the top and/or bottom edges of the flat plate at locations corresponding to the locations of the fins. The fins are then formed by bending the flat plates in a triangular shape while using the notches to determine where to form the fins.

Brief Description of the Drawings

[0022]

Fig. 1 is an isometric view of an evaporator constructed in accordance with the principles of the present invention.

Fig. 2 is a cross sectional view of portion of the evaporator of Fig. 1 taken along lines 2-2 of Fig. 1.

Fig. 3 is the same cross sectional view as Fig. 2 but shows the formation of ice cubes on some of the ice forming sites.

Fig. 4A is a cross sectional view of a pipe forming a preferred embodiment of the refrigerant conduit forming part of the evaporator of Fig. 1.

Fig. 4B is an enlarged view of a portion of the pipe shown in Fig. 4A.

Figs. 5A and 5B are enlarged views showing a portion of the outermost fins of the front and rear plates of the evaporator of Fig. 1 before and after the two plates are connected together.

Fig. 6 is a schematic view of an icemaker incorporating the evaporator of Fig. 1.

Fig. 7A is a plan view of a flat sheet used to construct the front or rear plate of the evaporator of Fig. 1.

Fig. 7B is a plan view of the flat sheet of Fig. 7A wherein notches have been added to the sheet to assist in the accurate formation of fins in the flat sheet.

Fig. 7C is an isometric view showing fins of the front and rear plates of the evaporator of Fig. 1 when the

plates are formed using the notches of Fig. 7B.

Figs. 8A through 8H show alternative shapes for the notches of Fig. 7B.

Detailed Description of the Preferred Embodiments

[0023] Referring now to the drawings wherein like numerals indicate like elements, there is shown in Fig. 1 an evaporator 10 comprising a serpentine refrigerant conduit 12 sandwiched by front and rear plates 14 and 16. The refrigerant conduit can be considered a coolant conduit. The front and rear plates 14, 16 are divided into a plurality of vertically extending ice forming columns 18 by a plurality of fins 20. A plurality of depressions 22, which can be considered dimples, are formed in the ice forming columns 18. In a preferred embodiment, the front and rear plates 14, 16 are formed from respective flat metal sheets. The sheets are first bent at spaced locations to form the fins 20. Thereafter depressions 22 are formed in the front and rear plates 14, 16 using tools similar to those shown in U.S. Application No. 14/022,887. When these tools are used, the portion of the refrigerant conduit 12 located adjacent to the depressions 22 is similarly deformed. However, as will become clearer below, the shape of the depressions 22 in the present embodiment is different than the shape of the depressions in U.S. Application No. 14/022,887 in order to achieve various improvements in the structure of the evaporator.

[0024] As best shown in Figs. 2 and 3, the depressions 22 are formed in the front and rear plates to form active cavities 24 and passive cavities 26. The refrigerant conduit 12 passes through the active cavities 24 but not through the passive cavities 26. As a result, the active cavities 24 are cooled by the refrigerant passing through the refrigerant conduit 12 during the ice forming cycle and, when water is applied to the surfaces of the front and rear plates 14, 16, will form ice cubes on ice forming sites 28 described in further detail below.

[0025] The depressions 22 have an inner flat portion 30 surrounded by two curved portions 32 which terminate at an outer flat portion 34 located between adjacent depressions. In the preferred embodiment, the inner flat portions 30 lie in a first plane and the outer flat portions 34 lie in a second plane, parallel to and spaced from the first plane. Each inner flat portion 30 on front plate 14 opposes a corresponding inner flat portion 30 on the rear plate 16 but is spaced from the opposed inner flat portion.

[0026] The combination of the curved portions 32 and the outer flat portions 34 on the front plate 14 define a series of first and second protrusions 36, 38 on the front plate 14, and the combination of the curved portions 32 and the outer flat portions 34 on the rear plate 16 similarly define a series of first and second protrusions 36, 38 on the rear plate 16. Each first protrusion 36 on the front plate 14 opposes a corresponding first protrusion on the rear plate 16 to form a respective active cavity 24. Each second protrusion 38 and the front plate 14 opposes a

corresponding second protrusion on the rear plate 16 to form a respective passive cavity 26. Respective pairs of inner flat portions 30 face one another to form respective spaced portions 40. As noted above, it has been found that if the inner flat portions 30 abut one another corrosion can occur. To avoid this problem, the opposed inner flat portions are spaced apart, preferably by 1-2 mm.

[0027] Each first protrusion 36 (forming part of a respective active cavity 24) is located between an adjacent pair of second protrusions 38 (forming part of respective passive cavities 26) and is connected thereto by respective spaced portions 40.

[0028] A portion of the refrigerant conduit 12 passes through and is in thermal contact (and more preferably in direct physical contact) with the first and second protrusions 36, 38 forming each of the active cavities 40. As a result, there is an efficient transfer of heat from the refrigerant in the refrigerant conduit 12 to the outer surface of the first protrusions 36. This will define the heart of the ice forming site 28-ice will form on the first protrusion 36 and will grow laterally outwardly, preferably onto its adjacent inner flat portions 30 and onto at least part of the curved portions 32 of the adjacent second protrusions 38 forming part of the adjacent passive cavities 26.

[0029] This is best seen in Fig. 3, which shows the formation of ice cubes 42 on the rear plate 16. Similar ice cubes, not shown, will be formed on the ice forming sites 28 of the front plate 14. The degree to which the ice extends over the inner flat portions 30 and the adjacent second protrusions 38 is determined, at least in part, by the length of time that water is applied to the front and rear plates 14, 16 during the ice forming cycle.

[0030] Once ice cubes 42 of sufficient size have been formed, the system will switch to a harvesting cycle wherein relatively warm coolant is passed through the refrigerant conduit 12 and the ice cubes 42 will separate from the ice forming sites 28 and be collected in an ice bin 60 discussed further below.

[0031] In the preferred embodiment, a single refrigerant conduit 12 having a serpentine shape is used. It includes a plurality of straight portions which run perpendicular to the ice forming columns 18 and curved portions located outside of the front and rear plates 14, 16 and connecting the straight portions. While a single refrigerant conduit 12 is preferred, more than one conduit can be used. By way of example and not limitation, a first cooling conduit can be used for the upper half of the evaporator 10 and a second cooling conduit can be used for the lower half of the evaporator 10.

[0032] The refrigerant conduit 12 is preferably a round pipe. However, during assembly of the evaporator 10, the pipe is placed between the front and rear plates 14, 16 and dies or other means are used to form the depressions 22 (and therefore the active and passive cavities 24, 26) thereby deforming portions of the pipe extending between the front and rear plates 14, 16 into the generally ovoid shape shown in Figs. 2 and 3. As a result, the outer surface of the pipe and the inner surface of the active

cavities 40 are pressed against one another. This ensures good thermal conduction between the refrigerant passing through the refrigerant conduit 12 and the outer surfaces of the first protrusions 36. In the preferred embodiment, the outer surface of the refrigerant conduit 12 directly abuts the inner surface of the first protrusions 36. However, it is possible to provide another material interfacing those surfaces as long as the material has a sufficiently high thermal conductivity to ensure efficient transfer of energy between the outer surface of the first protrusion 36 and the coolant passing through the refrigerant conduit 12.

[0033] To further improve the thermal conductivity between the refrigerant and the outer surfaces of the first protrusion 36, grooves 44 (see Figs. 4A and 4B) are preferably formed on the inner surface of the refrigerant conduit 12 to increase its inner surface area. The grooves preferably run in a helical manner relative to an axial center of the refrigerant conduit 12. The grooves 44 define projections 46 having the shape shown in Fig. 4B. More particularly, they are wider at their proximal base than at their distal tip and the tips are preferably rounded.

