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(54) **A method and system for controlling the initiation of a freeze cycle pre-set time in an ice maker**

(57) A novel control logic for an individual cube spray type ice machine. The duration of the freeze cycle is able to adapt to changes in inlet water temperature, changes in ambient air temperature, and the impact of warm temperatures of internal ice making parts within the ice machine due to off cycle periods. This is accomplished through a combination of starting a freeze time period only after the water temperature for the volume of water circulating over the evaporator has reached approximately 32°F, and a freeze time period value that is a function of the refrigerant temperature leaving the condenser at the time where the water reaches approximately 32°F.

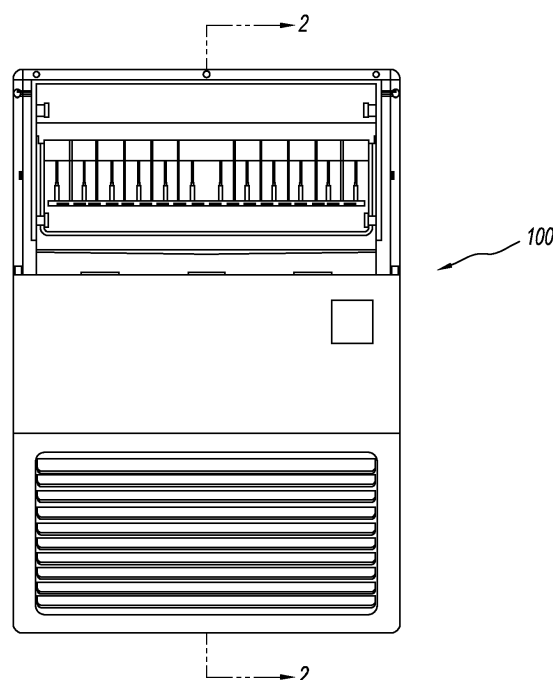


FIG. 1

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Description

BACKGROUND

1. Field

[0001] The present disclosure relates to a method and system for controlling a freeze cycle in an ice making machine.

2. Discussion of the Background Art

[0002] Inlet water temperature has a significant impact on the time required to freeze a full cube in a spray machine evaporator due to the sensible heat removal required for the entire volume of water and the relatively large volume of water relative to ice produced in each batch for a spray machine.

[0003] During extended off cycles, the evaporator, pump, and various components that make up the water circulation system warm up to a much higher temperature than the average during repetitive freeze and harvest cycles. In addition, refrigerant migrates to the colder sections of the refrigeration system during off times. This results in significantly longer periods of time for the refrigeration system to chill the water volume and evaporator to the freezing point during the first freeze cycle following an off cycle when compared to repetitive freeze and harvest cycles.

[0004] Conventional control strategies for spray machines set the freeze cycle time to a fixed value once a thermostat detects the evaporator temperature has reached a predetermined value. This results in partially formed ice cubes during the first cycle following an off cycle, or when the inlet water is higher than average.

[0005] Thus, there is a need for a method and system that controls a freeze cycle of an ice making machine with enhanced efficiency and reduced energy usage.

[0006] The present disclosure also provides many additional advantages, which shall become apparent as described below.

SUMMARY

[0007] A method and system of the present disclosure monitors the water temperature in a sump and refrigerant temperature exiting a condenser so that a start time of a freeze cycle/sequence is delayed until the water temperature reaches a predetermined value and a freeze cycle time period value based upon the temperature of the refrigerant is attained, thereby producing ice much more efficiently and saving energy.

[0008] The duration of the freeze cycle is able to adapt to changes in inlet water temperature, changes in ambient air temperature, and the impact of warm temperatures of internal ice making parts within the ice machine due to off cycle periods. This is accomplished through a combination of starting a freeze time period only after the

water temperature for the volume of water circulating over the evaporator has reached approximately 32°F, and a freeze time period value that is a function of the liquid temperature leaving the condenser at the time where the water reaches approximately 32°F.

[0009] In an embodiment of an ice making machine of the present disclosure, a heat exchange system comprises an evaporator and a condenser configured to make ice pieces with water applied to the evaporator during a freeze cycle. A controller controls a start time and an end time of the freeze cycle so that the start time begins only if a temperature of the water is 32 degrees F or lower and the end time is based on a temperature of refrigerant exiting the condenser when the start time begins.

[0010] In another embodiment of the ice making machine according to the present disclosure, the end time is determined from a table of time versus condenser refrigerant exit temperatures at a time when the water is approximately 32 degrees F.

[0011] In another embodiment of the ice making machine according to the present disclosure, the heat exchanger system further comprises one or more sprayers that spray the water on the evaporator.

