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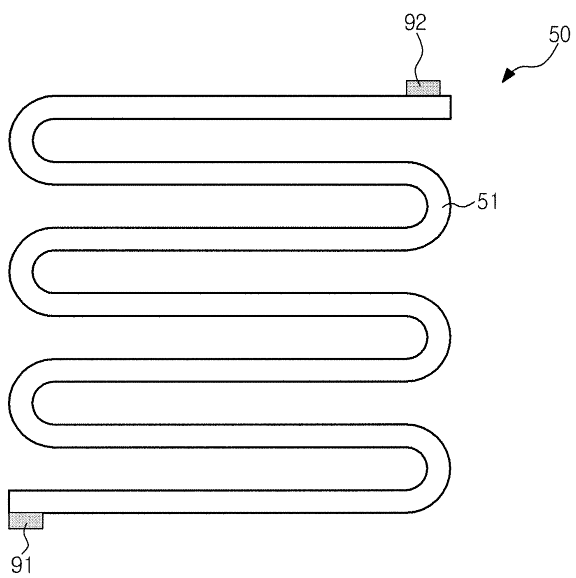
(54) Cooling system with a unit for determining the amount of frost and method of controlling such a system

(57) An oscillatory wave generating unit and an oscillatory wave sensing unit are installed at both ends of a refrigerant pipe of an evaporator of the cooling system, an amount of frost formed on the refrigerant pipe is determined by comparing a wave form of an oscillatory wave generated from one end of the refrigerant through the oscillatory wave generating unit and a wave form of the oscillatory wave sensed by the other one end of the refrigerant through the oscillatory wave sensing unit, and whether or not a defrosting operation is performed is determined by a result of the determination. The cooling system increases the accuracy in sensing the amount of the frost formed on the evaporator of a refrigerator, a Kimchi refrigerator, or an air conditioner, and respectively starts and ends the defrosting operation at proper points of time, thus enhancing a heat-exchanging performance and increasing energy efficiency.

FIG. 2



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Description

BACKGROUND

1. Field

[0001] The present invention relates to a cooling system and a method of controlling the same, and more particularly to a cooling system, which senses frost formed on an evaporator by heat exchange, and a method of controlling the cooling system.

2. Description of the Related Art

[0002] In general, cooling systems are apparatuses, which circulate a refrigerant according to a refrigerating cycle and thus cool a designated space, and include a refrigerator, a Kimchi refrigerator, an air conditioner, etc.

[0003] Here, the refrigerating cycle changes a refrigerant into four phases, such as compression, condensation, expansion, and evaporation, and thus needs to be provided with a compressor, a condenser, an expansion valve, an evaporator, etc. That is, when the refrigerant in a gas state is compressed by the compressor and is transmitted to the condenser, the compressed refrigerant exchanges heat with surrounding air in the condenser and thus is cooled. Thereafter, when the refrigerant in a liquid state obtained by cooling is injected into the evaporator under the condition that the flow rate of the refrigerant is adjusted by the expansion valve, the refrigerant is rapidly expanded and evaporated, and thus absorbs heat from surrounding air in the evaporator and supplies cold air to an indoor space, such as the interior of a room, thereby cooling the space. Thereafter, when the refrigerant in the gas state obtained in the evaporator is transmitted again to the compressor, the refrigerant in the gas state is compressed again into the refrigerant in the liquid state, and the above refrigerating cycle is repeated.

[0004] Since the surface temperature of the evaporator cooling the indoor space through the refrigerating cycle is lower than the temperature of air in the indoor space, moisture condensed from the air of a relatively higher temperature in the indoor space is stuck to the surface of the evaporator and thus frost is formed on the surface of the evaporator. The frost formed on the surface of the evaporator is gradually thickened as time goes by, and then the heat-exchanging efficiency of air passing through the evaporator is lowered and causes excessive power consumption.

[0005] In order to solve the problem, a defrosting operation, in which the operating time of the compressor is accumulated, and a heating unit installed around the evaporator is operated to remove the frost formed on the surface of the evaporator, when the accumulated operating time elapses a designated time, was conventionally performed. However, this defrosting operation is performed based on the operating time of the compressor regardless of the real amount of the front formed on the surface of the evaporator, and thus is limited in the effective removal of the frost formed on the surface of the evaporator.

SUMMARY

[0006] Therefore, one aspect of the invention is to provide a cooling system, which senses frost formed on an evaporator by heat exchange, and a method of controlling the cooling system.

[0007] Additional aspects and/or advantages will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the invention.

[0008] In accordance with one aspect, the present invention provides a cooling system including an oscillatory wave generating unit installed at one end of a refrigerant pipe and generating an oscillatory wave; an oscillatory wave sensing unit installed at the other end of the refrigerant pipe and sensing the oscillatory wave; and a control unit determining an amount of frost formed on the refrigerant pipe based on a difference of wave forms between the oscillatory wave generated from the oscillatory wave generating unit and the oscillatory wave sensed by the oscillatory wave sensing unit.

[0009] The difference of wave forms may be a phase difference between the oscillatory wave generated from the oscillatory wave generating unit and the oscillatory wave sensed by the oscillatory wave sensing unit.

