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(54) **Water inlet system for harvesting ice cubes in an ice making machine**

(57) A method and system of dispensing water in an ice making machine includes a tube having a plurality of tube apertures. The tube receives water. The water is dispensed at different locations along the tube onto different locations on an evaporator coil. The evaporator coil is in thermal communication with at least one ice forming area. The at least one ice forming area is positioned so that a portion of the water flows into contact therewith when ice is harvested from the ice forming area.

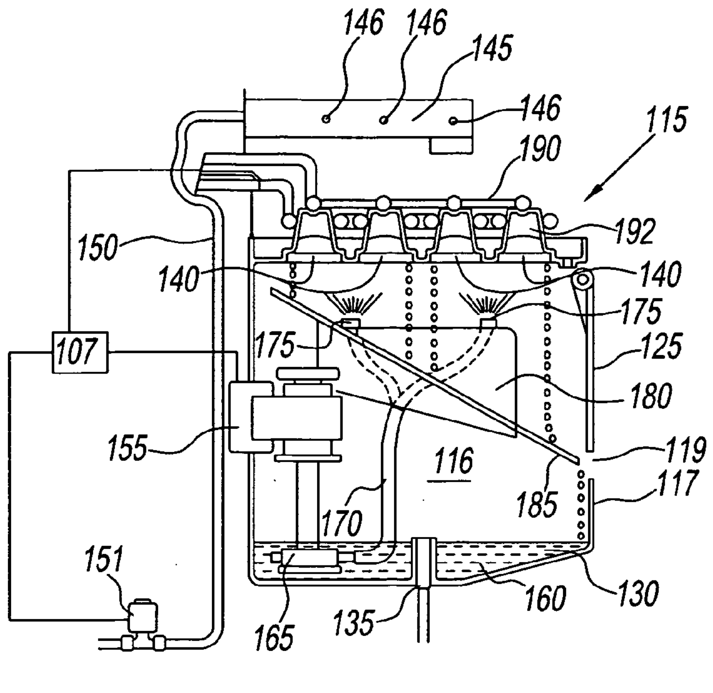

Fig. 3

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Description

CROSS REFERENCE TO RELATED PATENT APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/415,269, filed November 18, 2010. U.S. Provisional Application No. 61/415,269, filed November 18, 2010 is hereby incorporated herein by reference in its entirety.

BACKGROUND

1. Field of the Invention

[0002] The present disclosure relates to ice making machines. Particularly, the present disclosure relates to a system and method for harvesting ice cubes including a water inlet system in an ice making machine.

2. Description of the Related Art

[0003] Conventional ice making machines include an ice making system to make ice cubes during a freeze cycle and a harvest cycle. During the freeze cycle, the ice making system freezes water in molds or cups in thermal communication with an evaporator to form the ice cubes. During the harvest cycle, the ice cubes formed during the freeze cycle are removed from the cups or harvested, e.g., to a user via a dispenser or stored in an ice bin.

[0004] The conventional ice making machines have experienced harvest rate variation. Harvest rate variation is the deviation from standard manufacturing guidelines for ice harvest that occurs when some of the individual cubes do not harvest or release from the evaporator even though all cubes may have released during initial or previous harvest cycles. The issue with harvest rate variation of this nature is that a unit may appear to be functioning normally upon manufacture or install but extended run periods could potentially reduce the harvest rate to a level where ice making production is affected. Harvest rate variation occurs when all of the ice cubes are not harvested from the cups of the ice making system prior to activating a water pump of the ice making system to form the ice cubes in another freeze cycle. Ice cubes remaining in the cups of the ice making system can melt or become deformed as they spend more time in thermal communication with the evaporator and when the water pump restarts. This results in ice clarity and shape variation from individual cube to cube, a reduction in amount of cubes released from the evaporator during harvest cycle and decreased energy efficiency due to the fully-formed ice cubes that remain in the evaporator act as an insulator to prevent water from spraying into the empty cup and forming new ice. The harvest rate exhibited by finished ice machines may still meet or exceed manufacturing line testing guidelines, but additional manufacturing line testing of the ice making machine may be needed to validate that the harvest rate will still meet the design requirements. Validating the harvest rate in this function increases labor required to manufacture the ice making machine and decreases the throughput of the number of the ice making machines through a water test area resulting in bottlenecks in the water test area.

[0005] The present disclosure overcomes the deficiencies of such systems by reducing harvest rate variation.

SUMMARY

[0006] There is provided a method and system of dispensing water in an ice making machine that includes a tube having a plurality of tube apertures. The tube receives water. The water is dispensed at different locations along the tube onto different locations on an evaporator coil. The evaporator coil is in thermal communication with at least one ice forming area. The at least one ice forming area is positioned so that a portion of the water flows into contact therewith when ice is harvested from the ice forming area.

[0007] The above-described and other features and advantages of the present disclosure will be appreciated and understood by those skilled in the art from the following detailed description, drawings, and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is an ice making machine having a door in a closed position that may include a water inlet system of the present disclosure.

[0009] FIG. 2 is the ice making machine of FIG. 1 having the door in an opened position.

[0010] FIG. 3 is an illustrative diagram of an ice making system of the ice making machine of FIG. 1 during a freeze cycle.

[0011] FIG. 4 is an illustrative diagram of the ice making system of FIG. 3 during a harvest cycle.

[0012] FIG. 5 is an embodiment of a water inlet system of the present disclosure having a tube with apertures therethrough.

[0013] FIG. 6 is an embodiment of a water inlet system of the present disclosure having a tube with apertures therethrough.

[0014] FIG. 7 is an embodiment of a water inlet system of the present disclosure having a tube with apertures therethrough.

[0015] FIG. 8 is a bottom side perspective view of an embodiment of a tube of the water inlet system having apertures of FIG. 5.

[0016] FIG. 9 is an end view of the tube of FIG. 8.

[0017] FIG. 10 is a bottom view of the tube of FIG. 8.

[0018] FIG. 11 is a side view of the tube of FIG. 8.

[0019] FIG. 12 is a water inlet system having a tube including a single aperture.

[0020] FIG. 13 is a bottom side perspective view of a tube of the water inlet system of FIG. 12.

[0021] FIG. 14 is a end view of the tube of FIG. 13.

[0022] FIG. 15 is a bottom view of the tube of FIG. 13.

[0023] FIG. 16 is a side view of the tube of FIG. 13.

[0024] FIG. 17 is a table of flow rate test data of the water inlet systems of FIGS. 5-7 and 12.

[0025] FIG. 18 a table of flow rate test data of the water inlet system of FIG. 5.

[0026] FIG. 19 is a table of test data including the number of cubes and slab weights comparing the water inlet system of FIG. 5 and the water inlet system of FIG. 12.

[0027] FIG. 20 is a table of test data including the number of cubes and slab weights comparing the water inlet system of FIG. 5 and the water inlet system of FIG. 7.

[0028] FIG. 21 is a table of test data including freeze, harvest, number of cubes and slab weight of two of the water inlet systems of FIG. 5 over a nine month time period.