[0034] As best shown in Figs. 1, 5A, and 5B, projections 48 are formed on the outermost fins 50 and elongated slots 52 are formed in the projections 48 to receive rivets, bolts, or other connection means (not shown) to hold the front and rear plates 14, 16 together. The elongated slots are preferably formed at a 45 degree angle relative to the plane of the inner flat portions 30 and at 90 degrees with respect to one another.

[0035] In the past, round rivet receiving holes had been formed in the projections. However, this often made it difficult to pass the rivet through the holes due to tolerance errors or other variations in the process of forming the evaporator 10. The use of these elongated slots 52, especially when they run at a 45 degree angle relative to the plane of the inner flat portions 30 and at 90 degrees with respect to one another, overcomes this problem.

[0036] An ice forming machine 54 incorporating the evaporator 10 of the present invention is shown schematically in Fig. 6. The ice forming machine 54 includes a refrigerant system 56, a water supply 58, and an ice bin 60. The evaporator 10 forms part of the refrigerant system 56 which also includes a compressor 62, a condenser 64, and an expansion valve 66. The refrigerant system 56 preferably includes a valve 68, which switches between a first position where it passes low-temperature, low-pressure liquid refrigerant exiting the expansion valve 66 to the refrigerant conduit 12 of the evaporator 10 and a second position where it passes high-temperature, high-pressure gas existing the compressor 62 to the refrigerant conduit 12. A controller (not shown) detects how much ice is in the ice bin 60 and moves the refrigeration system between ice production and ice harvesting modes as a function thereof. When the controller determines that there is insufficient ice in the ice bin 60, it moves valve 68 into its first position so that low-temperature, low-pressure liquid coolant is supplied to the re-

frigerant conduit 12 thereby initiating the ice production mode. The controller maintains the valve 60 in this position until sufficiently sized ice cubes 42 are formed on the ice forming sites 28 and then switches the valve 68 into the second mode so that high-temperature, high-pressure coolant gas is supplied to refrigerant conduit 12 to thereby begin operation in the ice harvesting mode. During this mode, the temperature of the surface of the ice forming sites 28 will be raised and the ice cubes 42 will eventually separate from the ice forming sites 28 and be collected in the ice bin 60. If, after the harvesting mode has ended, there is still insufficient ice in the ice bin 60, the controller will recycle the refrigerant system 56 through the ice forming and ice harvesting modes until there is a sufficient level of ice in the ice bin 60. Once a sufficient amount of ice is in the ice bin 60, the controller will typically shut down the refrigerant system 56 until additional ice is required.

[0037] A process for forming the fins 20 in the front and rear plates 14, 16 will now be described with reference to Figs. 7A, 7B and 7C. As shown in Figs. 7A and 7B, each front and rear plate starts out as a rectangular, typically metal, plate. The fins 20 have to be formed at preferably equally spaced locations along the plate (only one such location is shown in Fig. 7A). Each fin 20 is formed by a bending machine (not shown) which bends the plate along three lines 70, 72, and 74 to form the triangular fin 20 shown in Fig. 7C.

[0038] After a given fin 20 is formed, a plate roller machine (not shown) moves the plate by a distance corresponding to the desired distance between adjacent fins 20. However, due to slippage and other variables, for example if the feeding direction is not perpendicular to the location of the bending machine, it is difficult to accurately and reliably do so. In order to overcome this problem, an aspect of the invention adds notches 76 to at least one of the side surfaces of the plate. The spacing of the notches 76 corresponds to the desired spacing of the fins 20. In the preferred embodiment, the notches 76 are located at the center line 72 corresponding to the center of the fins 20. However, the notches 76 need not be located at this position as long as they have a spacing which allows the plate roller machine to accurately locate the center line 72 of the fins 20. A locator 78 is then used to locate the position of the notch 76 and a controller (not shown) uses this information to cause the plate roller machine to accurately position the sheet relative to the bending machine, thereby ensuring that the fins 60 are formed at the correct locations.

[0039] Because of the use of the notches 76, the top and/or bottom of the front and rear plates 14, 16 will include a chamfer as shown in Fig. 7A. In the preferred embodiment, the notch 76 is a triangular notch and the chamfer has the shape shown. However, the notches can take other shapes (e.g., round, square, etc.) resulting in different chamfer profiles (as projected along a plane running perpendicular to the plane of the inner flat portions 30) such as those shown in Figs. 8A-8H.

Claims

1. An evaporator (10) for an ice making system comprising:

a refrigerant conduit (12); and
front and rear plates (14, 16) sandwiching the refrigerant conduit (12), each of the front and rear plates (14, 16) having:

inner flat portions (30), each inner flat portion (30) of the front plate (14) facing, but being spaced from, a respective inner flat portion (30) of the rear plate (16) to define a respective spaced portion (40);
a plurality of triangular fins (20) dividing the respective plate (14, 16) into a plurality of ice forming columns (18);
a set of first protrusions (36) defined in the respective ice forming columns (18), each first protrusion (36) on the front plate (14) facing a respective first protrusion (36) on the rear plate (16) to define a respective active cavity (24), the refrigerant conduit (12) extending through each of the active cavities (24); and
a set of second protrusions (38) defined in the respective ice forming columns (18), each second protrusion (38) on the front plate (14) facing a respective second protrusion (38) on the rear plate (16) to define a respective passive cavity (26), the refrigerant conduit (12) not extending through any of the passive cavities (26);
wherein the active and passive cavities (24, 26) are interspersed and separated by respective inner flat portions (30) so as to define a plurality of ice forming sites (28) in the ice forming columns (18) of the respective plate (14, 16).
2. The evaporator (10) of claim 1, wherein the refrigerant conduit (12) has a serpentine shape.
3. The evaporator (10) of claim 2, wherein the refrigerant conduit (12) is a pipe having grooves (44) formed along its inner surface.
4. The evaporator (10) of claim 3, wherein the grooves (44) run helically along the inner surface of the pipe.
5. The evaporator (10) of any one of claims 1 to 4, wherein the spacing between each respective pairs of inner flat faces defining a respective spaced portion (40) is between 1 and 2 mm as measured along a line running perpendicular to the inner flat faces.
6. The evaporator (10) of any one of claims 1 to 5,

wherein, for each active cavity (24), the entire inner surface of the first protrusion (36) that defines the active cavity (24) is in thermal contact with the outer surface of the refrigerant conduit (12) extending through the active cavity (24).
7. The evaporator (10) of claim 6, wherein, for each active cavity (24), the entire inner surface of the first protrusion (36) that defines the active cavity (24) abuts the outer surface of the refrigerant conduit (12) extending through the active cavity (24).
8. The evaporator (10) of claim 6, wherein each of the first protrusions (36) defining a respective active cavity (24) has an outer surface including an outer flat portion (34) surrounded by a pair of curved portions (32) extending from the outer flat portion (34) to the respective pair of inner flat portions (30).
9. The evaporator (10) of claim 8, wherein the inner flat portions (30) lie in a first plane and the outer flat portions (34) lie in a second plane spaced from the first plane.
10. The evaporator (10) of any one of claims 1 to 9, wherein the front and rear plates (14, 16) are connected to one another by fasteners extending through elongated slots (52) in the front and rear plates (14, 16).
11. The evaporator (10) of claim 10, wherein the elongated slots (52) are formed in outermost fins (50) of the front and rear plates (14, 16).
12. The evaporator (10) of claim 11, wherein the elongated slots (52) are formed at a 45 degree angle relative to a plane in which the inner flat portions (30) lie.
13. The evaporator of claim 12, wherein the plurality of fins (20) are formed at equally spaced locations along the plate (14, 16).
14. The evaporator (10) of any one of claims 1 to 13, wherein the ice forming columns (28) are parallel to one another.
15. The evaporator (10) of claim 14, wherein the refrigerant conduit (12) extends through at least some of the active cavities (24) in a direction perpendicular to the direction of the ice forming columns (18).
16. The evaporator (10) of any one of claims 1 to 15, wherein each of the plurality of fins (20) has upper and lower ends which, when projected onto a plane running perpendicular to the inner flat portions (30), each define a notch (76).