[0010] The difference of wave forms may be an amplitude difference between the oscillatory wave generated from the oscillatory wave generating unit and the oscillatory wave sensed by the oscillatory wave sensing unit.

[0011] The control unit may control a defrosting operation based on the amount of frost.

[0012] The control unit may determine an amount of frost remaining on the refrigerant pipe based on the difference of wave forms in the defrosting operation, and determine whether or not the defrosting operation is terminated based on the amount of the remaining frost.

[0013] The cooling system including a plurality of oscillatory wave generating units installed on a refrigerant pipe and a plurality of oscillatory wave sensing units installed on the refrigerant; and a control unit determining amounts of frost formed in sections of the refrigerant pipe based on differences of wave forms between the oscillatory waves generated from the oscillatory wave generating units and the oscillatory waves sensed by the oscillatory wave sensing units.

[0014] The plurality of oscillatory wave generating units may sequentially generate the oscillatory waves.

[0015] The refrigerant pipe may be divided into plural sections; and the plurality of oscillatory wave generating units may be respectively installed at ends of the sections and the plurality of oscillatory wave sensing units is respectively installed at the other ends of the sections.

[0016] The control unit may perform the defrosting operation when the amount of frost in at least one section of the sections is more than a reference amount.

[0017] In accordance with a further aspect, the present invention provides a method of controlling a cooling system, including generating an oscillatory wave by operating an oscillatory wave generating unit installed at one end of a refrigerant pipe; sensing the oscillatory wave by an oscillatory wave sensing unit installed at the other end of the refrigerant pipe; and determining an amount of frost formed on the refrigerant pipe based on a difference of wave forms between the generated oscillatory wave and the sensed oscillatory wave.

[0018] The determination of the amount of frost may include calculating a phase difference between the generated oscillatory wave and the sensed oscillatory wave.

[0019] The determination of the amount of frost may include calculating an amplitude difference between the generated oscillatory wave and the sensed oscillatory wave.

[0020] The method may further include determining whether or not it is a defrosting time point based on the amount of the frost formed on the refrigerant pipe.

[0021] The method may further include performing a defrosting operation, when it is determined that it is the defrosting time point; determining an amount of frost remaining on the refrigerant pipe by generating an oscillatory wave and sensing the oscillatory wave; and determining whether or not it is a defrosting operation ending time point based on the amount of the remaining frost.

[0022] The method of controlling a cooling system including generating oscillatory waves by operating a plurality of oscillatory wave generating units; sensing the oscillatory waves by a plurality of oscillatory wave sensing units corresponding to the plurality of oscillatory wave generating units; and determining amounts of frost formed in sections of a refrigerant pipe based on differences of wave forms between the generated oscillatory waves and the sensed oscillatory waves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

FIG. 1 is an exemplary view of a cooling system in accordance with an embodiment;
FIG. 2 is a detailed exemplary view of a cooling system in accordance with one embodiment;
FIG. 3 is a control diagram of the cooling system in accordance with one embodiment;
FIG. 4, parts (a) and (b), and FIG. 5, parts (a) and (b), are graphs illustrating wave forms of the cooling system in accordance with one embodiment;
FIG. 6 is a flow chart illustrating a method of controlling the cooling system in accordance with one embodiment;
FIG. 7 is a detailed exemplary view of a cooling system in accordance with another embodiment;
FIG. 8 is a control diagram of the cooling system in accordance with another embodiment; and
FIG. 9 is a flow chart illustrating a method of controlling the cooling system in accordance with another embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0024] Reference will now be made in detail to the embodiments of the present invention, an example of which is illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. The embodiments are described below to explain the present invention by referring to the annexed drawings.

[0025] In these embodiments, among cooling systems using a refrigerating cycle, a refrigerator will be exemplarily described.

[0026] As shown in FIG. 1, the refrigerator includes a main body 10 provided with an opened front surface, and a storage chamber 20 provided in the main body 10 to store foods. The storage chamber 20 is horizontally divided into a freezing chamber and a cooling chamber side by side by an intermediate diaphragm. The front surfaces of the freezing chamber and the cooling chamber are opened, and doors 30 to shield the freezing chamber and the cooling chamber from the outside are respectively provided at the opened front surfaces of the freezing chamber and the cooling chamber. Further, a duct 40, through which air flows, is formed between the main body 10 and the wall of the storage chamber 20, and a plurality of holes, through which air in the storage chamber and the duct 40 is circulated into each other, is formed through the wall of the storage chamber 20.

[0027] An evaporator 50 to cool surrounding air through a cooling effect that surrounding latent heat is absorbed by evaporating a refrigerant supplied from a condenser (not shown), a fan 60 to absorb air in the storage chamber 20 and transmit the air passed through the evaporator 50 to the storage chamber 20, and a heating unit 70 to remove frost formed on the evaporator 50 are installed in the duct 40. Further, a compressor 80 to compress the refrigerant and transmit the compressed refrigerant to the condenser (not shown), and the condenser (not shown) to condense the refrigerant in a high-temperature and high-pressure state compressed by the compressor 80 through the radiation of heat are installed in a machinery chamber provided in the lower portion of the inside of the main body 10.