[0012] In another embodiment of the ice making machine according to the present disclosure, a first temperature sensor is located in the water and a second temperature sensor is located to sense the temperature of the refrigerant exiting the condenser. The start and end times are determined based on temperatures sensed by the first and second temperature sensors.

[0013] In another embodiment of the ice making machine according to the present disclosure, a processor and program module are associated with the controller. The processor executes instructions of the program module to determine the start time and the end time of the freeze cycle.

[0014] An embodiment of a method for making ice with an ice making machine of the present disclosure, the method comprises:

configuring an evaporator and a condenser to make ice pieces with water applied to the evaporator during a freeze cycle;

controlling a start time of the freeze cycle to begin only if a temperature of the water is 32 degrees F or lower; and

controlling an end time of the freeze cycle based on a temperature of refrigerant exiting the condenser when the start time begins.

[0015] In another embodiment of the method of ice making according to the present disclosure, the method further comprises:

determining the end time from a table of time versus condenser refrigerant exit temperatures at a time when the water is approximately 32 degrees F.

[0016] In another embodiment of the method of ice making according to the present disclosure, the method further comprises:

locating a first temperature sensor to sense a temperature of the water; and
 locating a second temperature sensor to sense a temperature of refrigerant exiting the condenser.
 The start and end times are determined based on the temperatures sensed by the first and second temperature sensors.

[0017] In another embodiment of the method of ice making according to the present disclosure, the method further comprises: executing instructions of a program module to determine the start time and end time of the freeze cycle.

[0018] In another embodiment of the method of ice making according to the present disclosure, the method further comprises: spraying the water on the evaporator.

[0019] Further objects, features and advantages of the present disclosure will be understood by reference to the following drawings in which like reference numbers refer to like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

Fig. 1 is a schematic representation of a spray-type ice making machine according to the present disclosure.

Fig. 2 is a schematic representation of a cross-sectional view along line 2-2 of Fig. 1;

Fig. 3 is a schematic representation of water being sprayed during a freeze cycle on an evaporator of the ice making machine of Fig. 1.

Fig. 4 is a block diagram of a computer system for control of freeze cycles of the ice making machine of Fig. 1.

Fig. 5 is a logic or flow diagram for control of the freeze cycles of the ice making machine of Fig. 1.

Fig. 6 is a schematic representation depicting a temperature sensor disposed at the exit of a condenser of the ice making machine of Fig. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0021] The impact of the warm internal components and refrigerant migration following an off cycle is eliminated by starting the freeze cycle period at a 32°F water condition, which makes the first freeze cycle and all subsequent freeze cycles have essentially the same temperature conditions at the start of the timed freeze period.

[0022] The use of the refrigerant temperature leaving the condenser at the point in time that the water has reached 32°F means that the effect of the evaporator

load has been standardized, and so the condenser leaving temperature is almost entirely due to the ambient temperature for the condenser cooling medium (air or water) and the relative efficiency of the condenser. The evaporator heat removal capacity is strongly correlated to the liquid temperature, since it represents the enthalpy of the refrigerant entering the evaporator, and the time required to freeze a full cube in the evaporator once the water has reached 32°F is directly related to the enthalpy of the entering refrigerant. This relationship provides an accurate method for setting freeze time from the point where the water has reached 32°F.

[0023] Referring to Fig. 1, an ice making machine 100 includes a freeze cycle/sequence controller of the present disclosure. The ice making machine 100 makes and stores ice.

[0024] Referring to Fig. 2, ice making machine 100 comprises a door 105 in a closed position, 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. Ice making machine 100 comprises an evaporator 2, spray assembly 3, water temperature sensor 4 and water trough or sump 130.

[0025] Referring to Fig. 3 there is shown 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. Temperature sensor 4 is located in sump 130. 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.

[0026] A pump 155 is disposed 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.

[0027] 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 2 having an evaporator tube 190, a compressor (not shown), a condenser 604 (see Fig. 6) and a thermal expansion valve (not shown). The evaporator tube 190 is in thermal communication with the interior volume of cups 140.

[0028] As shown in Fig. 6, condenser 604 has a liquid line 600 leaving condenser 604, wherein a temperature sensor 620 (shown in Fig. 4) is disposed under insulation sleeve (black foam) 608 disposed before condenser coil

602.

[0029] During 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.

[0030] Referring to Fig. 4, a system 400 comprises a computer 405 coupled to a network 420, e.g., the Internet. Computer 405 may be a part of controller 107 or separate from controller 107. In either case, connections between controller 107 and computer 405 allow the freeze cycle sequence to operate.