[0029] FIG. 22 is a top view of the water inlet system of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0030] FIG. 1 is an ice making machine 100 having a door 105 in a closed position that may include a water inlet system of the present disclosure. The ice making machine 100 makes and stores ice.

[0031] FIG. 2 is ice making machine 100 having door 105 in an opened position. The ice making machine 100 has an ice storage area 110 and an ice making system 115. Ice storage area 110 has a bin 120 that holds ice cubes. Ice making system 115 makes ice cubes, and dispenses the ice cubes into bin 120 from above bin 120 through gate 125.

[0032] FIG. 3 is an illustrative diagram of ice making system 115 of ice making machine 100 during a freeze cycle. Ice making system 115 has a housing 117 enclosing a housing volume 116. Housing 117 has an opening 119 therethrough covered by gate 125. Housing 117 has a bottom portion that forms a sump 130 and a drain 135. A top portion of housing 117 forms cups 140. Each of cups 140 surrounds an interior volume. Housing 117 has a water inlet 145 having apertures 146 that receives water from a water supply through a water supply tube 150. Water supply tube 150 has a valve 151, for example, a solenoid valve that opens to allow water from a water supply to flow through supply tube 150, and closes to block water from flowing through supply tube 150. The water supply, for example, is a public water supply.

[0033] A pump 155 is in housing volume 116. Pump 155 has a pump chamber 165 and a pump tube 170. Pump tube 170 is connected to pump tube outlets 175. Pump tube outlets 175 are connected to a mount 180 positioning pump tube outlets 175 in housing volume 116 above a baffle 185.

[0034] Ice making system 115 has a heat exchange system that performs a vapor compression cycle in thermal communication with housing 117. The heat exchange system includes an evaporator having evaporator tube 190, a compressor (not shown), a condenser (not shown) and a thermal expansion valve (not shown). The evaporator tube 190 is in thermal communication with the interior volume of cups 140.

[0035] Duri ng a freeze cycle, a controller 107 activates pump 155 that generates suction drawing water 160 in sump 130 into pump chamber 165. Pump 155 generates a flow of the water from pump chamber 165 to pump tube 170, for example, by an impeller in pump chamber 165 operated by a motor. The flow in pump tube 170 is directed to pump tube outlets 175, so that the flow generates a spray out of pump tube outlets 175 into cups 140. Controller 107 activates the heat exchange system to flow cooled refrigerant through evaporator tube 190 during the freeze cycle. The evaporator tube 190 is in thermal communication with the interior volume of cups 140 to cool the interior volume of cups 140. At least a portion of the water from the spray dispensed by pump tube outlets 175 freezes in the interior volume of cups 140 forming ice cubes 192. The remaining water from the spray dispensed by pump tube outlets 175 that does not freeze in cups 140 falls away from cups 140 due to gravity onto baffle 185 into sump 130 or directly into sump 130. After a predetermined time period, controller 107 deactivates pump 155 so that water is no longer sprayed into cups 140 and controller 107 deactivates the heat exchange system to stop flow of cooled refrigerant through evaporator tube 190 ending the freeze cycle. Valve 151 is closed to block water from flowing through supply tube 150 during the freeze cycle.

[0036] FIG. 4 is an illustrative diagram of ice making system 115 during a harvest cycle. At the beginning of the harvest cycle, the interior volume of cups 140 are filled with frozen water or ice cubes 192 when controller 107 activates the heat exchange system to begin a flow of heated gas through evaporator tube 190. The evaporator tube 190 is in thermal communication with the interior volume of cups 140 to warm the interior volume of cups 140. At the beginning of the harvest cycle, valve 151 is also opened by controller 107 allowing flow of water through supply tube 150 into a water inlet system having water inlet 145, connected to housing 117, and out of apertures 146 onto evaporator tube 190 and/or cups exterior 140. The water from water inlet 145 is at a temperature that is higher than in the interior volume of cups 140 and warms the interior of cups 140. The water from water inlet 145 that contacts evaporator tube 190 conducts heat from evaporator tube 190 to the interior of cups 140 to warm the interior of cups 140. After contact with evaporator tube 190 and/or cups 140, the water is drained from on top of housing 117 through a hole 195 therethrough into housing volume 116 onto baffle 185 to sump 130. Drain 135 has a standpipe of a predetermined height that drains water above the predetermined height. The flow from supply tube 150 provides fresh water to ice making system 115. The evaporator tube 190 warming the interior volume of cups 140 and the flow of water through apertures 146 of water inlet 145 onto evaporator tube 190 and cups 140 melt a portion of the ice cubes 192 disconnecting ice cubes 192 from cups 140. Ice cubes 192 fall from cups 140 onto baffle 185 out of ice making system 115 through opening 119 into ice bin 120. Ice cubes 192 move gate 125 to uncover opening 119. After a predetermined time period, controller 107 closes valve 151 to block water from flowing through supply tube 150 and controller 107 deactivates the heat exchange system to stop the flow of heated gas through evaporator tube 190 ending the harvest cycle.

[0037] FIG. 5 is an embodiment of the water inlet system having a water inlet 145 having apertures 146. Apertures 146 are each about 2 millimeters (mm) in diameter. Water inlet 145 is a tube having three apertures 146a on a first side 145a, three apertures (not shown) on a second side 145b and a single aperture 146c on a bottom 145c. Each of three apertures 146a forms a water flow 200 from the water source in a shape of a parabola with one of apertures 146 on second side 145b. Aperture 146c forms a straight flow 205 of the water from the water source.

[0038] FIG. 6 is an embodiment of the water inlet system having a water inlet 145 having apertures. The apertures are each about 1.5 millimeters (mm) in diameter.

[0039] FIG. 7 is an embodiment of the water inlet system having a water inlet 145 having apertures 146. Apertures 146 are each about 2.5 millimeters (mm) in diameter. Water inlet 145 is a tube having three apertures 146d on a first side 145d and three apertures 146e on a second side 145e. A single aperture (not shown) is on the bottom of water inlet 145 to ensure the tube drains out after the harvest cycle. Each of three apertures 146d forms a water flow 210 from the water source in a shape of a spray pattern with one of apertures 146e on second side 145e.

[0040] FIGS. 8-11 show water inlet 145 having apertures 146a, 146b and 146c of FIG. 5. Apertures 146a, 146b and 146c are the same size, each about 2 millimeters (mm) in diameter, and located in the same position as 146a, 146b and 146c of FIG. 5. Water inlet 145 is a tube having three apertures 146a on a first side 145a, three apertures 146b on a second side 145b and a single aperture 146c on a bottom 145c. Each of three apertures 146a forms a water flow from the water source in a shape of a parabola with one of apertures 146b on second side 145b. Aperture 146c forms a straight flow of the water from the water source.

[0041] FIG. 12 is a water inlet system having a tube 300 having a single aperture 305. Single aperture 305 has a diameter of about 8.5mm. Single aperture 305 forms a single flow of the water flowing through the tube 300 directly below the single aperture 305. Water flows through single aperture 305 into a center of evaporator tube 190.

[0042] FIGS. 13-16 show tube 300.