[0028] The evaporator 50 includes a refrigerant pipe 51, in which the refrigerant flows, and a plurality of refrigerant pins (not shown) mounted on the refrigerant pipe 51 to increase a heat-exchanging efficiency. The evaporator 50 evaporates the refrigerant in a low-temperature and low-pressure state at a low temperature and a low pressure and exchanges heat with air having a relatively higher temperature in the refrigerator, and thus serves to lower the temperature in the refrigerator, and frost is continuously formed on the refrigerant pipe 51 and the refrigerant pins due to a temperature difference. Therefore, a defrosting operation to remove the frost formed on the evaporator 50 is indispensably performed. In order to perform the defrosting operation, an amount of frost formed on the evaporator 50 needs to be detected.

[0029] Thereby, in order to detect the amount of the front formed on the refrigerant pipe 51, an oscillatory wave generating unit 91 and an oscillatory wave sensing unit 92 are installed on the refrigerant pipe 51 of the evaporator 50. The oscillatory wave generating unit 91 and the oscillatory wave sensing unit 92 will be described with reference to FIG. 2.

[0030] The oscillatory wave generating unit 91 is installed at one end of the refrigerant pipe 51 and generates an oscillatory wave, and the oscillatory wave sensing unit 92 is installed at the other end of the refrigerant pipe 51 and senses the oscillatory wave of the refrigerant pipe 51. That is, when it is supposed that the refrigerant flows from one end of the refrigerant pipe 51 to the other end of the refrigerant pipe 51, one of the oscillatory wave generating unit 91 and the oscillatory wave sensing unit 92 is installed at one end of the refrigerant pipe 51 and the other one of the oscillatory wave generating unit 91 and the oscillatory wave sensing unit 92 is installed at the other end of the refrigerant pipe 51.

[0031] A piezoelectric element or a small-sized motor, which can generate an oscillatory wave, is used as an actuator of the oscillatory wave generating unit 91. Further, actuators of various kinds, which can generate an oscillation, may be used as the actuator of the oscillatory wave generating unit 91.

[0032] A piezoelectric element or an acceleration sensor, which can sense the oscillatory wave flowing along the refrigerant pipe 51, convert the sensed oscillatory wave into a voltage, and output a wave form corresponding to the voltage, is used as a sensor of the oscillatory wave sensing unit 92. Further, sensors of various kinds, which can convert an oscillatory wave into a voltage, may be used as the sensor of the oscillatory wave sensing unit 92.

[0033] That is, the oscillatory wave generating unit 91 transmits an oscillatory wave corresponding to a reference wave form having regular frequency and amplitude, which are predetermined, to the refrigerant pipe 51 according to the instructions of a control unit 100, and the oscillatory wave sensing unit 92 senses the oscillatory wave flowing along the refrigerant pipe 51, converts the sensed oscillatory wave into a voltage, and outputs the wave form of the voltage to the control unit 100.

[0034] Here, the control unit 100 controls the cooling of the fan 60, the heating unit 70, and the compressor 80 and the defrosting operation according to the wave form of the oscillatory wave transmitted from the oscillatory wave sensing unit 92. This control will be described with reference to FIG. 3.

[0035] FIG. 3 is a control diagram of the cooling system in accordance with one embodiment. The cooling system includes the oscillatory wave generating unit 91, the oscillatory wave sensing unit 92, the control unit 100, a storing unit 110, a fan driving unit 120, a heating unit driving unit 130, and a compressor driving unit 140.

[0036] The oscillatory wave generating unit 91 generates an oscillatory wave corresponding to the reference wave form having regular frequency and amplitude, which are predetermined, at a set time according to the instructions of the control unit 100, and transmits the oscillatory wave to the refrigerant pipe 51.

[0037] The oscillatory wave sensing unit 92 senses the oscillatory wave flowing along the refrigerant pipe 51, converts the sensed oscillatory wave into a voltage, and outputs the wave form (sensed wave form) of the voltage to the control unit 100.

[0038] Frost formed on the evaporator 50 becomes a resistance factor to the flow of the oscillatory wave along the refrigerant pipe 51, and changes the wave form of the oscillatory wave. That is, the change degree of the reference wave form corresponding to the oscillatory wave is varied according to the amount of the front formed on the evaporator 50. This change of the reference wave form will be described with reference to FIG 4, parts (a) and (b), and FIG. 5, parts (a) and (b).

[0039] FIG 4, parts (a) and (b), respectively illustrate a reference wave form and a sensed wave form of an oscillatory wave, in case that the amount of the frost formed on the evaporator 50 is small, and FIG. 5, parts (a) and (b), respectively illustrate a reference wave form and a sensed wave form of an oscillatory wave, in case that the amount of the frost formed on the evaporator 50 is large. By comparison, a phase difference (T1) between the reference wave form of FIG. 4, part (a), and the sensed wave form of FIG. 4, part (b), is smaller than a phase difference (T2) between the reference wave form of FIG. 5, part (a), and the sensed wave form of FIG. 5, part (b), and an amplitude difference between the reference wave form of FIG. 4, part (a), and the sensed wave form of FIG. 4, part (b), is smaller than an amplitude difference between the reference wave form of FIG. 5, part (a), and the sensed wave form of FIG. 5, part (b). As described above, it is appreciated that the oscillatory wave generated when the amount of the frost formed on the evaporator 50 is large has a large phase difference between the reference wave form and the sensed wave form, a larger amplitude between the reference wave form and the sensed wave form, and a more distorted shape of the sensed wave form, compared with the oscillatory wave generated when the amount of the frost formed on the evaporator 50 is small.