17. A method for making an evaporator (10) for an ice making system, the method comprising:
forming front and rear plates (14, 16) of the evaporator (10) from respective flat plates, each of the front and rear plates (14, 16) comprising:

inner flat portions (30), each inner flat portion (30) of the front plate (14) facing, but being spaced from, a respective inner flat portion (30) of the rear plate (16) to define a respective spaced portion (40);
a plurality of fins (20) dividing the respective plate (14, 16) into a plurality of ice forming columns (18);
a set of first protrusions (36) defined in the respective ice forming columns (18), each first protrusion (36) on the front plate (14) facing a respective first protrusion (36) on the rear plate (16) to define a respective active cavity (24);
a set of second protrusions (38) defined in the respective ice forming columns (18), each second protrusion (38) on the front plate (14) facing a respective second protrusion (38) on the rear plate (16) to define a respective passive cavity (26); and wherein the active and passive cavities (24, 26) are interspersed and separated by respective inner flat portions (30) so as to define a plurality of ice forming sites (28) in the ice forming columns (18) of the respective plate (14, 16);
forming each of the plurality of fins (20) by bending the flat plates into a triangular shape; and
sandwiching a refrigerant conduit (12) of the evaporator (10) between the front and rear plates (14, 16), the refrigerant conduit (12) extending through each of the active cavities (24) but not extending through any of the passive cavities (26).

18. The method of claim 17, wherein each of the respective flat plates defines a top edge and a bottom edge, the method further comprising forming a plurality of notches (76) in each of the top edge and the bottom edge of the respective flat plate, each notch (76) of the plurality of notches (76) defined in a portion of the respective flat plate defining one of the plurality of fins (20).

19. An ice making system (54) comprising:
a refrigerant system (56) for circulating cold refrigerant through an evaporator (10), the evaporator (10) including:

a refrigerant conduit (12); and
front and rear plates (14, 16) sandwiching the refrigerant conduit (12), the front and rear plates (14, 16) having:

inner flat portions (30), each inner flat por-

tion (30) of the front plate (14) facing, but being spaced from, a respective inner flat portion (30) of the rear plate (16) to define a respective spaced portion (40);
a plurality of fins (20) dividing the respective plate (14, 16) into a plurality of ice forming columns (18);
a set of first protrusions (36) defined in the respective ice forming columns (18), each first protrusion (36) on the front plate (14) facing a respective first protrusion (36) on the rear plate (16) to define a respective active cavity (24), the refrigerant conduit (12) extending through each of the active cavities (24); and
a set of second protrusions (36) defined in the respective ice forming columns (18), each second protrusion (36) on the front plate (14) facing a respective second protrusion (36) on the rear plate (16) to define a respective passive cavity (26), the refrigerant conduit (12) not extending through any of the passive cavities (26);
wherein the active and passive cavities (24, 26) are interspersed and separated by respective inner flat portions (30) so as to define a plurality of ice forming sites (28) in the ice forming columns (18) of the respective plate (14, 16); and
a source of water applying liquid water to the front and rear plates (14, 16) whereby ice will be formed at the respective ice forming sites (28).

Patentansprüche

1. Verdampfer (10) für ein Eisherstellungssystem, umfassend:

eine Kühlmittleitung (12); und
vordere und hintere Platten (14, 16), die die Kühlmittleitung (12) zwischen sich einschließen, wobei jede von den vorderen und hinteren Platten (14, 16) aufweisen:

innere flache Bereiche (30), wobei jeder innere flache Bereich (30) der vorderen Platte (14) einem jeweiligen inneren flachen Bereich (30) der hinteren Platte (16) zugewandt aber davon beabstandet ist, um einen jeweiligen beabstandeten Bereich (40) zu definieren;
eine Mehrzahl von dreieckigen Finnen (20), die die jeweilige Platte (14, 16) in eine Mehrzahl von Eisbildungssäulen (18) unterteilen;
eine Menge von ersten Vorsprüngen (36),

- die in den jeweiligen Eisbildungssäulen (18) definiert sind, wobei jeder erste Vorsprung (36) an der vorderen Platte (14) einem jeweiligen ersten Vorsprung (36) an der hinteren Platte (16) zugewandt ist, um eine jeweilige aktive Kavität (24) zu definieren, wobei sich die Kühlmittleitung (12) durch jede von den aktiven Kavitäten (24) erstreckt; und eine Menge von zweiten Vorsprüngen (38), die in den jeweiligen Eisbildungssäulen (18) definiert sind, wobei jeder zweite Vorsprung (38) an der vorderen Platte (14) einem jeweiligen zweiten Vorsprung (38) an der hinteren Platte (16) zugewandt ist, um eine jeweilige passive Kavität (26) zu definieren, wobei sich die Kühlmittleitung (12) nicht durch eine von den passiven Kavitäten (26) erstreckt; wobei die aktiven und passiven Kavitäten (24, 26) durch jeweilige innere flache Bereiche (30) durchsetzt und getrennt sind, um eine Mehrzahl von Eisbildungstätten (28) in den Eisbildungssäulen (18) der jeweiligen Platte (14, 16) zu definieren.
2. Verdampfer (10) nach Anspruch 1, wobei die Kühlmittleitung (12) eine Serpentinform aufweist.
 3. Verdampfer (10) nach Anspruch 2, wobei die Kühlmittleitung (12) ein Rohr ist, das Nuten (44) aufweist, die entlang dessen innerer Oberfläche ausgebildet sind.
 4. Verdampfer (10) nach Anspruch 3, wobei die Nuten (44) schraubenförmig entlang der inneren Oberfläche des Rohrs verlaufen.
 5. Verdampfer (10) nach jedem der Ansprüche 1 bis 4, wobei die Beabstandung zwischen jedem der jeweiligen Paare von inneren flachen Flächen, die einen jeweiligen beabstandeten Bereich (40) definieren, zwischen 1 und 2 mm liegt, wie entlang einer Linie gemessen, die senkrecht zu den inneren flachen Flächen verläuft.
 6. Verdampfer (10) nach jedem der Ansprüche 1 bis 5, wobei sich für jede aktive Kavität (24) die gesamte innere Oberfläche des ersten Vorsprungs (36), der die aktive Kavität (24) definiert, in thermischen Kontakt mit der äußeren Oberfläche der Kühlmittleitung (12) befindet, die sich durch die aktive Kavität (24) erstreckt.
 7. Verdampfer (10) nach Anspruch 6, wobei für jede aktive Kavität (24) die gesamte innere Oberfläche des ersten Vorsprungs (36), der die aktive Kavität (24) definiert, an die äußere Oberfläche der Kühlmittleitung (12) angrenzt, die sich durch die aktive Kavität (24) erstreckt.
 8. Verdampfer (10) nach Anspruch 6, wobei jeder von den ersten Vorsprüngen (36), die eine jeweilige aktive Kavität (24) definieren, eine äußere Oberfläche aufweist, die einen äußeren flachen Bereich (34) enthält, der von einem Paar von gekrümmten Bereichen (32) umgeben ist, die sich von dem äußeren flachen Bereich (34) zu dem jeweiligen Paar von inneren flachen Bereichen (30) erstrecken.
 9. Verdampfer (10) nach Anspruch 8, wobei die inneren flachen Bereiche (30) in einer ersten Ebene liegen und die äußeren flachen Bereiche (34) in einer zweiten Ebene liegen, die von der ersten Ebene beabstandet ist.
 10. Verdampfer (10) nach jedem der Ansprüche 1 bis 9, wobei die vorderen und hinteren Platten (14, 16) miteinander durch Befestigungsmittel verbunden sind, die die sich durch längliche Schlitzte (52) in den vorderen und hinteren Platten (14, 16) erstreckt.
 11. Verdampfer (10) nach Anspruch 10, wobei die länglichen Schlitzte (52) in äußersten Finnen (50) der vorderen und hinteren Platten (14, 16) ausgebildet sind.
 12. Verdampfer (10) nach Anspruch 11, wobei die länglichen Schlitzte (52) in einem 45-Grad-Winkel, relativ zu einer Ebene, in der die inneren flachen Bereiche (30) liegen, ausgebildet sind.
 13. Verdampfer nach Anspruch 12, wobei die Mehrzahl von Finnen (20) an gleichmäßig beabstandeten Orten entlang der Platte (14, 16) ausgebildet sind.
 14. Verdampfer (10) nach jedem der Ansprüche 1 bis 13, wobei die Eisbildungssäulen (28) parallel zueinander sind.
 15. Verdampfer (10) nach Anspruch 14, wobei sich die Kühlmittleitung (12) durch zumindest einige von den aktiven Kavitäten (24) in eine Richtung erstreckt, die senkrecht zu der Richtung der Eisbildungssäulen (18) ist.
 16. Verdampfer (10) nach jedem der Ansprüche 1 bis 15, wobei jede von der Mehrzahl von Finnen (20) obere und untere Enden aufweisen, von denen, wenn sie auf eine Ebene projiziert werden, die senkrecht zu den inneren flachen Bereichen (30) verläuft, jedes eine Vertiefung (76) definiert.
 17. Verfahren zum Herstellen eines Verdampfers (10) für ein Eisherstellungssystem, wobei das Verfahren umfasst:
Ausbilden von vorderen und hinteren Platten (14, 16) des Verdampfers (10) aus jeweiligen flachen