[0043] It has been found by the present disclosure that a water inlet system having a tube with a plurality of apertures, such as, for example, water inlets 145 of FIGS. 5-7, improves harvesting the ice cubes over a water inlet system having a tube with a single aperture such as tube 300 having a single aperture 305. Further, it has been found by the present disclosure that a water inlet system having a tube with a plurality of apertures meets or exceeds manufacturing line testing criteria and reduces or eliminates harvest rate variation. It has also been found by the present disclosure that a water inlet system having a tube with a plurality of apertures reduces harvest rate variation reducing harvest cycles needed to confirm an ice making machine to meet or exceed the manufacturing line testing criteria, which reduces labor and increases throughput relieving bottlenecks in a water test area while manufacturing the ice making machine including the water inlet system of the present disclosure, in particular, water inlets 145 of FIGS. 5-7.

[0044] Testing was conducted by the inventors of the present disclosure of flow rates of the water inlet systems of FIGS. 5-7 and 12 each with water having pressure of about 30 pounds per square inch (psi). As shown by the test results of FIG. 17, the flow rates in liters per minute (Umin) through the water inlet systems of FIGS. 5-7 and 12 are very similar. Accordingly, it was determined by the inventors of the present disclosure that water inlets 145 of FIGS. 5-7 allow a similar amount of water into the ice making machine from the water supply as the water inlet 300 of FIG. 12.

[0045] The inventors of the subject matter of the present disclosure conducted testing with water inlets 145 of FIGS. 5-7. It was found by the present inventors that the water inlet 145 of FIG. 5 having apertures each with a diameter of about 2mm provided the best performance and consistency in the range of water pressure from about 20 psi to about 80 psi. As shown by the test results of FIG. 18, water pressure from about 20 psi to about 80 psi through the water inlet 145 of FIG. 5 results in a flow of between about 0.68 L/min to about 0.79 Umin.

[0046] The inventors of the subject matter of the present disclosure conducted testing of the number of cubes and slab weights in grams comparing the water inlet system 145 of FIG. 5 and the water inlet system having a tube 300 having a single aperture 305 of FIG. 12. FIG. 19 is a table of test data including freeze cycle time in minutes, harvest cycle time in minutes, the number of cubes and slab weights in grams of the water inlet system 145 of FIG. 5 and the water inlet system of FIG. 12. Slab weight, which may also be referred to as harvest rate or mass, is the amount of ice harvested during the harvest cycle. The slab weight is a measurement of the total mass of ice harvested (in grams). The slab weight allows one to monitor a ice making machine's performance both for manufacturing approval and service diagnostics. Slab weight measurement is a primary focus. The number of cubes is a secondary measurement or another indicator of performance. As shown in FIG. 19, the water inlet system 145 of FIG. 5 had a more consistent number of ice cubes, between 15 and 16, as opposed to number of ice cubes between 1 and 15 of the water inlet system of FIG. 12. In addition, the water inlet system 145 of FIG. 5 had a more consistent slab weight, between 256 and 280, as opposed to slab weight, between 20 and 230, of the water inlet system of FIG. 12. Therefore, the water inlet system 145 of FIG. 5 consistently made a greater number of ice cubes, average of 15.9 ice cubes, with a greater slab weight, average of 265.6, than the water inlet system of FIG. 12 having an average number of ice cubes being 5.6 with an average slab weight of 89.9, as shown in FIG. 19.

[0047] FIG. 20 is a table of test data including freeze cycle time in minutes, harvest cycle time in minutes, the number of cubes and slab weights in grams comparing the water inlet system of FIG. 5 and the water inlet system of FIG. 7. The testing was under common testing conditions, for example, the same air and water temperature to test units throughout duration of test. As shown in FIG. 20, the water inlet system 145 of FIG. 5 had a more consistent number of ice cubes, between 15 and 16, as opposed to number of ice cubes between 12 and 16 of the water inlet system of FIG. 7. In addition, the water inlet system 145 of FIG. 5 had a more consistent slab weight, between 256 and 280, as opposed to slab weight, between 192 and 236, of the water inlet system of FIG. 7. Therefore, the water inlet system 145 of FIG. 5 consistently made a greater number of ice cubes, average of 15.9 ice cubes, with a greater slab weight, average of 265.6, than the water inlet system of FIG. 7 having an average number of ice cubes being 13.8 with an average slab weight of 213.6, as shown in FIG. 20.

[0048] The inventors of the present disclosure performed testing including freeze cycle time in minutes, harvest cycle time in minutes, the number of cubes and slab weights in grams of two of the water inlet systems of FIG. 5 over a nine month time period. The test data of FIG. 21 shows that the water inlet systems of FIG. 5 improves both in initial use and over extended periods of time over the tube of FIG. 12 and an ice making machine without a water inlet system. A concern that apertures 146 may be blocked with normal operation of the ice making machine with naturally present or occurring water mineral scale, either by freezing water or by TDS (total dissolved solids) in water. The test data of FIG. 21 shows that no such blockage occurred. Continuous low temperature testing was also performed in a test room to confirm freezing did not occur to block apertures 146, which it did not. This test was performed under "All conditions," which refers to test condition ranges that the unit is specified to operate in, for example, low ambient temperatures that may present an operational risk.

[0049] Eight ice making machines included the water inlet system having a tube 300 having a single aperture 305 of FIG. 12 were determined to have unsatisfactory performance, so tube 300 having a single aperture 305 of FIG. 12 was replaced by the water inlet 145 of FIG. 5 in each of the eight ice making machines, which improved performance repeatedly.

[0050] Referring now to FIG. 22 that shows the water inlet system of FIG. 5, three apertures 146a on first side 145a and three apertures 145b on second side 145b are above evaporator tube 190 to harvest at least twelve ice cubes in cups 140 in rows 405, 410, 415. Single aperture 146c drains any residual water left in water inlet 145 after the harvest cycle ends. Each of three apertures 146a forms a water flow 200 from the water source in a shape of a parabola with one of apertures 146 on second side 145b. Aperture 146c forms a straight flow 205 of the water from the water source. The water flows out of apertures 146a, 146b and 146 to flow onto evaporator tube 190 and then onto cups 140 decreasing a time period for the ice cubes to disconnect from cups 140 than if the water flows out of apertures 146a, 146b and 146 directly onto cups 140. The inventors of the present disclosure determined that the water inlet 145 of FIG. 5 improves harvesting the ice cubes over an ice making machine without a water inlet system, a water inlet system having a tube with a single of aperture such as tube 300 having a single aperture 305, and water inlet 145 of FIGS. 6 and 7. The size and pattern of the apertures of the water inlet system may be adjusted based upon the present disclosure for different ice making machine configurations.

[0051] It should also be recognized that the terms "first", "second", "third", "upper", "lower", and the like may be used herein to modify various elements. These modifiers do not imply a spatial, sequential, or hierarchical order to the modified elements unless specifically stated.

[0052] While the present disclosure has been described with reference to one or more exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the disclosure without departing from the scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment(s) disclosed as the best mode contemplated, but that the disclosure will include all embodiments falling within the scope of the appended claims.