[0040] That is, as the amount of the frost formed on the evaporator 50 is increased, resisting force to the oscillatory wave is increased, and a difference between an oscillatory wave generating time and an oscillatory wave sensing time is increased and thus a phase difference is increased. Further, an amplitude difference between the reference wave form of the generated oscillatory wave and the sensed wave form of the sensed oscillatory wave is increased, and a distorted degree of the sensed oscillatory wave is increased.

[0041] The control unit 100 transmits the reference wave regular frequency and regular amplitude, which are predetermined, to the oscillatory wave generating unit 91 at a set time, determines the amount of the frost formed on the evaporator 50 by comparing the sensed wave form with the reference wave, when the sensed wave form is inputted from the oscillatory wave sensing unit 92 to the control unit 100, and performs a defrosting operation at the optimum defrosting time point according to a result of the determination.

[0042] Here, the control unit 100 measures the amount of the frost formed on the refrigerant pipe 51 of the evaporator 50 based on at least one of the phase difference and the amplitude difference between the reference wave form of the oscillatory wave generated from the oscillatory wave generating unit 91 and the sensed wave form of the oscillatory wave sensed by the oscillatory wave sensing unit 92.

[0043] To be more particular, in case that the control unit 100 determines the amount of frost using the phase difference between the wave forms, the control unit 100 calculates the phase difference by comparing the phase of the sensed wave form of the oscillatory wave with the phase of the reference wave form of the oscillatory wave, and determines the amount of frost by comparing the calculated phase difference with a phase difference data stored in the storing unit 110.

[0044] In case that the control unit 100 determines the amount of frost using the amplitude difference between the wave forms, the control unit 100 calculates the amplitude difference by comparing the amplitude of the sensed wave form of the oscillatory wave with the amplitude of the reference wave form of the oscillatory wave, and determines the amount of frost by comparing the calculated amplitude difference with an amplitude difference data stored in the storing unit 110.

[0045] In case that the control unit 100 determines the amount of frost using the phase difference and the amplitude difference between the wave forms, the control unit 100 calculates the phase difference by comparing the phase of the sensed wave form of the oscillatory wave with the phase of the reference wave form of the oscillatory wave, calculates the amplitude difference by comparing the amplitude of the sensed wave form of the oscillatory wave with the amplitude of the reference wave form of the oscillatory wave, and determines the amount of frost by matching the calculated phase difference and the calculated amplitude difference with each other and comparing the obtained matching value with a phase difference and amplitude difference matching data stored in the storing unit 110.

[0046] Further, the control unit 100 determines whether or not it is a defrosting time point by comparing the determined amount of frost with a reference amount of frost, and operates of the heating unit 70 to perform a defrosting operation, when it is determined that it is a defrosting time point.

[0047] The control unit 100 determines whether or not a defrosting operation executing time reaches a predetermined reference time, and stops the heating unit 70, when it is determined that the defrosting operation executing time reaches the predetermined reference time.

[0048] Otherwise, the control unit 100 determines the amount of frost remaining on the refrigerant pipe 51 of the evaporator 50 by controlling the operation of a frost amount measuring unit 90 during the defrosting operation, and determines whether or not the operation of the heating unit 70 is stopped by determining whether or not it is a defrosting operation ending time point according to a result of the determination. Here, a method of determining the amount of frost remaining on the refrigerant pipe 51 by controlling the operation of the frost amount measuring unit 90 is equal to a method of determining the amount of the frost formed on the refrigerant pipe 51 by controlling the operation of the frost amount measuring unit 90.

[0049] As described above, the defrosting operation is performed at a proper point of time and is stopped at a proper point of time, and thus power consumed by the defrosting operation is cut down.

[0050] The storing unit 110 stores a frost amount data corresponding to the phase difference data between the reference wave form and the sensed wave form of the oscillatory wave, and a frost amount data corresponding to the amplitude difference data between the reference wave form and the sensed wave form of the oscillatory wave. The storing unit 110 further stores a frost amount data corresponding to the phase difference and amplitude difference matching data. The storing unit 110 further stores a reference amount of frost.

[0051] The fan driving unit 120 rotates the fan 60 at a predetermined speed according to the operation mode of the refrigerator, the heating unit driving unit 130 operates the heating unit 70 according to the instructions of the control unit 100, when the amount of the frost formed on the evaporator 50 reaches the predetermined reference amount of frost, and stops the operation of the heating unit 70 according to the instructions of the control unit 100, the compressor driving unit 140 turns on/off the compressor 80 based on the operation mode of the refrigerator to maintain the inside of the storage chamber at a designated set temperature corresponding to the operation mode, and stops the compression of the refrigerant by the compressor 80 according to the instructions of the control unit 100 in the defrosting operation. This method of controlling the cooling system will be described with reference to FIG. 6.

[0052] FIG. 6 is a flow chart illustrating a method of controlling the cooling system in accordance with one embodiment of the present invention.