[0031] Computer 405 includes a user interface 410, a processor 415, and a memory 425. Computer 405 may be implemented on a general-purpose microcomputer. Although computer 405 is represented herein as a standalone device, it is not limited to such, but instead can be coupled to other devices (not shown) via network 420.

[0032] Processor 415 is configured of logic circuitry that responds to and executes instructions.

[0033] Memory 425 stores data and instructions for use by processor 415. Memory 425 may be implemented in a random access memory (RAM), a hard drive, a read only memory (ROM), or a combination thereof. One of the components of memory 425 is a program module 430.

[0034] Program module 430 contains instructions for controlling processor 415 to execute for control of the methods described herein, in particular, the control of freeze cycles of ice making machine 100. Program module 430 includes a table 440 of time versus refrigerant temperature (e.g., a look-up table) and a freeze countdown timer 445. The term "module" is used herein to denote a functional operation that may be embodied either as a stand-alone component or as an integrated configuration of a plurality of sub-ordinate components. Thus, program module 430 may be implemented as a single module or as a plurality of modules that operate

in cooperation with one another. Moreover, although program module 430 is described herein as being installed in memory 425, and therefore being implemented in software, it could be implemented in any of hardware (e.g., electronic circuitry), firmware, software, or a combination thereof.

[0035] User interface 410 includes an input device, such as a keyboard or speech recognition subsystem, for enabling a user to communicate information and command selections to processor 415. User interface 410 also includes an output device such as a display or a printer. A cursor control such as a mouse, track-ball, or joy stick, allows the user to manipulate a cursor on the display for communicating additional information and command selections to processor 415.

[0036] Processor 415 outputs, to user interface 410, a result of an execution of the methods described herein. Alternatively, processor 415 could direct the output to a remote device (not shown) via network 420.

[0037] While program module 430 is indicated as already loaded into memory 425, it may be configured on a storage medium 435 for subsequent loading into memory 425. Storage medium 435 can be any conventional storage medium that stores program module 430 thereon in tangible form. Examples of storage medium 435 include a floppy disk, a compact disk, a magnetic tape, a read only memory, an optical storage media, universal serial bus (USB) flash drive, a digital versatile disc, or a zip drive. Alternatively, storage medium 435 can be a random access memory, or other type of electronic storage, located on a remote storage system and coupled to computer 405 via network 420.

[0038] Referring to Fig. 5, the controller operated freeze sequence according the present disclosure uses processor 415 to execute instructions of program module 430 to control the freeze cycle with steps 530. At the start of freeze cycle, processor 415 initiates the freeze cycle sequence. At step 502, processor 415 monitors the sump water temperature as sensed by temperature sensor 205 of the water in the sump 130. At step 504, processor 415 checks to determine if the water temperature in the sump 130 is about 32°F or less. If the water temperature in sump 130 is higher than 32°F, then processor 415 returns to step 502. If the water temperature in sump 130 is less than or equal to 32°F, then at step 506 processor 415 checks the temperature of the refrigerant leaving the condenser as monitored by condenser temperature sensor 620. At step 508, processor 415 uses the condenser temperature to determine a remaining freeze time from table 440 of time versus refrigerant temperature (i.e. a freeze time period value that is a function of the refrigerant temperature leaving the condenser at the time where the water reaches approximately 32°F). Once the water temperature in sump 130 is equal to or less than 32°F, then processor 415 at step 510 starts freeze countdown timer from the freeze time value determined from look-up table 440. Processor 415 then at step 512 monitors the freeze countdown timer value. At step 514, if the freeze timer

value is not equal to a time out value, e.g., zero, steps 512 and 514 are repeated when the countdown freeze timer value is equal to zero, processor 415 at step 516 stops the freeze cycle and starts the harvest cycle or sequence.

[0039] Specific data for the relationship between freeze period time and condenser leaving refrigerant temperature will be provided from test data showing the variation in time required for the water to reach 32°F from the start of the freeze operation for both first cycles following an extended off period, and subsequent freeze cycles during continuous freeze and harvest operation, over a range of ambient and inlet water conditions.

[0040] While we have shown and described several embodiments in accordance with our invention, it is to be clearly understood that the same may be susceptible to numerous changes apparent to one skilled in the art. Therefore, we do not wish to be limited to the details shown and described but intend to show all changes and modifications that come within the scope of the appended claims.

Claims

1. An ice making machine comprising:

a heat exchange system comprising an evaporator and a condenser configured to make ice pieces with water applied to said evaporator during a freeze cycle; and
a controller that controls a start time and an end time of the freeze cycle, wherein the start time begins only if a temperature of said water is 32 degrees F or lower and the end time is based on a temperature of refrigerant exiting said condenser when the start time begins.