Claims

1. An ice maker comprising:

an evaporator having a coil, said coil having a front surface and a rear surface;
at least one vessel having a rear portion, said rear portion connected to said front surface of said coil;
a tube disposed above said rear surface of said coil and said at least one vessel, said tube having a plurality of outlets that each dis-

pense water onto said rear surface of said coil and said rear portion of said at least one vessel to conduct heat from said coil to said vessel.

2. The ice maker of claim 1, wherein said tube has a top portion opposite a bottom portion and a first side portion opposite a second side portion, wherein said bottom portion is adjacent said coil and said rear portion of said vessel, and wherein at least one of said plurality of outlets is through said first side portion and at least one of said plurality of outlets is through said second side portion.

3. The ice maker of claim 2, wherein at least one of said plurality of outlets is through said bottom portion.

4. The ice maker of claim 2, wherein said at least one of said plurality of outlets through said first side portion is aligned with said at least one of said plurality of outlets through said second side portion so that flow of water out of said at least one of said plurality of outlets through said first side portion and said at least one of said plurality of outlets through said second side portion forms a parabola shaped flow of water.

5. The ice maker of claim 1, wherein said tube has a top portion opposite a bottom portion and a first side portion opposite a second side portion, wherein said bottom portion is adjacent said coil and said rear portion of said vessel, wherein said plurality of outlets comprises a first plurality of outlets through said first side portion and a second plurality of outlets through said second side portion, wherein each of said first plurality of outlets is aligned with one of said second plurality of outlets so that flow of water out of said first plurality of outlets and said second plurality of outlets forms a plurality of parabola shaped flows of water.

6. The ice maker of claim 5, wherein said plurality of outlets further comprises an outlet through said bottom portion.

7. The ice maker of claim 1, wherein said plurality of outlets each have a diameter between 1.5 millimeters and 2.5 millimeters.

8. The ice maker of claim 1, wherein said plurality of outlets each have a diameter of 2.0 millimeters.

9. The ice maker of claim 1, wherein said at least one vessel is a plurality of vessels forming a plurality of rows of vessels, and wherein said tube is disposed above at least two of said plurality of rows of vessels.

10. The ice maker of claim 1, wherein said coil is a forms a plurality of curved portions and a plurality of straight portions, and wherein said tube is disposed above at least two of said plurality of straight portions.

11. The ice maker of claim 1, further comprising a controller that selectively connects said tube to a water source generating a flow of water through said tube, wherein said controller connects said tube to said water source for a predetermined time during a harvest cycle so that water is dispensed from said plurality of outlets onto said rear surface of said coil and said rear portion of said at least one vessel to conduct heat from said coil to said vessel, and wherein said controller disconnects said tube from said water source after said predetermined time upon completion of said harvest cycle.