Platten, wobei jede der vorderen und hinteren Platten (14, 16) umfasst:

innere flache Bereiche (30), wobei jeder innere flache Bereich (30) der vorderen Platte (14) einem jeweiligen inneren flachen Bereich (30) der hinteren Platte (16) zugewandt aber davon beabstandet ist, um einen jeweiligen beabstandeten Bereich (40) zu definieren;
 eine Mehrzahl von Finnen (20), die die jeweilige Platte (14, 16) in eine Mehrzahl von Eisbildungssäulen (18) unterteilen;
 eine Menge von ersten Vorsprüngen (36), die in den jeweiligen Eisbildungssäulen (18) definiert sind, wobei jeder erste Vorsprung (36) an der vorderen Platte (14) einem jeweiligen ersten Vorsprung (36) an der hinteren Platte (16) zugewandt ist, um eine jeweilige aktive Kavität (24) zu definieren;
 eine Menge von zweiten Vorsprüngen (38), die in den jeweiligen Eisbildungssäulen (18) definiert sind, wobei jeder zweite Vorsprung (38) an der vorderen Platte (14) einem jeweiligen zweiten Vorsprung (38) an der hinteren Platte (16) zugewandt ist, um eine jeweilige passive Kavität (26) zu definieren; und
 wobei die aktiven und passiven Kavitäten (24, 26) durch jeweilige innere flache Bereiche (30) durchsetzt und getrennt sind, um eine Mehrzahl von Eisbildungsstätten (28) in den Eisbildungssäulen (18) der jeweiligen Platte (14, 16) zu definieren
 Ausbilden jeder der Mehrzahl von Finnen (20) durch Biegen der flachen Platten in eine dreieckige Form; und Einschließen einer Kühlmittleitung (12) des Verdampfers (10) zwischen den vorderen und hinteren Platten (14, 16), wobei sich die Kühlmittleitung (12) durch jede der aktiven Kavitäten (24) erstreckt, sich aber nicht durch eine von den passiven Kavitäten (26) erstreckt.

18. Verfahren nach Anspruch 17, wobei jede von den jeweiligen flachen Platten eine obere Kante und eine untere Kante definiert, wobei das Verfahren weiter umfasst Ausbilden einer Mehrzahl Vertiefungen (76) in jeder von der oberen Kante und der unteren Kante der jeweiligen flachen Platte, wobei jede Vertiefung (76) von der Mehrzahl von Vertiefungen (76), die in einem Bereich der jeweiligen flachen Platte definiert sind, eine von der Mehrzahl von Finnen (20) definiert.

19. Eisherstellungssystem (54), umfassend:
 ein Kühlmittelsystem (56) zum Umwälzen eines kalten Kühlmittels durch einen Verdampfer (10), wobei der Verdampfer (10) enthält:

eine Kühlmittleitung (12); und
 vordere und hintere Platten (14, 16), die die Kühlmittleitung (12) einschließen, wobei die vorderen und hinteren Platten (14, 16) aufweisen:

innere flache Bereiche (30), wobei jeder innere flache Bereich (30) der vorderen Platte (14) einem jeweiligen inneren flachen Bereich (30) der hinteren Platte (16) zugewandt aber davon beabstandet ist, um einen jeweiligen beabstandeten Bereich (40) zu definieren;
 eine Mehrzahl von Finnen (20), die die jeweilige Platte (14, 16) in eine Mehrzahl von Eisbildungssäulen (18) unterteilen;
 eine Menge von ersten Vorsprüngen (36), die in den jeweiligen Eisbildungssäulen (18) definiert sind, wobei jeder erste Vorsprung (36) an der vorderen Platte (14) einem jeweiligen ersten Vorsprung (36) an der hinteren Platte (16) zugewandt ist, um eine jeweilige aktive Kavität (24) zu definieren, wobei sich die Kühlmittleitung (12) durch jede von den aktiven Kavitäten (24) erstreckt; und eine Menge von zweiten Vorsprüngen (38), die in den jeweiligen Eisbildungssäulen (18) definiert sind, wobei jeder zweite Vorsprung (38) an der vorderen Platte (14) einem jeweiligen zweiten Vorsprung (38) an der hinteren Platte (16) zugewandt ist, um eine jeweilige passive Kavität (26) zu definieren, wobei sich die Kühlmittleitung (12) nicht durch eine von den passiven Kavitäten (26) erstreckt;
 wobei die aktiven und passiven Kavitäten (24, 26) durch jeweilige innere flache Bereiche (30) durchsetzt und getrennt sind, um eine Mehrzahl von Eisbildungsstätten (28) in den Eisbildungssäulen (18) der jeweiligen Platte (14, 16) zu definieren; und
 eine Wasserquelle, die flüssiges Wasser auf die vorderen und hinteren Platten (14, 16) aufbringt, wodurch Eis an den jeweiligen Eisbildungsstätten (28) ausgebildet wird.