2. The ice making machine of claim 1, wherein the end time is determined from a table of time versus condenser refrigerant exit temperatures at a time when the water is approximately 32 degrees F.

3. The ice making machine of claim 1, wherein said heat exchanger system further comprises one or more sprayers that spray the water on the evaporator.

4. The ice making machine of claim 1, further comprising a first temperature sensor located in the water and a second temperature sensor located to sense the temperature of the refrigerant exiting the condenser, and wherein the start and end times are determined based on temperatures sensed by the first and second temperature sensors.

5. The ice making machine of claim 1, further comprising a processor and program module associated with

the controller, wherein the processor executes instructions of the program module to determine the start time and the end time of the freeze cycle.

6. A method of controlling ice making of an ice making machine comprising:

configuring an evaporator and a condenser to make ice pieces with water applied to said evaporator during a freeze cycle;
controlling a start time of the freeze cycle to begin only if a temperature of said water is 32 degrees F or lower; and
controlling an end time of the freeze cycle based on a temperature of refrigerant exiting said condenser when the start time begins.

7. The method of claim 6, further comprising:

determining the end time from a table of time versus condenser refrigerant exit temperatures at a time when the water is approximately 32 degrees F.

8. The method of claim 6, further comprising:

locating a first temperature sensor to sense a temperature of the water;
locating a second temperature sensor to sense a temperature of refrigerant exiting the condenser, and wherein the start and end times are determined based on the temperatures sensed by the first and second temperature sensors.

9. The method of claim 6, further comprising:

executing instructions of a program module to determine the start time and end time of the freeze cycle.

10. The method of claim 6, further comprising:

spraying the water on the evaporator.