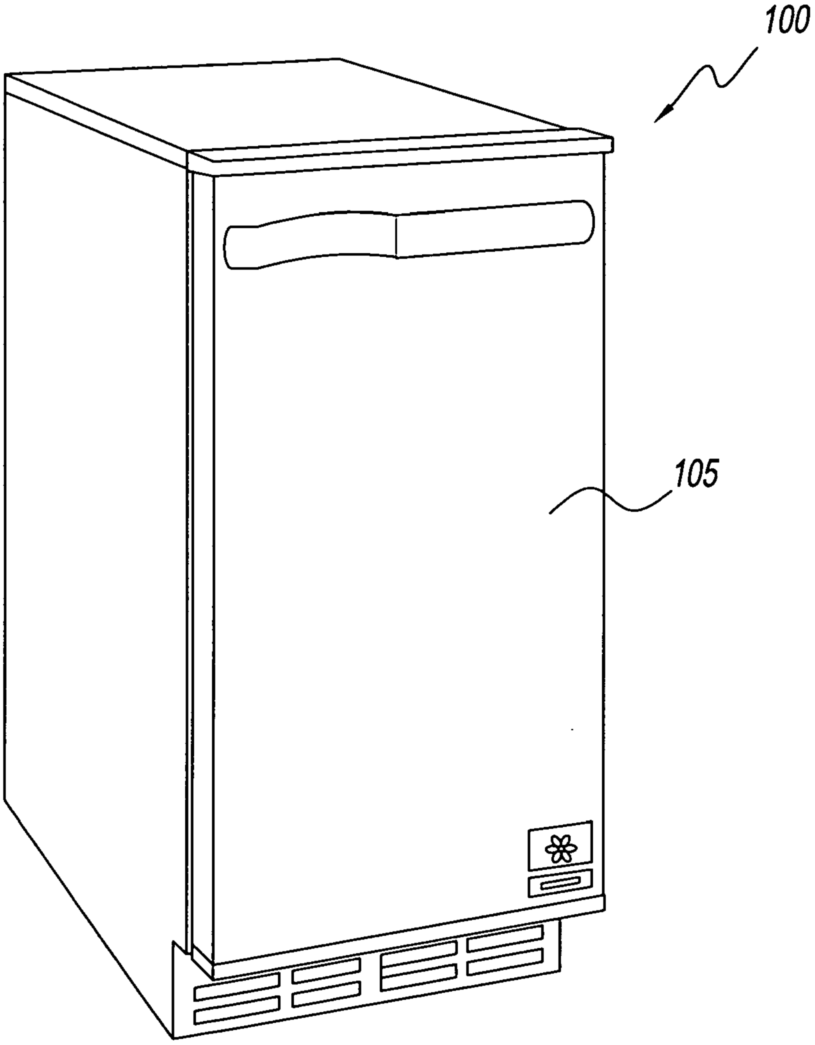

Fig. 1

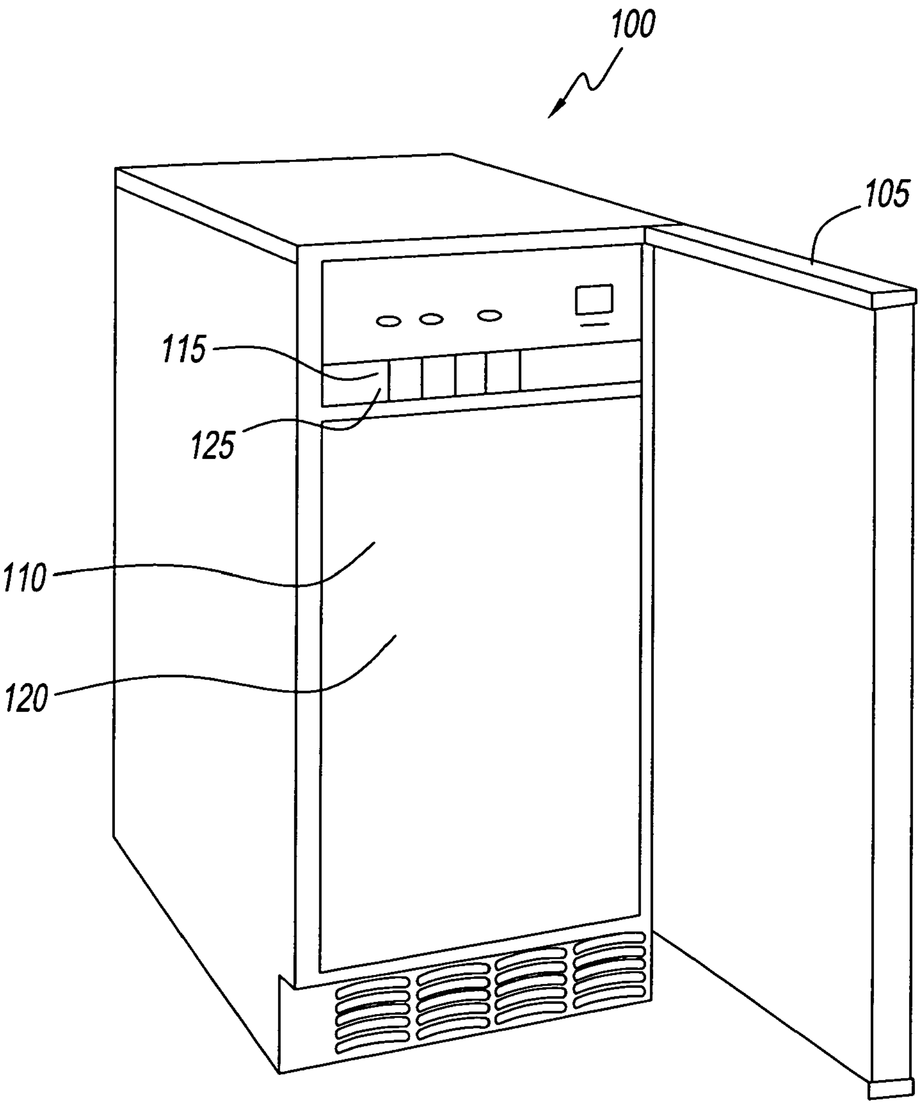

Fig. 2

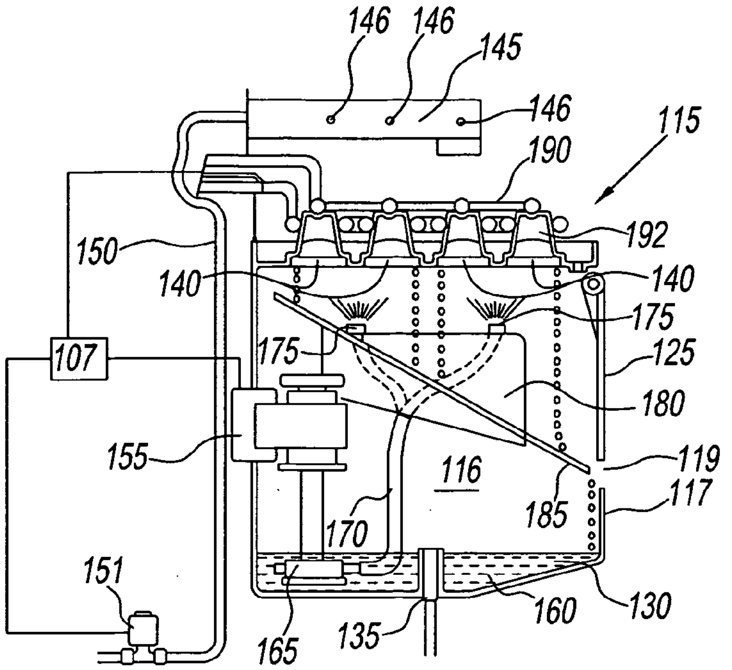
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Fig. 3

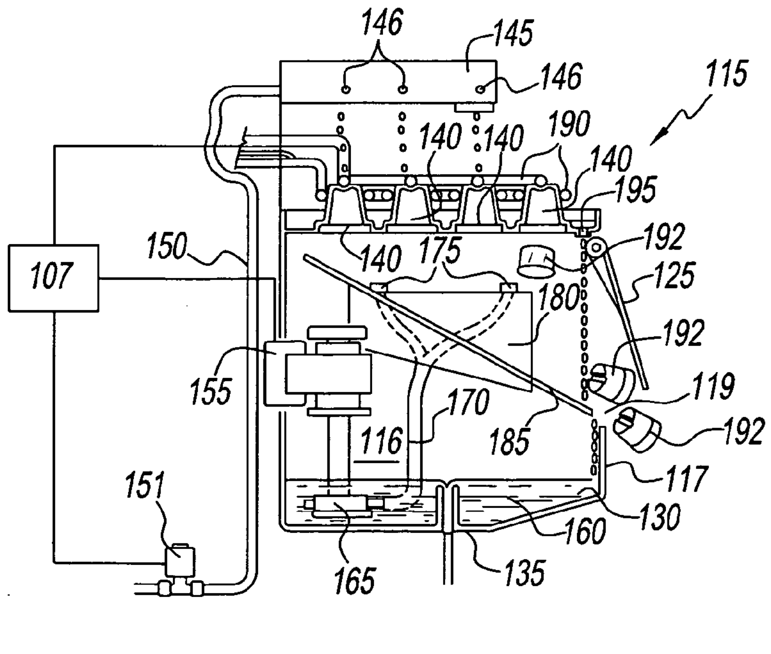
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Fig. 4