[0053] The compressor 80 is turned on/off according to the refrigerating cycle corresponding to an operation mode selected by a user, and the rotation of the fan 60 is controlled and thus the inside of the storage chamber is maintained at the designated temperature. Then, the operation of the frost amount measuring unit 90 is periodically controlled, and thus the amount of the frost formed on the refrigerant pipe 51 of the evaporator 50 is determined.

[0054] To be more particular, the oscillatory wave generating unit 91 of the frost amount measuring unit 90 is operated and generates an oscillatory wave corresponding to the reference wave form having predetermined regular frequency and regular amplitude (operation 301), and transmits the oscillatory wave to the refrigerant pipe 51. Then, the oscillatory wave flows along the refrigerant pipe 51, and the oscillatory wave sensing unit 92 of the frost amount measuring unit 90 senses the oscillatory wave (operation 302). The oscillatory wave sensing unit 92 converts the sensed oscillatory wave into a voltage, and outputs the wave form of the voltage.

[0055] When the oscillatory wave flows along the refrigerant pipe 51, the shape of the oscillatory wave is changed, i.e., the sensed wave form is decreased in amplitude and is distorted, by the frost formed on the refrigerant pipe 51. That is, the reference wave form and the sensed wave form of the oscillatory wave become different. Further, a time (a phase) taken to sense the oscillatory wave, generated from the oscillatory wave generating unit 91, by the oscillatory wave sensing unit 92 is varied according to the amount of the frost formed on the refrigerant pipe 51.

[0056] The control unit 100 compares the sensed wave form of the oscillatory wave sensed by the oscillatory wave sensing unit 92 with the reference wave form of the oscillatory wave generated from the oscillatory wave generating unit 91 (operation 303), and thus determines the amount of the frost formed on the refrigerant pipe 51 of the evaporator 50 (operation 304). That is, the control unit 100 determines the amount of the frost formed on the refrigerant pipe 51 of the evaporator 50 based on at least one of a phase difference and an amplitude phase between the reference wave form and the sensed wave form of the oscillatory wave.

[0057] To be more particular, first, in a case where the control unit 100 determines the amount of the frost using the phase difference between the wave forms, the control unit 100 calculates the phase difference by comparing the phase of the sensed wave form of the oscillatory wave with the phase of the reference wave form of the oscillatory wave, and determines the amount of the frost by comparing the calculated phase difference with the phase difference data stored in the storing unit 110.

[0058] Secondly, in a case where the control unit 100 determines the amount of the frost using the amplitude difference between the wave forms, the control unit 100 calculates the amplitude difference by comparing the amplitude of the sensed wave form of the oscillatory wave with the amplitude of the reference wave form of the oscillatory wave, and determines the amount of the frost by comparing the calculated amplitude difference with the amplitude difference data stored in the storing unit 110.

[0059] Thirdly, in a case where the control unit 100 determines the amount of the frost using the phase difference and the amplitude difference between the wave forms, the control unit 100 calculates the phase difference by comparing the phase of the sensed wave form of the oscillatory wave with the phase of the reference wave form of the oscillatory wave, calculates the amplitude difference by comparing the amplitude of the sensed wave form of the oscillatory wave with the amplitude of the reference wave form of the oscillatory wave, and determines the amount of the frost by matching the calculated phase difference and the calculated amplitude difference with each other and comparing the obtained matching value with the phase difference and amplitude difference matching data stored in the storing unit 110.

[0060] The control unit 100 determines whether or not it is a defrosting operation time point by comparing the amount of the frost determined by the above method with the reference amount of frost (operation 305). That is, when the amount of the frost formed on the refrigerant pipe 51 is more than the reference amount of frost, the control unit 100 determines that it is the defrosting operation time point, and operates the heating unit 70 to perform the defrosting operation (operation 306).

[0061] Further, the control unit 100 determines whether of not the defrosting operation executing time reaches a predetermined reference time by counting the defrosting operation executing time, and stops the operation of the heating unit 70, when it is determined that the defrosting operation executing time reaches the reference time.

[0062] Otherwise, the control unit 100 determines the amount of frost remaining on the refrigerant pipe 51 of the evaporator 50 by controlling the operations of the oscillatory wave generating unit 91 and the oscillatory wave sensing unit 92 in the defrosting operation, and determines whether or not the operation of the heating unit 70 is stopped according to a result of the determination. Here, the method of determining the amount of frost remaining on the refrigerant pipe 51 by controlling the operations of the oscillatory wave generating unit 91 and the oscillatory wave sensing unit 92 is equal to the method of determining the amount of the frost formed on the refrigerant pipe 51 by controlling the operations of the oscillatory wave generating unit 91 and the oscillatory wave sensing unit 92.

[0063] The defrosting operation is performed at a proper point of time and is stopped at a proper point of time, as described above, and thus power consumed by the defrosting operation is cut down.

[0064] FIG. 7 is a detailed exemplary view of a cooling system in accordance with another embodiment, and FIG. 8 is a control diagram of the cooling system in accordance with another embodiment.

[0065] As a refrigerant flows along a refrigerant pipe 51, the refrigerant is varied in pressure and temperature and thus the amounts of frost formed on respective sections of the refrigerant pipe 51 are varied. Therefore, in order to measure the amounts of frost formed in the respective sections of the refrigerant pipe 51, the refrigerant pipe 51 of the evaporator 50 is divided into a plurality of sections, and frost amount measuring units 90 are respectively installed at the sections to measures the amounts of frost formed in the respective sections of the refrigerant pipe 51.