Revendications

1. Un évaporateur (10) pour un système de fabrication de glace comprenant :

un conduit de réfrigérant (12) ; et
 des plaques avant et arrière (14, 16) prenant en sandwich le conduit de réfrigérant (12), chacune des plaques avant et arrière (14, 16) ayant :

- des parties plates intérieures (30), chaque partie plate intérieure (30) de la plaque avant (14) faisant face à une partie plate intérieure respective (30) de la plaque arrière (16), mais étant espacée de celle-ci, pour définir une partie espacée respective (40) ;
- une pluralité d'éléments triangulaires des nageoires (20) divisant la plaque respective (14, 16) en une pluralité de glaces formant des colonnes (18) ;
- un ensemble de premières saillies (36) définies dans les colonnes de formation de glace (18), chaque première saillie (36) sur la plaque avant (14) faisant face à une première saillie respective (36) sur la plaque arrière (16) pour définir une cavité active respective (24), le conduit de réfrigérant (12) s'étendant à travers chacune des cavités actives (24) ; et
- un ensemble de secondes protubérances (38) définies dans les colonnes de formation de glace (18), chaque seconde protubérance (38) sur la plaque avant (14) faisant face à une seconde protubérance respective (38) sur la plaque arrière (16) pour définir une cavité passive respective (26), le conduit de réfrigérant (12) ne s'étendant à travers aucune des cavités passives (26) ;
- dans lequel les cavités active et passive (24, 26) sont intercalées et séparées par des parties plates intérieures (30) respectives de manière à définir une pluralité de sites de formation de glace (28) dans les colonnes de formation de glace (18) de la plaque respective (14, 16).
2. Evaporateur (10) selon la revendication 1, dans lequel le conduit de réfrigérant (12) a une forme serpentine.
 3. Evaporateur (10) selon la revendication 2, dans lequel le conduit de réfrigérant (12) est un tuyau ayant des rainures (44) formées le long de sa surface interne.
 4. Evaporateur (10) selon la revendication 3, dans lequel les rainures (44) s'étendent de manière hélicoïdale le long de la surface intérieure du tuyau.
 5. Evaporateur (10) selon l'une quelconque des revendications 1 à 4, dans lequel l'espacement entre chaque paire respective de faces plates intérieures définissant une partie espacée respective (40) est compris entre 1 et 2 mm, tel que mesuré le long d'une ligne s'étendant perpendiculairement aux faces plates intérieures.
 6. Evaporateur (10) selon l'une quelconque des revendications 1 à 5, dans lequel, pour chaque cavité active (24), toute la surface intérieure de la première protubérance (36) qui définit la cavité active (24) est en contact thermique avec la surface extérieure du conduit de réfrigérant (12) s'étendant à travers la cavité active (24).
 7. Evaporateur (10) selon la revendication 6, dans lequel, pour chaque cavité active (24), toute la surface intérieure de la première saillie (36) qui définit la cavité active (24) est en contact avec la surface extérieure du conduit de réfrigérant (12) s'étendant à travers la cavité active (24) .
 8. Evaporateur (10) selon la revendication 6, dans lequel chacune des premières saillies (36) définissant une cavité active respective (24) a une surface extérieure comprenant une partie plate extérieure (34) entourée par une paire de parties courbes (32) s'étendant de la partie plate extérieure (34) à la paire respective de parties plates intérieures (30).
 9. Evaporateur (10) selon la revendication 8, dans lequel les parties plates intérieures (30) se trouvent dans un premier plan et les parties plates extérieures (34) se trouvent dans un second plan espacé du premier plan.
 10. Evaporateur (10) selon l'une quelconque des revendications 1 à 9, dans lequel les plaques avant et arrière (14, 16) sont reliées entre elles par des attaches s'étendant à travers des fentes allongées (52) dans les plaques avant et arrière (14, 16).
 11. Evaporateur (10) selon la revendication 10, dans lequel les fentes allongées (52) sont formées dans les ailerons extérieurs (50) des plaques avant et arrière (14, 16).
 12. Evaporateur (10) selon la revendication 11, dans lequel les fentes allongées (52) sont formées à une distance de 45 degré d'angle par rapport à un plan dans lequel se trouvent les parties plates intérieures (30).
 13. Evaporateur selon la revendication 12, dans lequel la pluralité d'ailettes (20) sont formées à des endroits équidistants le long de la plaque (14, 16).
 14. Evaporateur (10) selon l'une quelconque des revendications 1 à 13, dans lequel les colonnes de formation de glace (28) sont parallèles entre elles.
 15. Evaporateur (10) selon la revendication 14, dans lequel le conduit de réfrigérant (12) s'étend à travers au moins certaines des cavités actives (24) dans une direction perpendiculaire à la direction des colonnes

de formation de glace (18).

16. Evaporateur (10) selon l'une quelconque des revendications 1 à 15, dans lequel chacune de la pluralité d'ailettes (20) a des extrémités supérieure et inférieure qui, lorsqu'elles sont projetées sur un plan s'étendant perpendiculairement aux parties plates intérieures (30), définissent chacune une encoche (76).
17. Procédé de fabrication d'un évaporateur i (10) pour un système de fabrication de glace, le procédé comprenant :
- la formation de plaques avant et arrière (14, 16) de l'évaporateur (10) à partir de plaques plates respectives, chacune des plaques avant et arrière (14, 16) comprenant :
- des parties plates intérieures (30), chaque partie plate intérieure (30) de la plaque avant (14) faisant face, mais étant espacée d'une partie plate intérieure respective (30) de la plaque arrière (16) pour définir une partie espacée respective (40) ;
- une pluralité d'ailettes (20) divisant la plaque respective (14, 16) en une pluralité de colonnes de formation de glace (18) ;
- un ensemble de premières saillies (36) définies dans les colonnes de formation de glace respectives (18), chaque première saillie (36) sur la plaque avant (14) faisant face à une première saillie respective (36) sur la plaque arrière (16) pour définir une cavité active respective (24) ;
- un ensemble de secondes protubérances (38) définies dans les colonnes respectives de formation de glace (18), chaque seconde saillie (38) sur la plaque avant (14) faisant face à une seconde saillie respective (38) sur la plaque arrière (16) pour définir une cavité passive respective (26) ; et
- dans laquelle les cavités actives et passives (24, 26) sont intercalées et séparées par des parties plates intérieures respectives (30) de manière à définir une pluralité de sites de formation de glace (28) dans les colonnes de formation de glace (18) de la plaque respective (14, 16) ;
- former chacune de la pluralité d'ailettes (20) en courbant les plaques plates en une forme triangulaire ; et
- en prenant en sandwich un conduit de réfrigérant (12) de l'évaporateur (10) entre les plaques avant et arrière (14, 16), le conduit de réfrigérant (12) s'étendant à travers chacune des cavités actives (24) mais ne s'étendant à travers aucune des cavités passives (26).
18. Procédé selon la revendication 17, dans lequel chacune des plaques plates respectives définit un bord

supérieur et un bord inférieur, le procédé comprenant en outre la formation d'une pluralité d'encoches (76) dans chacun du bord supérieur et du bord inférieur de la plaque plate respective, chaque encoche (76) de la pluralité d'encoches (76) définie dans une partie de la plaque plate respective définissant une de la pluralité d'ailettes (20).

19. Un système de fabrication de glace (54) comprenant :

un système réfrigérant (56) pour faire circuler un réfrigérant froid à travers un évaporateur (10),

l'évaporateur (10) comprenant :

un conduit de frigorigène (12) ; et

plaques avant et arrière (14, 16) prenant en sandwich le conduit de réfrigérant (12), les plaques avant et arrière (14, 16) ayant :

des parties plates intérieures (30), chaque partie plate intérieure (30) de la plaque avant (14) faisant face à une partie plate intérieure respective (30) de la plaque arrière (16), mais étant espacée de celle-ci, pour définir une partie espacée respective (40) ;

une pluralité d'ailettes (20) divisant la plaque respective (14, 16) en une pluralité de colonnes de formation de glace (18) ;

un ensemble de premières saillies (36) définies dans les colonnes de formation de glace respectives (18), chaque première saillie (36) sur la plaque avant (14) faisant face à une première saillie respective (36) sur la plaque arrière (16) pour définir une cavité active respective (24), le conduit de réfrigérant (12) s'étendant à travers chacune des cavités actives (24) ; et

un ensemble de secondes protubérances (36) définies dans les colonnes respectives de formation de glace (18), chaque seconde saillie (36) sur la plaque avant (14) faisant face à une seconde saillie respective (36) sur la plaque arrière (16) pour définir une cavité passive respective (26), le conduit de réfrigérant (12) ne s'étendant à travers aucune des cavités passives (26) ;

dans lequel les cavités active et passive (24, 26) sont intercalées et séparées par des parties plates intérieures respectives (30) de manière à définir une pluralité de sites de formation de glace (28)

dans les colonnes de formation de la glace (18) de la plaque respective (14, 16)

une source d'eau qui applique de l'eau liquide sur les plaques avant et arrière (14, 16), de sorte que de la glace se forme aux endroits respectifs de formation de la glace (28) .