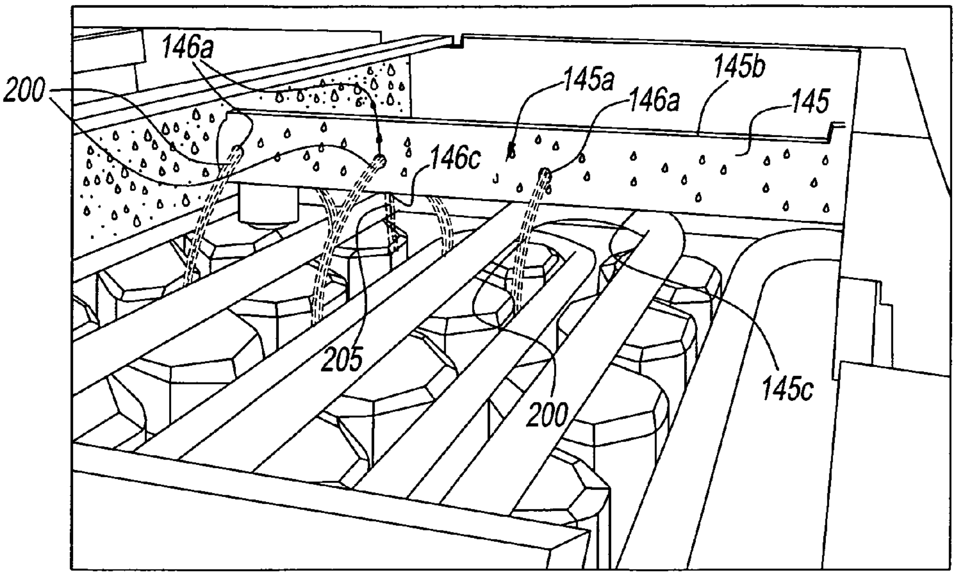

Fig. 5

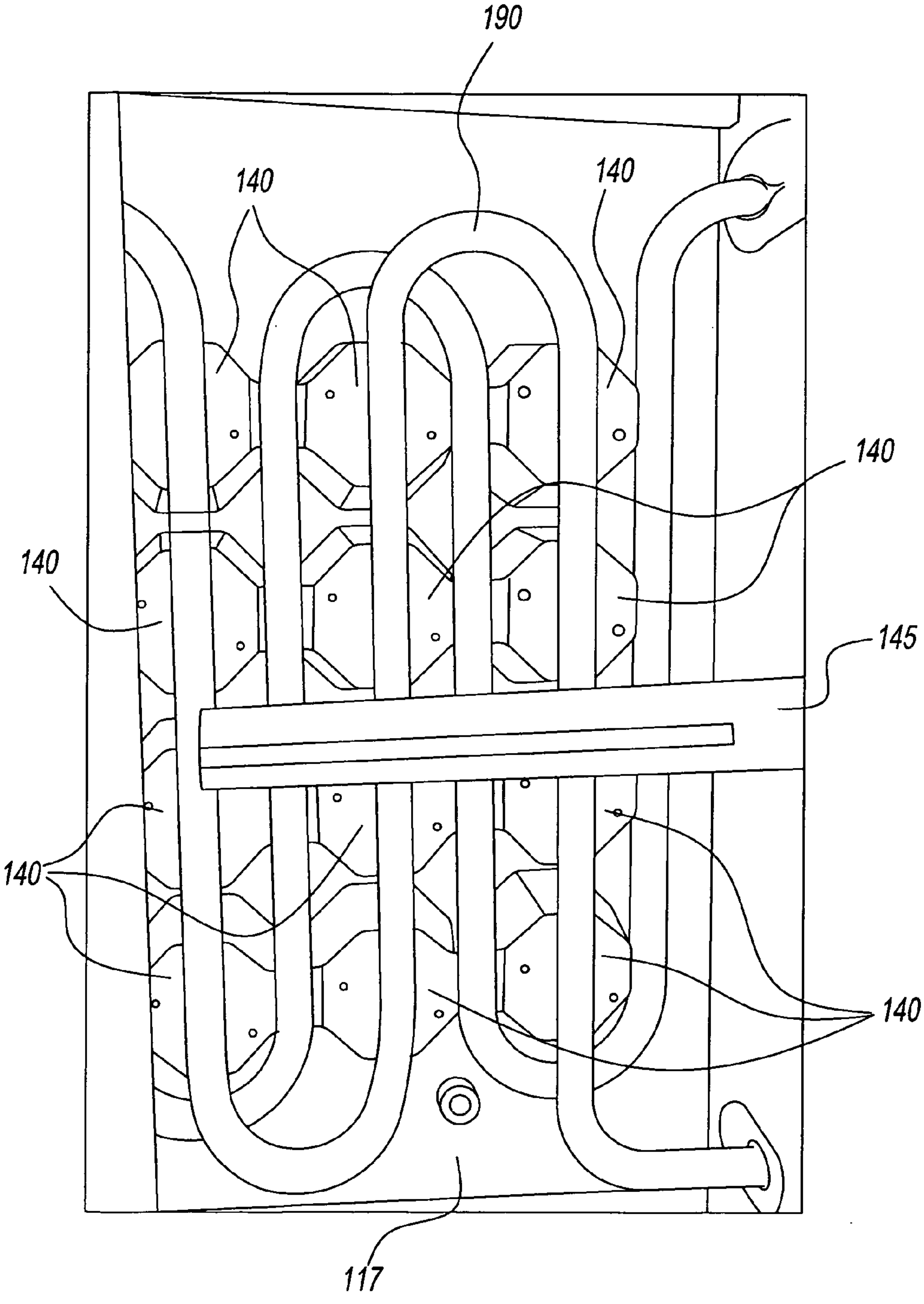

Fig. 6

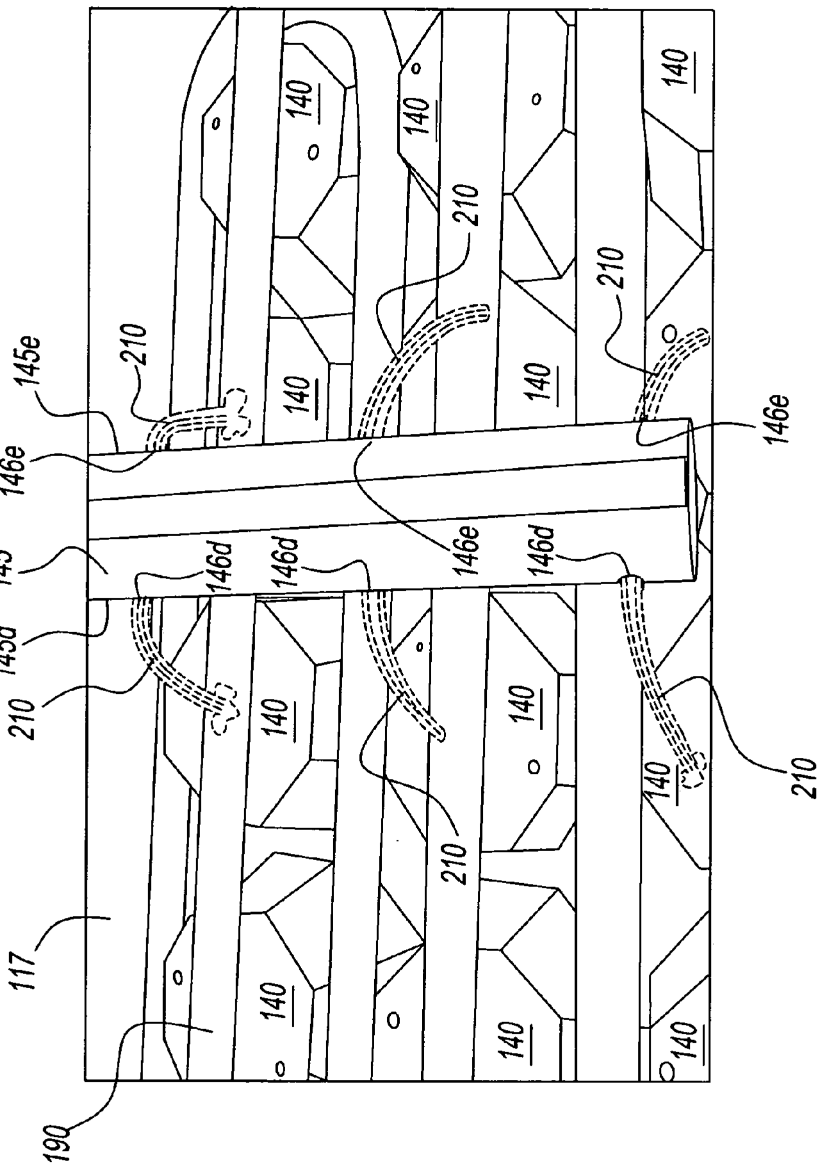
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Fig. 7