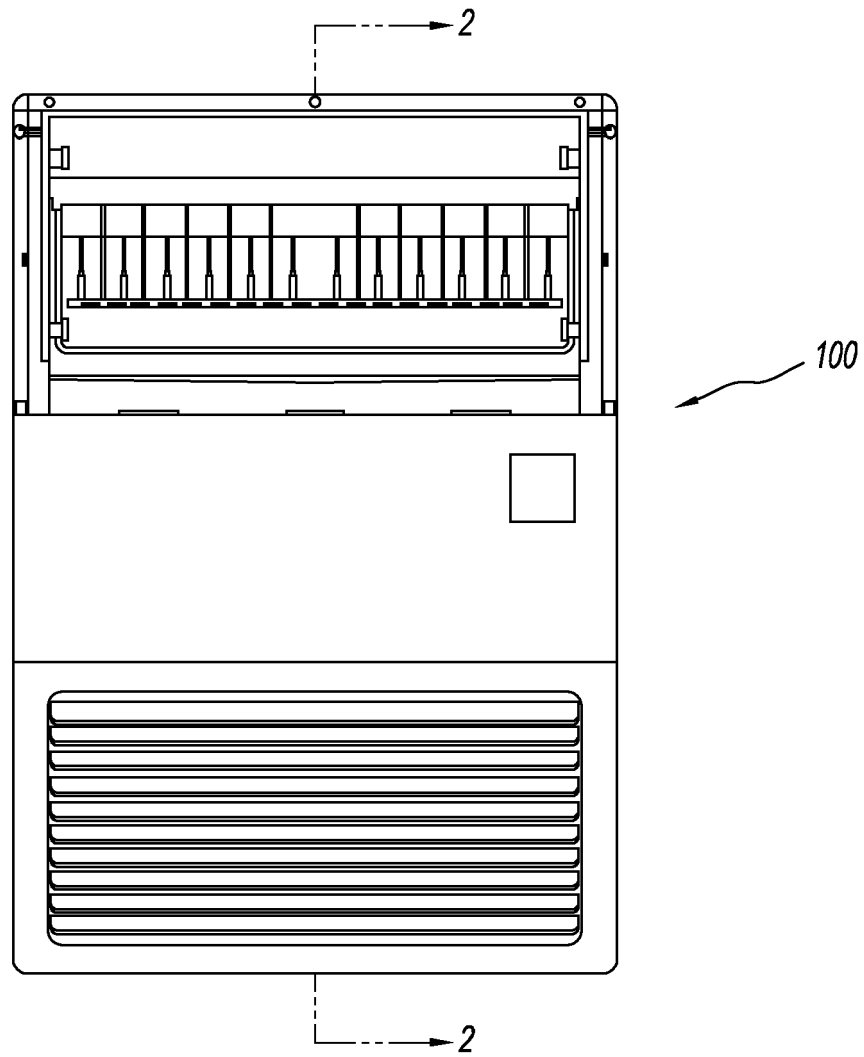


FIG. 1

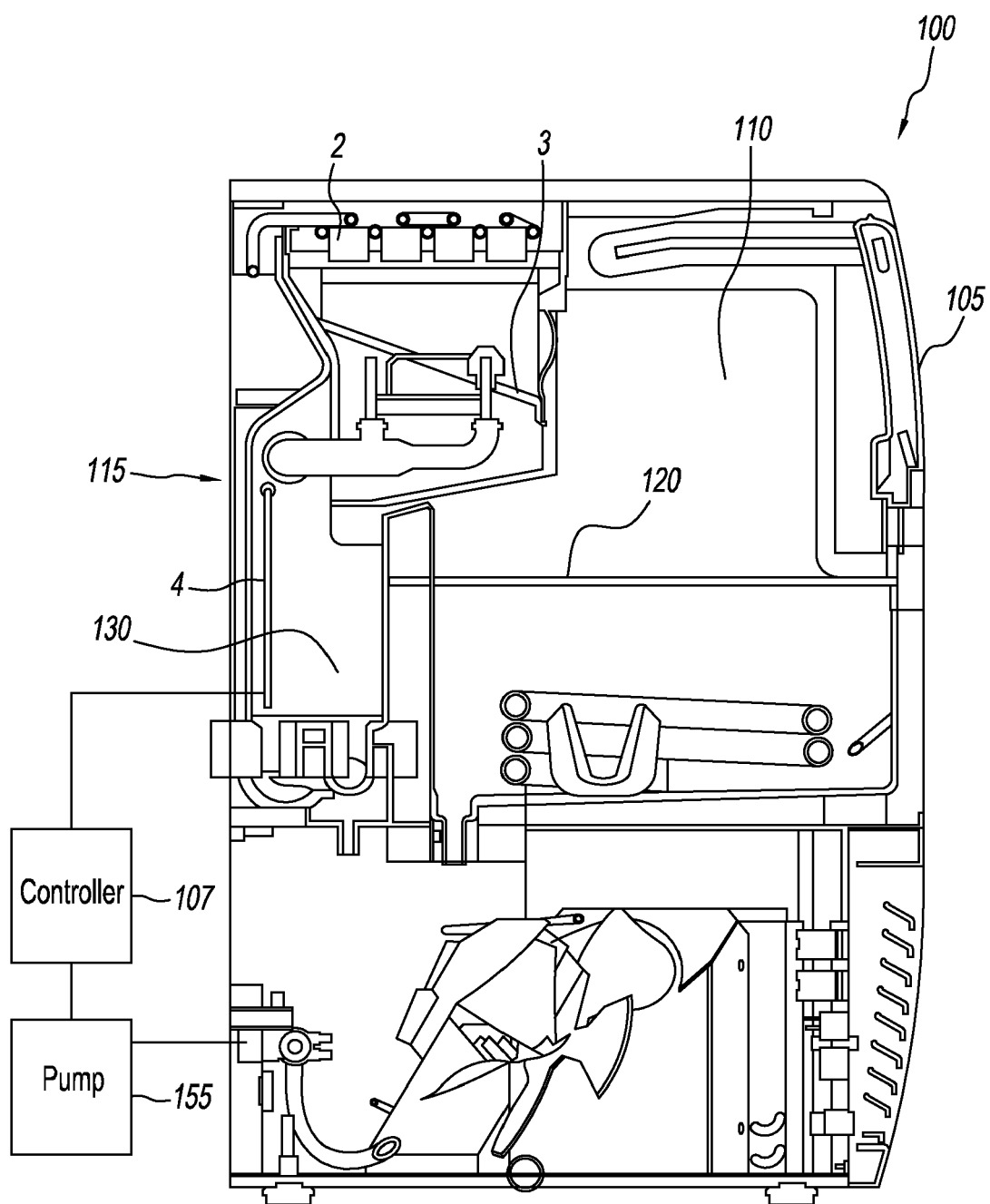