10

15

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25

30

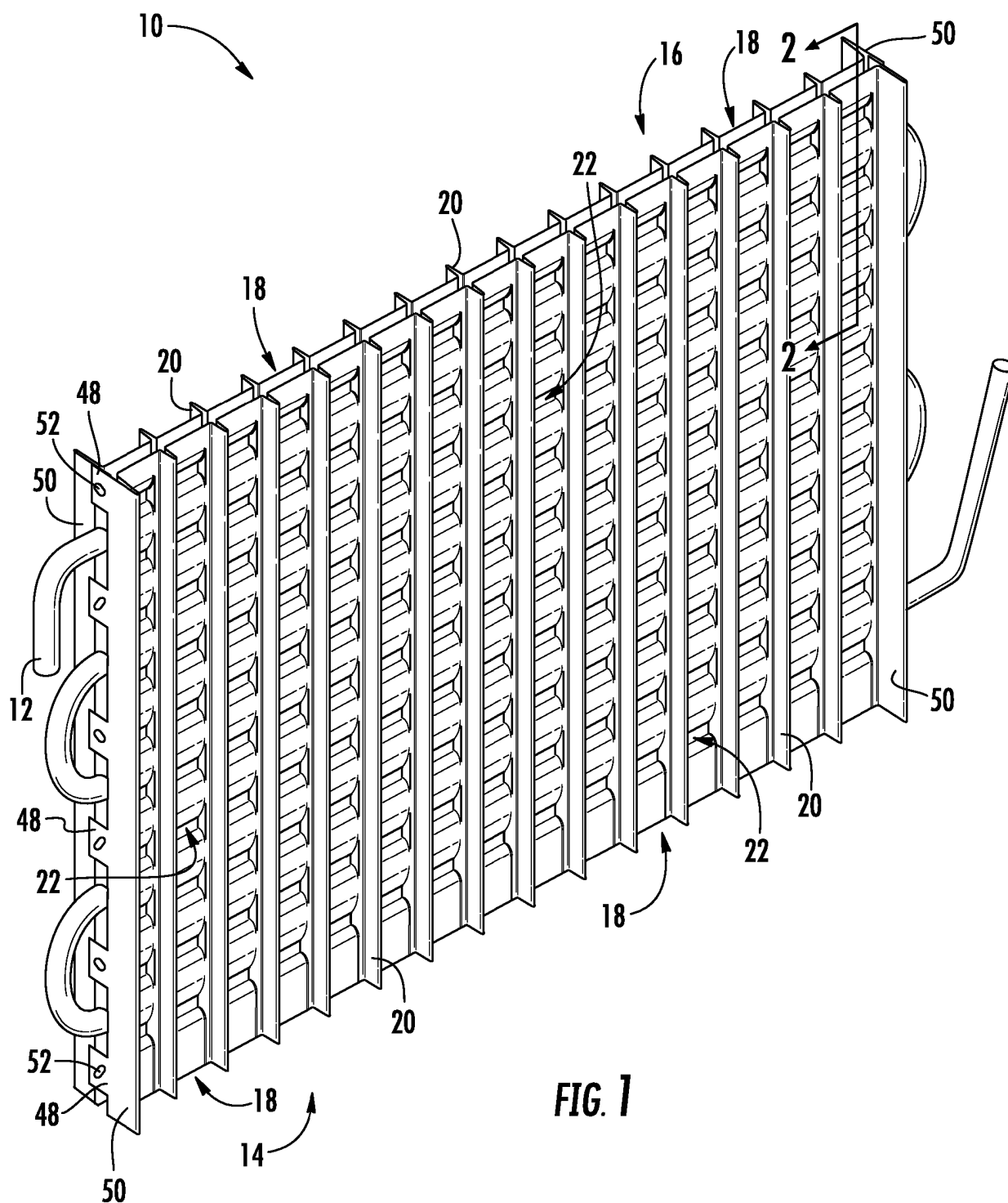
35

40

45

50

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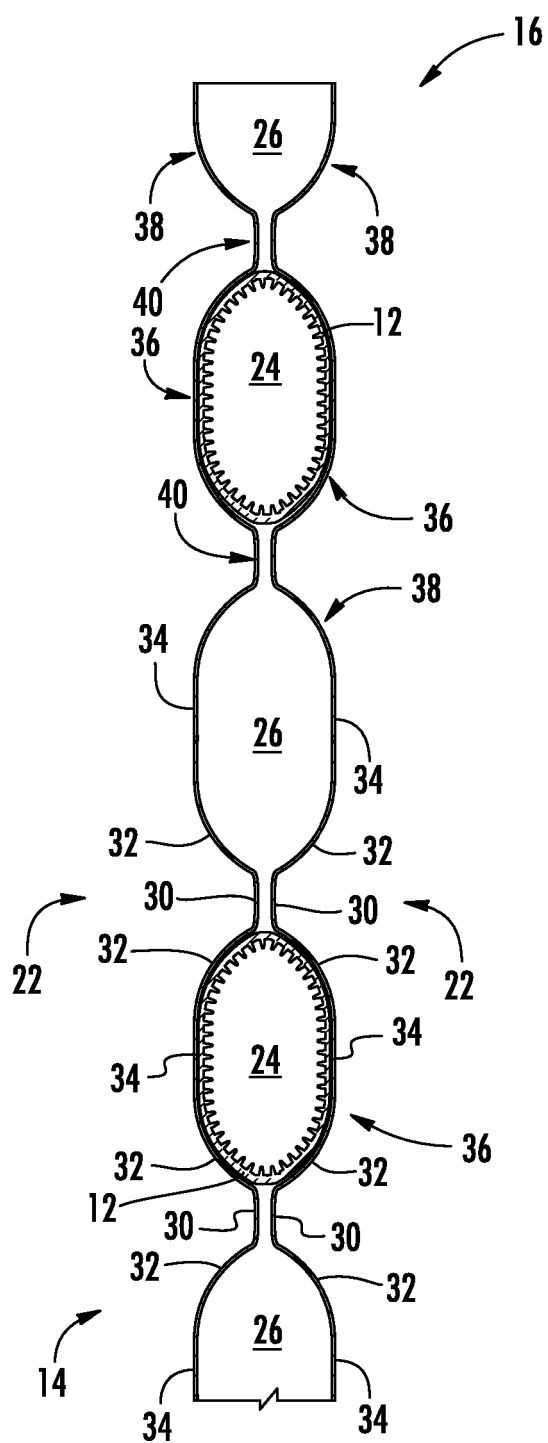