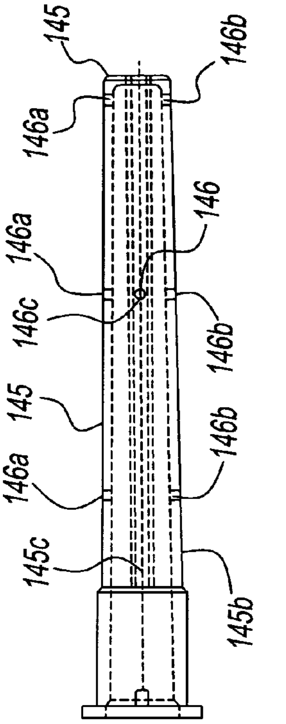

FIG. 10

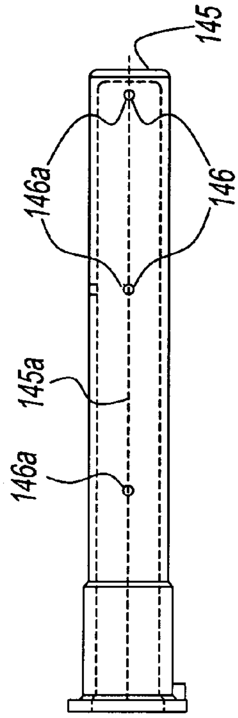

FIG. 11

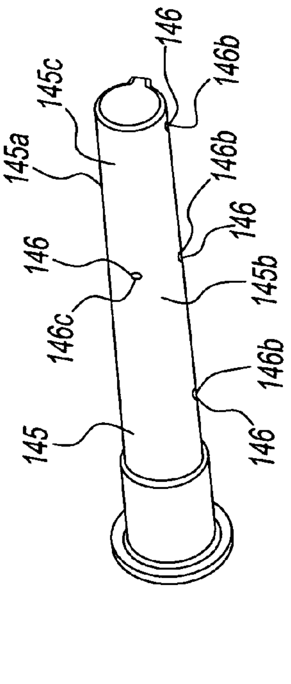

FIG. 8

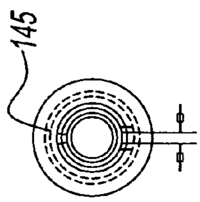

FIG. 9

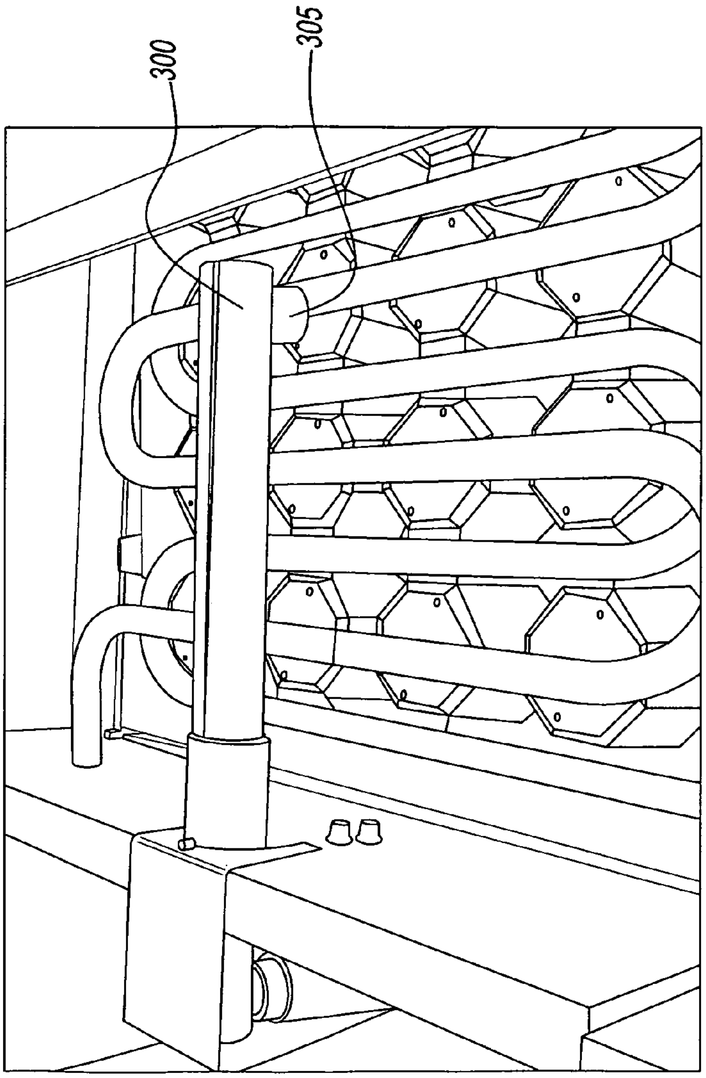

FIG. 12

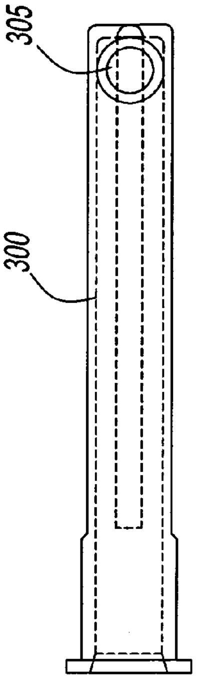

FIG. 15

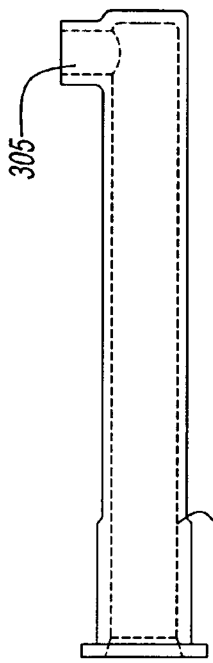

FIG. 16

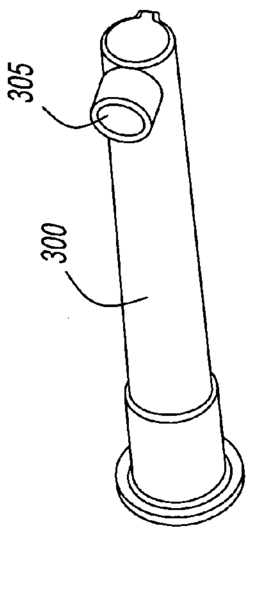

FIG. 13

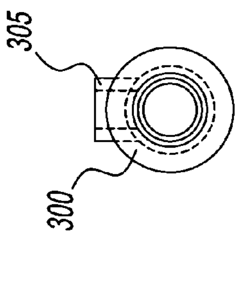

FIG. 14

flow rate test data				L/min
	1.5mm* 7 (Fig. 6)	(Fig. 5) 2mm*7	2.5mm*7 (Fig. 7)	Single Apperture Tube (Fig. 12)
1	0.71	0.73	0.73	0.73
2	0.69	0.72	0.74	0.75
3	0.72	0.69	0.74	0.73
4	0.69	0.69	0.72	0.72
5	0.74	0.71	0.73	0.73
6	0.73	0.73	0.74	0.72
7	0.73	0.73	0.73	0.74
8	0.74	0.71	0.71	0.73
9	0.69	0.71	0.72	0.72
10	0.68	0.71	0.71	0.71
spec	0.72	0.72	0.72	0.72
ave	0.712	0.713	0.727	0.728
stdev	0.023	0.015	0.012	0.011
max	0.74	0.73	0.74	0.75
min	0.68	0.69	0.71	0.71
note:	1.5mm is straight spray pattern 2mm is parabola spray pattern 2.5mm is in drop pattern			