FIG. 2

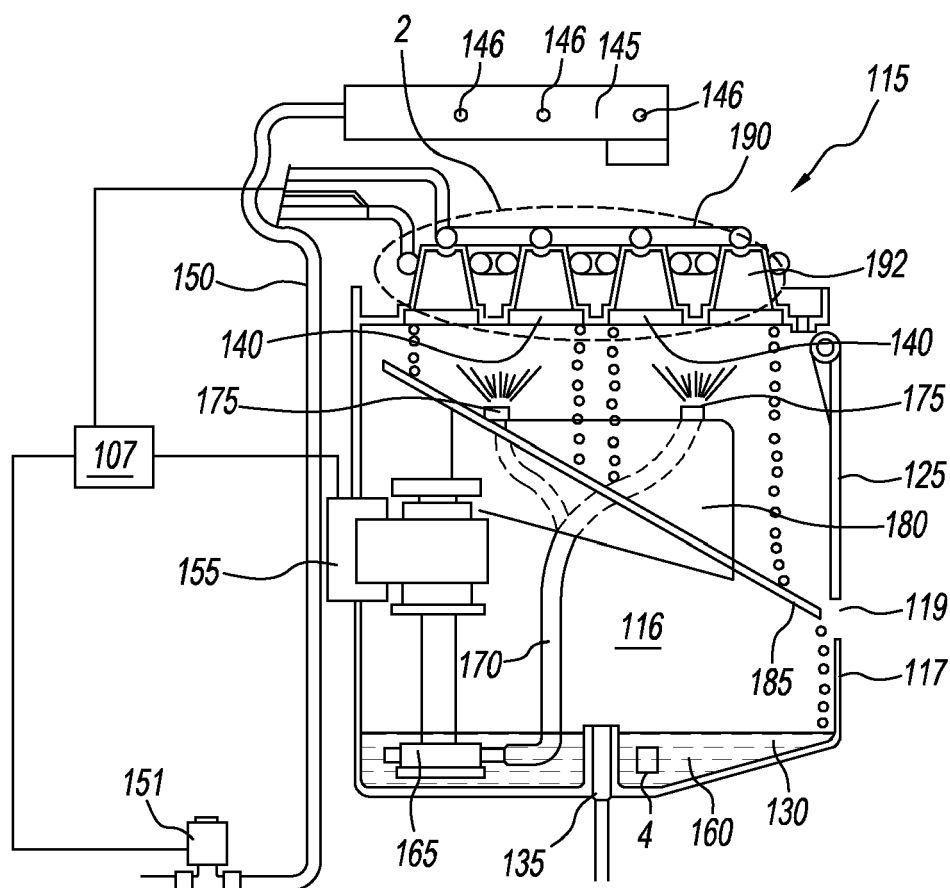


FIG. 3