[0066] That is, an oscillatory wave generating unit 93 and an oscillatory wave sensing unit 94 in a pair are installed in each of the plural sections of the refrigerant pipe 51. As shown in FIG. 7, one of the oscillatory wave generating units 93 and the oscillatory wave sensing units 94 is installed at one end of each of the sections of the refrigerant pipe 51, and the other one of the oscillatory wave generating units 93 and the oscillatory wave sensing units 94 is installed at the other end of each of the sections of the refrigerant pipe 51.

[0067] The plural oscillatory wave generating units 93 sequentially transmits oscillatory waves corresponding to a reference wave form having regular frequency and amplitude, which are predetermined, to the refrigerant pipe 51 according to the instructions of a control unit 200, and the plural oscillatory wave sensing units 94 senses the oscillatory waves flowing along the corresponding sections of the refrigerant pipe 51, convert the sensed oscillatory waves into voltages, and output the wave forms (sensed wave forms) of the voltages to the control unit 200.

[0068] Here, the control unit 200 controls the cooling of the fan 60, the heating unit 70, and the compressor 80 and the defrosting operation according to changes in the wave forms of the oscillatory waves transmitted from the plural oscillatory wave sensing units 94. This control will be described with reference to FIG. 8.

[0069] FIG. 8 is a control diagram of the cooling system in accordance with another embodiment. The cooling system includes the plural oscillatory wave generating unit 93, the plural oscillatory wave sensing units 94, the control unit 200, a storing unit 210, a fan driving unit 220, a heating unit driving unit 230, and a compressor driving unit 240.

[0070] The plural oscillatory wave generating units 93-1 to 93-n sequentially generate oscillatory waves corresponding to the reference wave form having regular frequency and amplitude, which are predetermined, at a set time according to the instructions of the control unit 200, and transmit the oscillatory waves to the refrigerant pipe 51. The plural oscillatory wave sensing units 94-1 to 94-n sense the oscillatory waves flowing along the corresponding sections of the refrigerant pipe 51, convert the sensed oscillatory waves into voltages, and output the wave forms (sensed wave forms) of the voltages to the control unit 200.

[0071] At this time, the oscillatory waves generated from the plurality oscillatory wave generating units 93-1 to 93-n may have different frequencies, and the oscillatory waves sensed by the plural oscillatory wave sensing units 94-1 to 94-n may have the corresponding frequencies of the oscillatory waves generated from the plurality oscillatory wave generating units 93-1 to 93-n. Thereby, the plurality oscillatory wave generating units 93-1 to 93-n may generate oscillatory waves at the same point of time.

[0072] When the oscillatory wave generated from one section of the refrigerant pipe 51 flows along the refrigerant pipe 51, frost formed in the section of the refrigerant pipe 51 becomes a resistance factor to the flow of the oscillatory wave, and changes the wave form of the oscillatory wave. Further, the traveling times of the oscillatory waves are changed according to the amounts of the frost in the respective sections of the refrigerant pipe 51.

[0073] The control unit 200 sequentially transmits the reference wave having predetermined regular frequency and regular amplitude to the oscillatory wave generating units 93-1 to 93-n of the frost amount measuring unit 90, and determines the amounts of the frost formed in the respective sections of the refrigerant pipe 51 based on the changes of the wave forms of the oscillatory waves in the respective sections, when the sensed wave forms in the respective sections are inputted from the oscillatory wave sensing units 94-1 to 94-n to the control unit 200. Here, the control unit 200 measures the amounts of the frost formed in the respective sections of the refrigerant pipe 51 based on at least one of phase differences and amplitude differences between the reference wave forms and the sensed wave forms of the oscillatory waves in the respective sections.

[0074] To be more particular, first, in a case where the control unit 200 determines the amounts of the frost using the phase differences between the wave forms, the control unit 200 calculates the phase differences by comparing the phases of the sensed wave forms of the oscillatory waves in the respective sections with the phase of the reference wave form of the oscillatory wave, and determines the amounts of the frost in the respective sections by comparing the calculated phase differences with a phase difference data stored in the storing unit 210.

[0075] Secondly, in a case where the control unit 200 determines the amounts of the frost using the amplitude differences between the wave forms, the control unit 200 calculates the amplitude differences by comparing the amplitudes of the sensed wave forms of the oscillatory waves in the respective sections with the amplitude of the reference wave form of the oscillatory wave, and determines the amounts of the frost in the respective sections by comparing the calculated amplitude differences with an amplitude difference data stored in the storing unit 210.

[0076] Thirdly, in a case where the control unit 200 determines the amounts of the frost using the phase differences and the amplitude differences between the wave forms, the control unit 200 calculates the phase differences by comparing the phases of the sensed wave forms of the oscillatory waves in the respective sections with the phase of the reference wave form of the oscillatory wave, calculates the amplitude differences by comparing the amplitudes of the sensed wave forms of the oscillatory waves in the respective sections with the amplitude of the reference wave form of the oscillatory wave, and determines the amounts of the frost in the respective sections by matching the calculated phase differences and the calculated amplitude differences with each other and comparing the obtained matching values with a phase difference and the amplitude difference matching data stored in the storing unit 210.