Fig. 17

flow rate test data-pressure

	20 psi	30 psi	40 psi	50 psi	60 psi	70 psi	80 psi	current tube
1	0.71	0.73	0.73	0.73	0.73	0.76	0.74	0.73
2	0.69	0.72	0.74	0.69	0.69	0.72	0.74	0.75
3	0.72	0.69	0.74	0.74	0.73	0.73	0.77	0.73
4	0.69	0.69	0.72	0.69	0.69	0.71	0.72	0.72
5	0.68	0.71	0.71	0.78	0.72	0.75	0.71	0.73
6	0.73	0.73	0.74	0.73	0.73	0.73	0.74	0.72
7	0.73	0.73	0.73	0.79	0.72	0.71	0.76	0.74
8	0.74	0.71	0.71	0.72	0.73	0.73	0.73	0.73
9	0.69	0.71	0.72	0.69	0.69	0.72	0.74	0.72
10	0.68	0.71	0.71	0.73	0.73	0.73	0.74	0.71
spec	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
ave	0.706	0.713	0.725	0.729	0.716	0.729	0.739	0.728
stdev	0.023	0.015	0.013	0.035	0.018	0.016	0.017	0.011
max	0.74	0.73	0.74	0.79	0.73	0.76	0.77	0.75
min	0.68	0.69	0.71	0.69	0.69	0.71	0.71	0.71

note: hole size is 2 mm

FIG. 18

Performance comparison- Tube of FIG. 5 vs. Tube of FIG. 12
4 units 90/80F on line

Tube of FIG. 12

	Freeze	Harvest	Number of Cubes	Slab Weight
avera	17.8	2.2	5.6	89.9
stdev	0.3	0.2	2.8	44.6
max	18.4	2.7	15	230
min	17.1	1.7	1	20
spec	18	2.5	16	286-322
temp	18	2.5	10	190

Tube of FIG. 15

	Freeze	Harvest	Number of Cubes	Slab Weight
avera	17.9	2.3	15.9	265.6
stdev	0.3	0.2	0.2	5.2
max	18.7	2.7	16	280
min	17.4	1.8	15	256
spec	18	2.5	16	286-322
temp	18	2.5	10	190

FIG. 19

Tube having 2mm diameter
Apertures of FIG. 5

	Freeze	Harvest	Number of Cubes	Slab Weight
avera	17.9	2.3	15.9	265.6
stdev	0.3	0.2	0.2	5.2
max	18.7	2.7	16	280
min	17.4	1.8	15	256
spec	18	2.5	16	286-322
temp	18	2.5	10	190

Tube having 2.5 mm diameter
Apertures of FIG. 7

	Freeze	Harvest	Number of Cubes	Slab Weight
avera	17.7	2.3	13.8	213.6
stdev	0.3	0.3	1.1	11.6
max	18.7	2.8	16	236
min	17.3	1.9	12	192
spec	18	2.5	16	286-322
temp	18	2.5	10	190

FIG. 20

Life test data summary: Tube of FIG. 5, Apertures 2.0mm, life test, 2 units, 9 months data

	Freeze	Harvest	Number of Cubes	Slab Weight
ave	18.3	2.0	16.0	301.3
stdev	0.9	0.1	0.0	7.0
max	20.3	2.1	16	311
min	17	1.6	16	285
spec	18	2.5	16	286-322
temp sp	18	2.5	16	190

FIG. 21

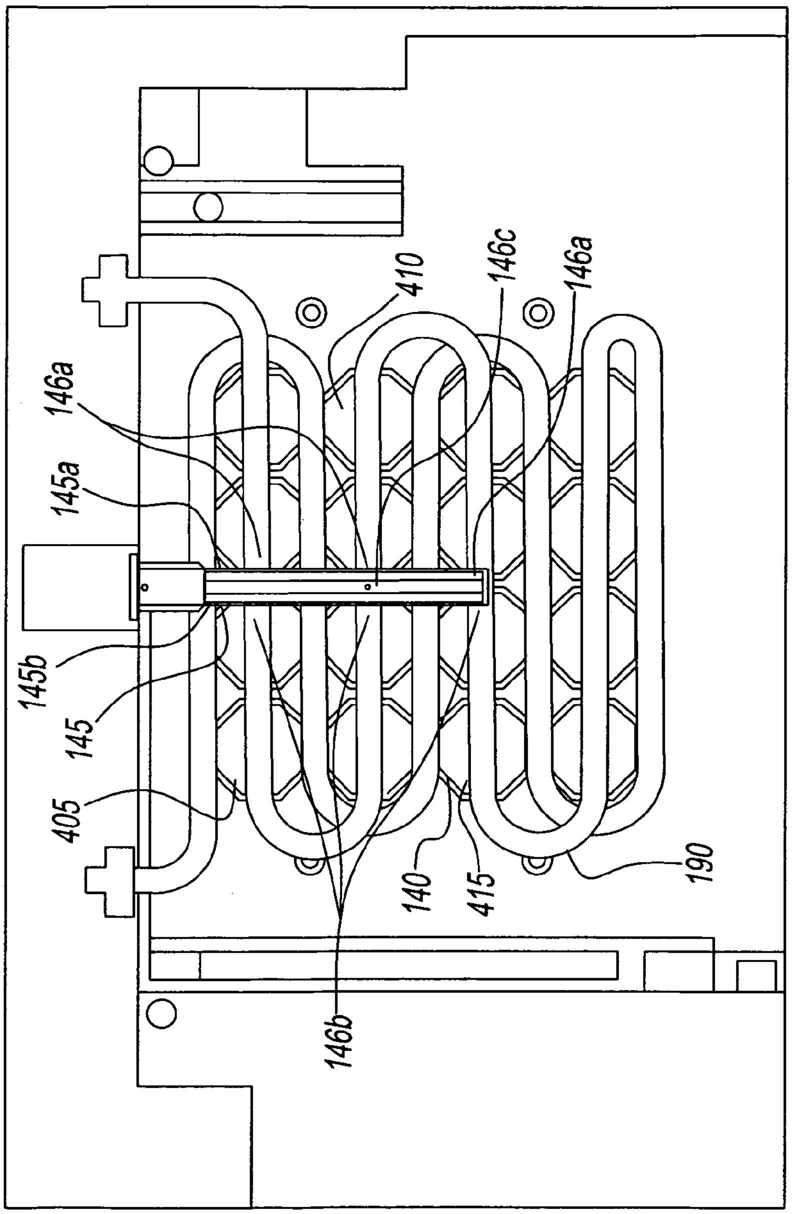

FIG. 22

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 61415269 A **[0001]**