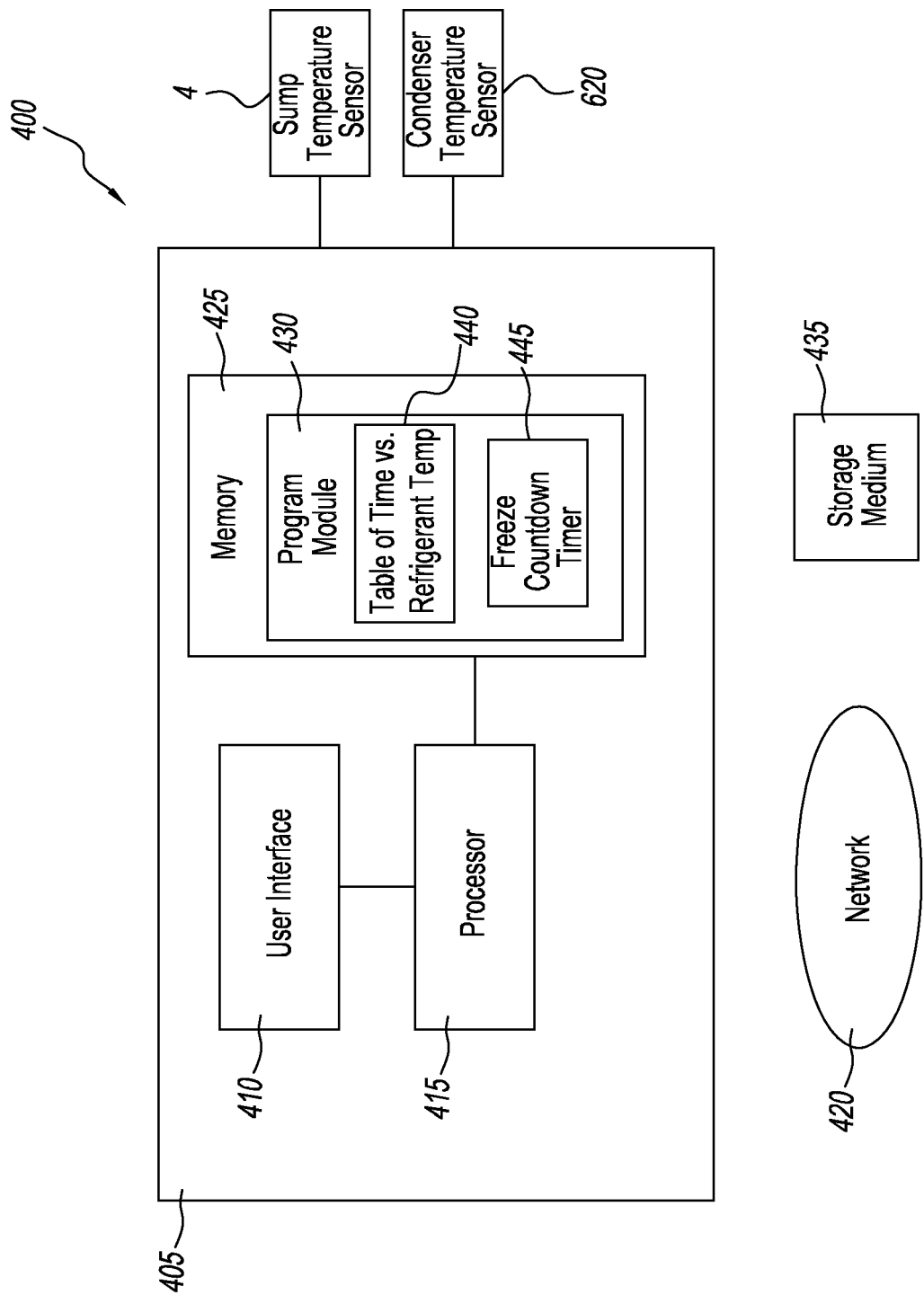
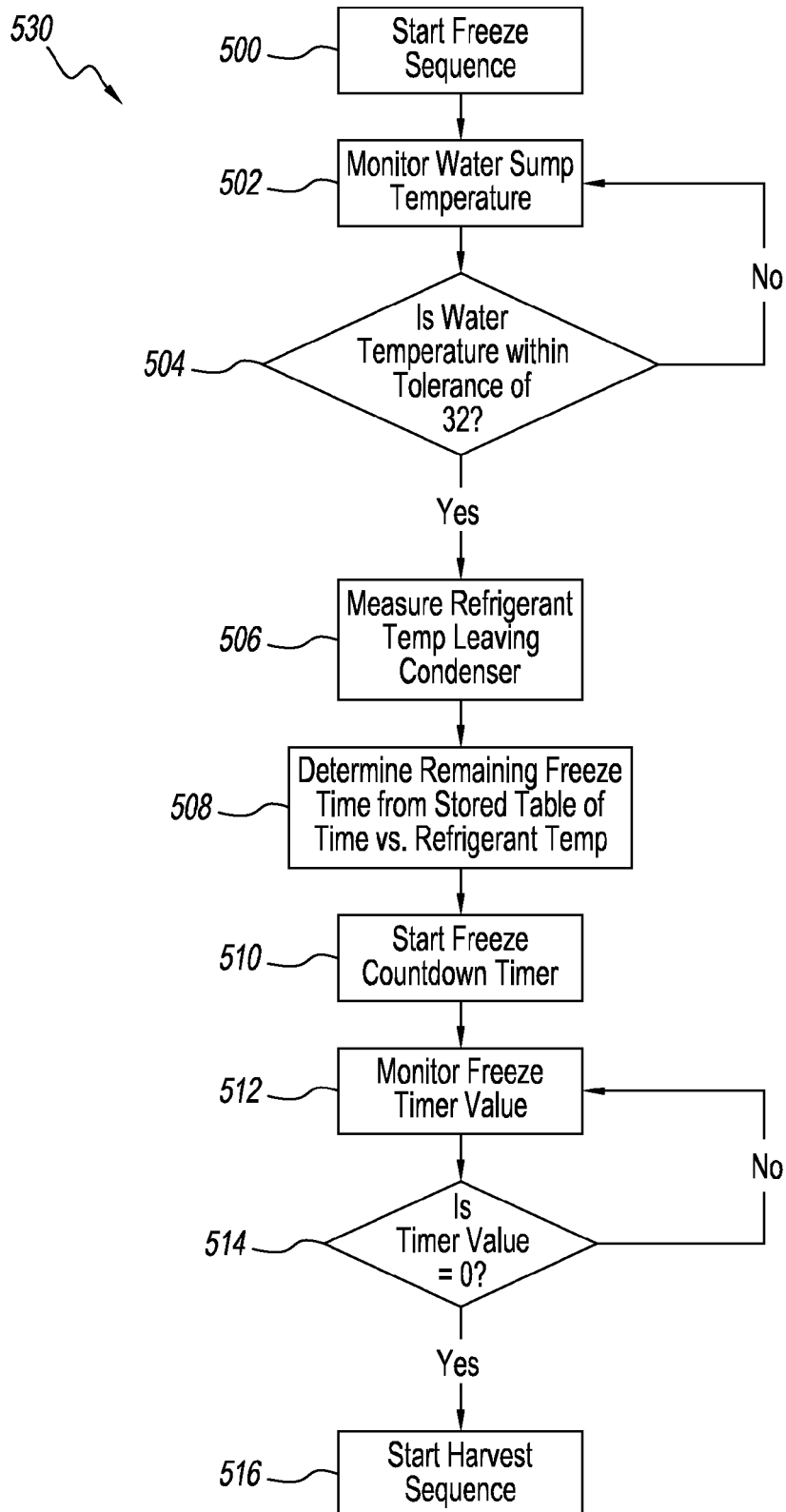