[0077] Further, the control unit 200 determines whether or not it is a defrosting time point by respectively comparing the determined amounts of the frost in the sections with a reference amount of frost, and operates of the heating unit 70 to perform a defrosting operation, when it is determined that it is a defrosting time point. Here, in a case where the amount of the frost formed in at least one section is more than the reference amount of frost, the control unit 200 determines that it is a defrosting time point.

[0078] The control unit 200 determines whether or not a defrosting operation executing time reaches a predetermined reference time, and stops the operation of the heating unit 70, when it is determined that the defrosting operation executing time reaches the predetermined reference time.

[0079] Otherwise, the control unit 200 determines the amounts of the frost remaining in the respective sections of the refrigerant pipe 51 of the evaporator 50 by controlling the operations of the oscillatory wave generating units 93 and the oscillatory wave sensing units 94 during the defrosting operation, and determines whether or not the operation of the heating unit 70 is stopped by determining whether or not it is a defrosting operation ending time point according to a result of the determination. Here, a method of determining the amounts of the frost remaining in the respective sections of the refrigerant pipe 51 by controlling the operations of the oscillatory wave generating units 93 and the oscillatory wave sensing units 94 is equal to a method of determining the amounts of the frost formed in the respective sections of the refrigerant pipe 51 by controlling the operations of the oscillatory wave generating units 93 and the oscillatory wave sensing units 94.

[0080] As described above, the defrosting operation is performed at a proper point of time and is stopped at a proper point of time, and thus power consumed by the defrosting operation is cut down.

[0081] The storing unit 210 stores frost amount data corresponding to the phase difference data between the reference wave forms of the oscillatory waves generated from the oscillatory wave generating units 93-1 to 93-n and the sensed wave forms of the oscillatory waves sensed by the oscillatory wave sensing units 94-1 to 94-n, and frost amount data corresponding to the amplitude difference data between the reference wave forms of the oscillatory waves generated from the oscillatory wave generating units 93-1 to 93-n and the sensed wave forms of the oscillatory waves sensed by the oscillatory wave sensing units 94-1 to 94-n. The storing unit 210 further stores frost amount data corresponding to the phase difference and the amplitude difference matching data. The storing unit 210 further stores a reference amount of frost.

[0082] The fan driving unit 220 rotates the fan 60 at a predetermined speed according to the operation mode of the refrigerator, the heating unit driving unit 230 operates the heating unit 70 according to the instructions of the control unit 200, in case that the amounts of the frost formed on the evaporator 50 reach the predetermined reference amount of frost, and stops the operation of the heating unit 70 according to the instructions of the control unit 200, the compressor driving unit 240 turns on/off the compressor 80 based on the operation mode of the refrigerator to maintain the inside of the storage chamber at a designated set temperature corresponding to the operation mode, and stops the compression of the refrigerant by the compressor 80 according to the instructions of the control unit 200 in the defrosting operation. This method of controlling the cooling system will be described with reference to FIG. 9.

[0083] FIG. 9 is a flow chart illustrating a method of controlling the cooling system in accordance with another embodiment.

[0084] The compressor 80 is turned on/off according to the refrigerating cycle corresponding to an operation mode selected by a user, and the rotation of the fan 60 is controlled and thus the inside of the storage chamber is maintained at the designated temperature. Then, the operations of the plural frost amount measuring units 90 are periodically controlled, and thus the frost amount measuring units 90 respectively determine the amounts of the frost formed in the sections of the refrigerant pipe 51 of the evaporator 50.

[0085] To be more particular, the plural oscillatory wave generating units 93 are sequentially operated and generate oscillatory waves corresponding to the reference wave form having predetermined regular frequency and regular amplitude (operation 401), and transmit the oscillatory waves to the refrigerant pipe 51. Then, the oscillatory waves sequentially flow along the respective sections of the refrigerant pipe 51, and the oscillatory wave sensing units 94 installed at the corresponding sections sense the oscillatory waves (operation 402). The plural oscillatory wave sensing units 94 convert the sensed oscillatory waves into voltages, and output the wave forms (sensed wave forms) of the voltages.

[0086] Here, the sensed wave forms in the respective sections of the refrigerant pipe 51 are varied, i.e., are decreased in amplitude and distorted, according to the amounts of the frost in the sections. Further, phase differences between the reference wave forms of the oscillatory waves generated from the oscillatory wave generating units 93 and the sensed wave forms of the oscillatory waves sensed by the oscillatory wave sensing units 94 are varied according to the amounts of the frost formed in the respective sections of the refrigerant pipe 51.

[0087] The control unit 200 compares the sensed wave forms of the oscillatory waves with the reference wave forms of the oscillatory waves (operation 403), and then determines the amounts of the frost formed in the respective sections of the refrigerant pipe 51 based on the changes in the wave forms of the oscillatory waves. That is, the control unit 200 determines the amounts of the frost formed in the respective sections of the refrigerant pipe 51 of the evaporator 50 based on at least one of phase differences and amplitude phases between the reference wave forms and the sensed wave forms of the oscillatory waves in the respective sections (operation 404).