FIG. 2

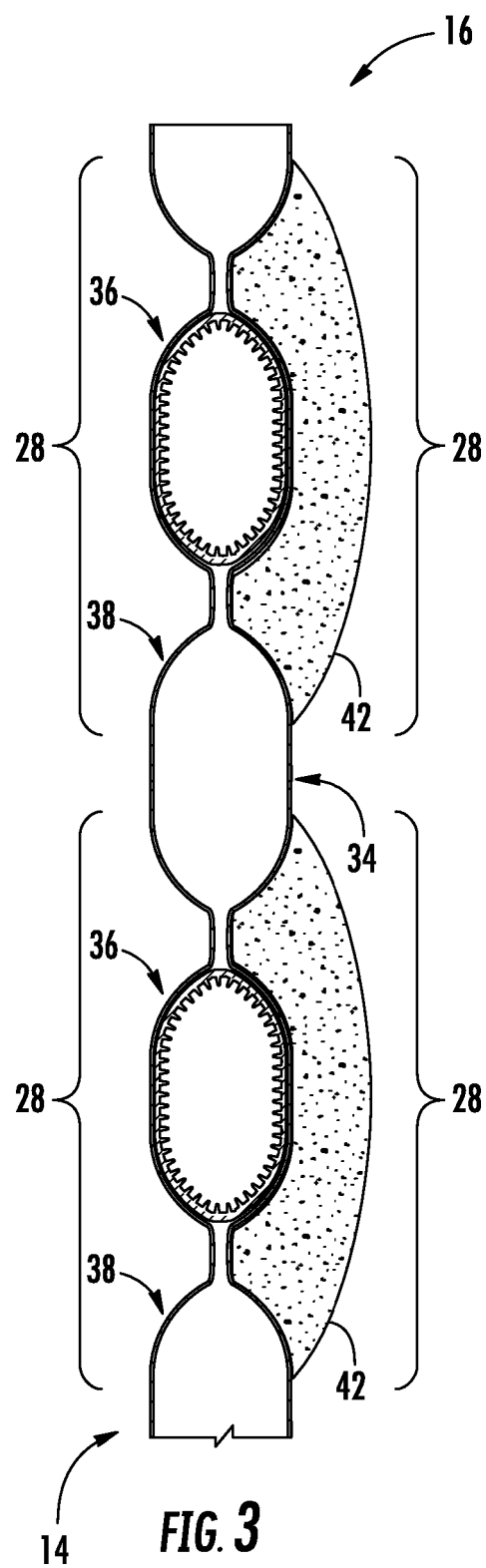


FIG. 3

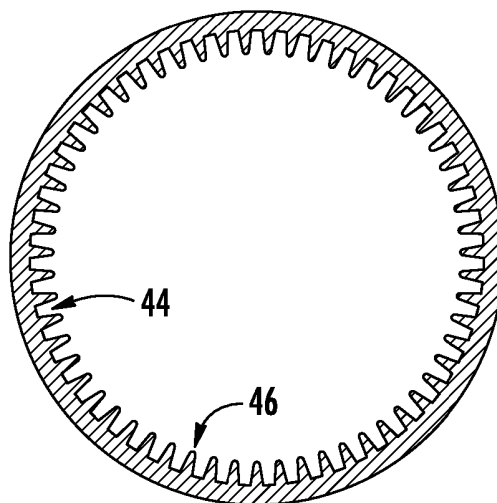


FIG. 4A

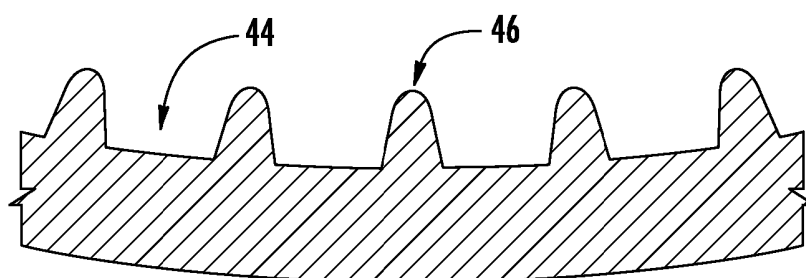


FIG. 4B

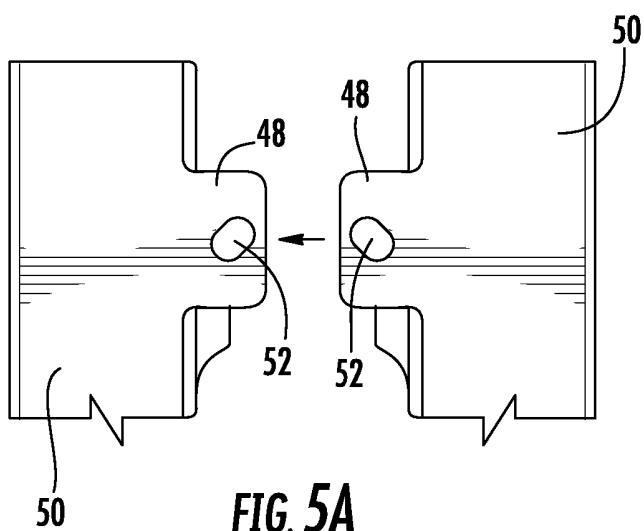


FIG. 5A

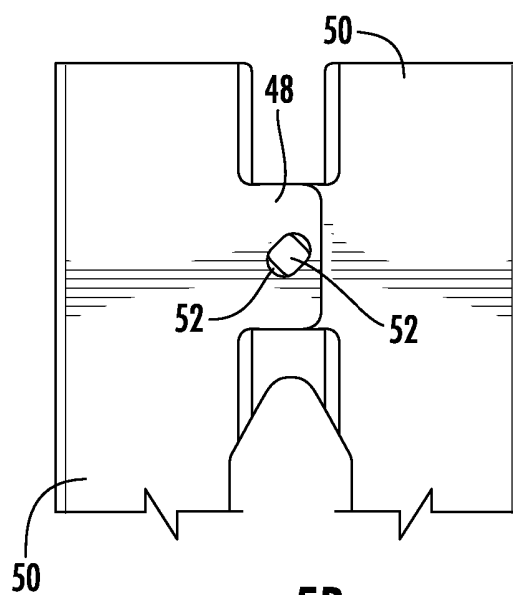


FIG. 5B

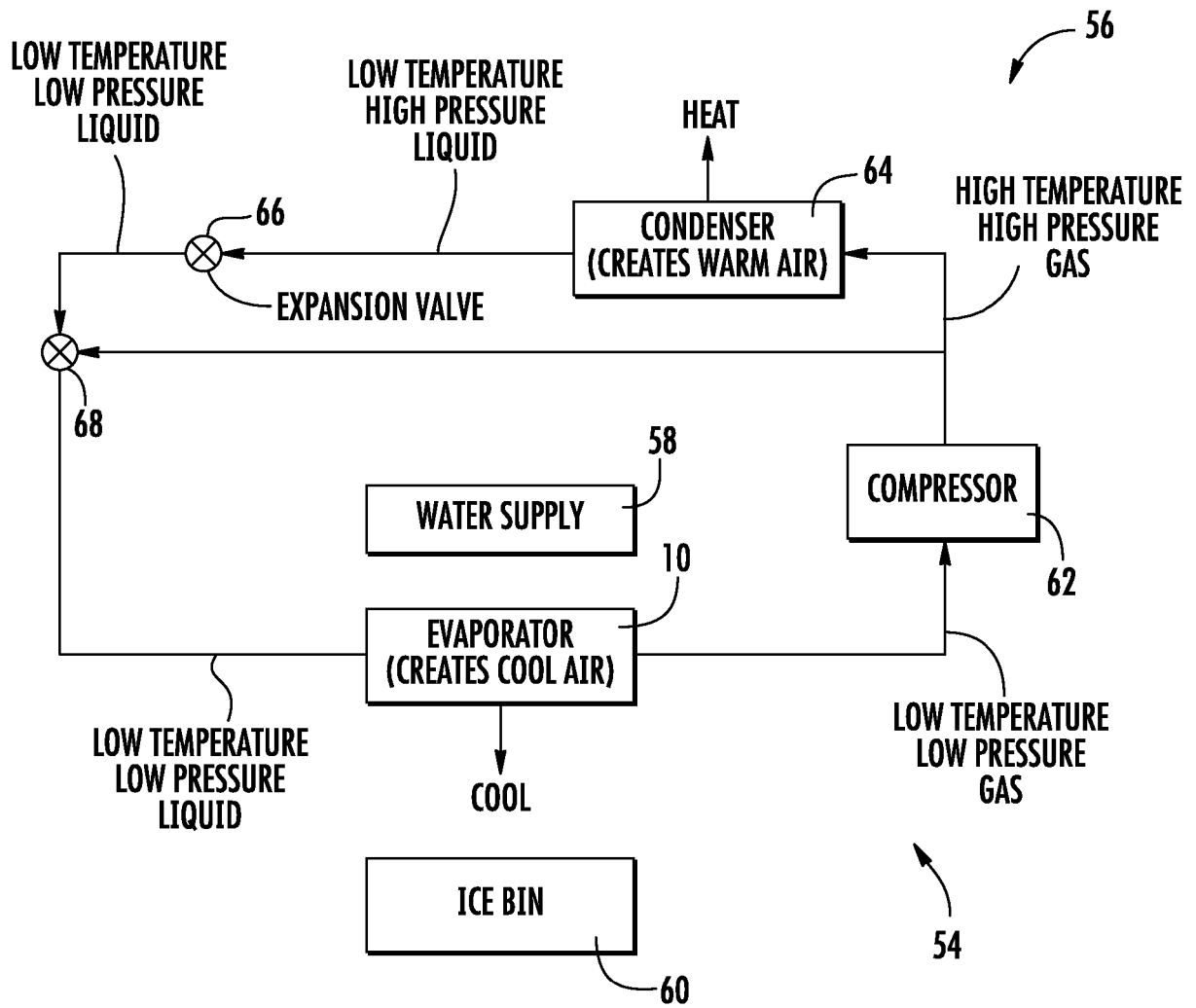


FIG. 6

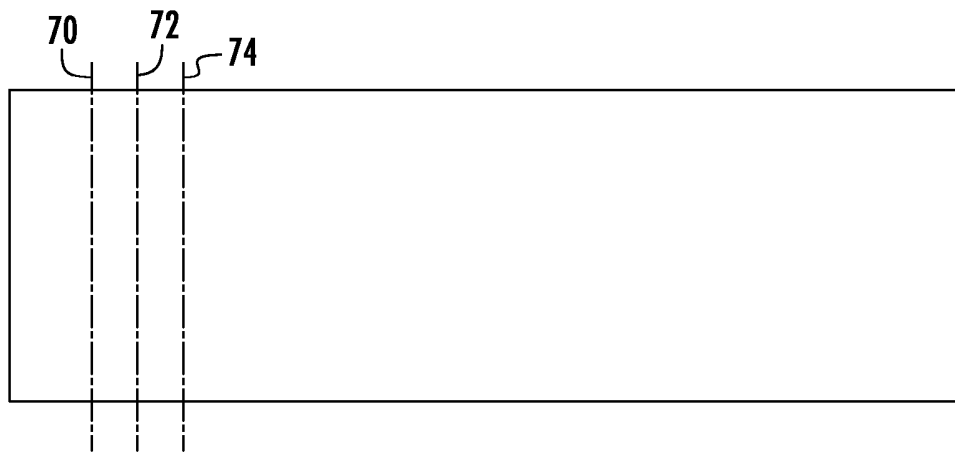


FIG. 7A

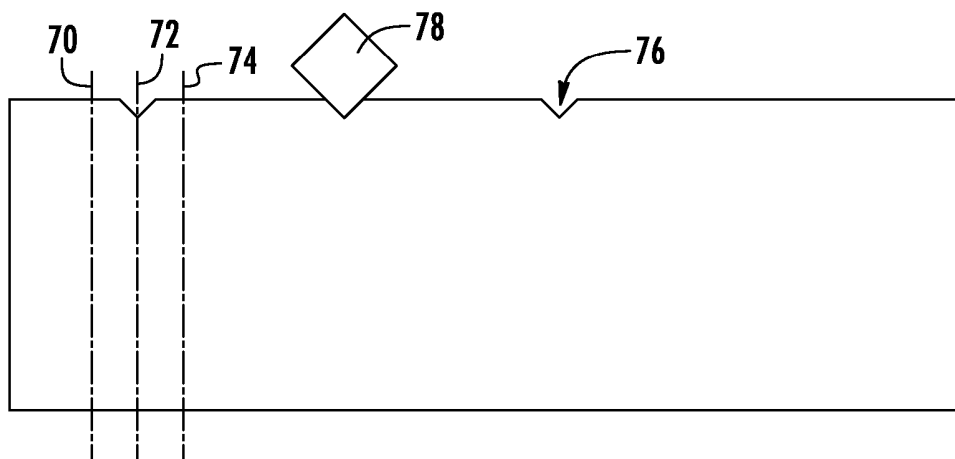


FIG. 7B

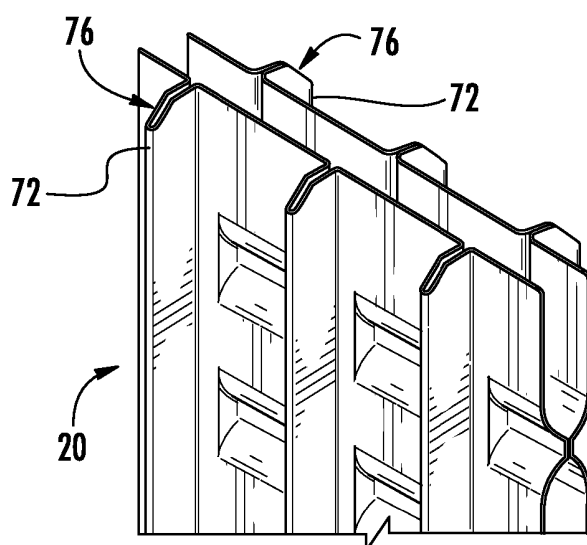


FIG. 7C