FIG. 4

**FIG. 5**

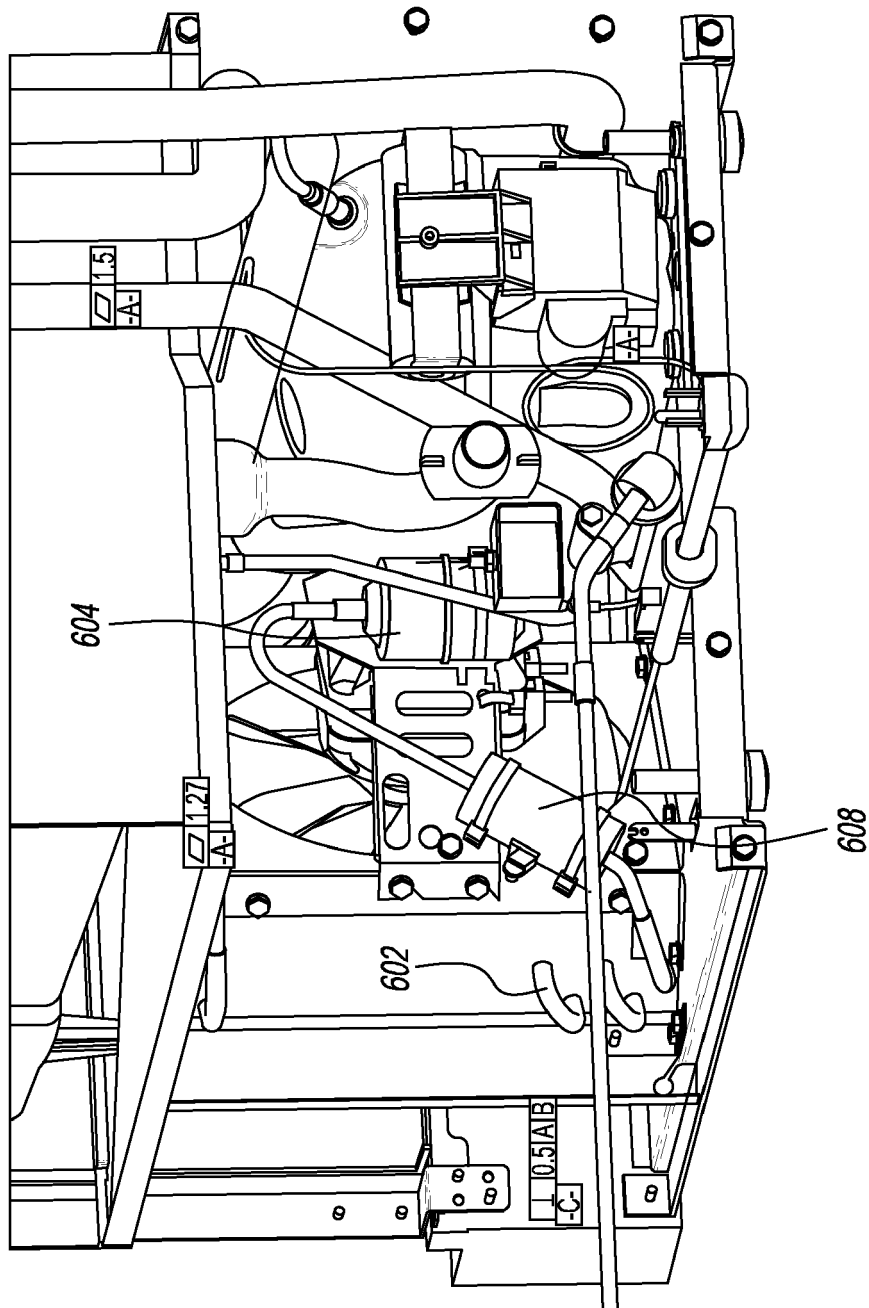


FIG. 6