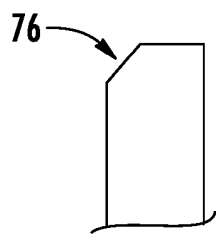


FIG. 8A

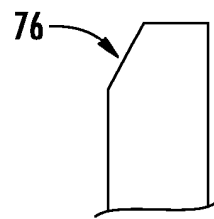


FIG. 8B

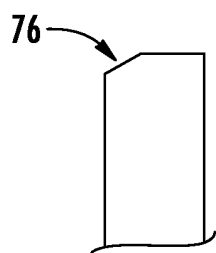


FIG. 8C

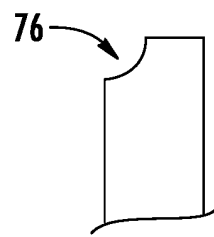


FIG. 8D

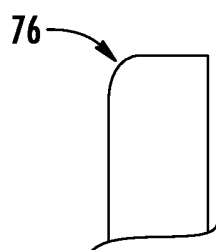


FIG. 8E

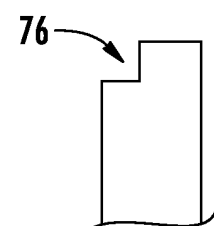


FIG. 8F

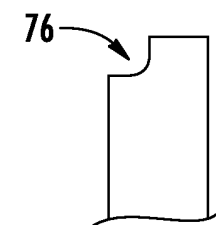


FIG. 8G

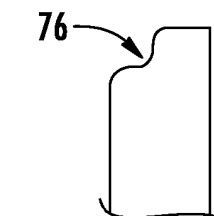


FIG. 8H

REFERENCES CITED IN THE DESCRIPTION

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