[0088] To be more particular, first, in a case where the control unit 200 determines the amounts of the frost using the phase differences between the wave forms, the control unit 200 calculates the phase differences by comparing the phases of the sensed wave forms of the oscillatory waves in the respective sections with the phases of the reference wave forms of the oscillatory waves, and determines the amounts of the frost in the respective sections by comparing the calculated phase differences with the phase difference data stored in the storing unit 210.

[0089] Secondly, in a case where the control unit 200 determines the amounts of the frost using the amplitude differences between the wave forms, the control unit 200 calculates the amplitude differences by comparing the amplitudes of the sensed wave forms of the oscillatory waves in the respective sections with the amplitudes of the reference wave forms of the oscillatory waves, and determines the amounts of the frost in the respective sections by comparing the calculated amplitude differences with the amplitude difference data stored in the storing unit 210.

[0090] Thirdly, in a case where the control unit 200 determines the amounts of the frost using the phase differences and the amplitude differences between the wave forms, the control unit 200 calculates the phase differences by comparing the phases of the sensed wave forms of the oscillatory waves in the respective sections with the phase of the reference wave forms of the oscillatory waves, calculates the amplitude differences by comparing the amplitudes of the sensed wave forms of the oscillatory waves in the respective sections with the amplitude of the reference wave forms of the oscillatory waves, and determines the amounts of the frost in the respective sections by matching the calculated phase differences and the calculated amplitude differences with each other and comparing the obtained matching values with the phase difference and the amplitude difference matching data in the storing unit 210.

[0091] The control unit 200 determines whether or not it is a defrosting operation time point by comparing the amounts of the frost formed in the respective sections with the reference amount of frost (operation 405). That is, when the amount of the frost formed in at least one section of the refrigerant pipe 51 is more than the reference amount of frost, the control unit 200 determines that it is the defrosting operation time point (operation 406), and operates the heating unit 70 to perform the defrosting operation (operation 407).

[0092] Further, the control unit 200 determines whether of not a defrosting operation executing time reaches a predetermined reference time by counting the defrosting operation executing time, and stops the operation of the heating unit 70, when it is determined that the defrosting operation executing time reaches the reference time.

[0093] Otherwise, the control unit 200 determines the amount of frost remaining on the refrigerant pipe 51 of the evaporator 50 by controlling the operation of at least one pair of the oscillatory wave generating unit 93 and the oscillatory wave sensing unit 94 in the defrosting operation, and determines whether or not the operation of the heating unit 70 is stopped according to a result of the determination. Here, the at least one pair of the oscillatory wave generating unit 93 and the oscillatory wave sensing unit 94 is installed in a section, in which it is determined that the amount of frost formed is larger than the reference amount of frost.

[0094] The defrosting operation is performed at a proper point of time and is stopped at a proper point of time, as described above, and thus power consumed by the defrosting operation is cut down.

[0095] In accordance with one aspect of the present invention, the amount of the frost formed on the refrigerant pipe of the evaporator is sensed by comparing a wave form of an oscillatory wave generated from one end of the refrigerant and a wave form of the oscillatory wave sensed by the other one end of the refrigerant, thus increasing the accuracy in sensing the amount of the frost formed on the refrigerator.

[0096] In accordance with another aspect of the present invention, it is possible to prevent the lowering of a heat-exchanging performance and the excessive consumption of power due to the formation of frost during a heat-exchanging process of the cooling system, such as a refrigerator, a Kimchi refrigerator, or an air conditioner. That is, the amount of the frost formed on the evaporator is accurately sensed and a proper defrosting operation starting time point and a proper defrosting operation ending time point are determined, thereby optimizing the defrosting operation and thus enhancing a heat-exchanging performance and increasing energy efficiency.

[0097] In accordance with a further aspect of the present invention, the amounts of frost formed in sections of the refrigerant pipe are easily sensed, thereby optimizing the defrosting operation although the amounts of frost in the respective sections are different.

[0098] Although embodiments of the invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

Claims

1. A cooling system comprising:

   an oscillatory wave generating unit installed at one end of a refrigerant pipe and
   generating an oscillatory wave;
   an oscillatory wave sensing unit installed at the other end of the refrigerant pipe and
   sensing the oscillatory wave; and
   a control unit determining an amount of frost formed on the refrigerant pipe based on a difference of wave forms between the oscillatory wave generated from the oscillatory wave generating unit and the oscillatory wave sensed by the oscillatory wave sensing unit.

2. The cooling system according to claim 1, wherein the difference of wave forms is a phase difference between the oscillatory wave generated from the oscillatory wave generating unit and the oscillatory wave sensed by the oscillatory wave sensing unit.

3. The cooling system according to claim 1, wherein the difference of wave forms is an amplitude difference between the oscillatory wave generated from the oscillatory wave generating unit and the oscillatory wave sensed by the oscillatory wave sensing unit.

4. The cooling system according to claim 1, wherein the control unit controls a defrosting operation based on the amount of frost.

5. The cooling system according to claim 4, wherein the control unit determines an amount of frost remaining on the refrigerant pipe based on the difference of wave forms in the defrosting operation, and determines whether or not the defrosting operation is terminated based on the amount of the remaining frost.

6. The cooling system according to claim 1, wherein a plurality of oscillatory wave generating units and a plurality of oscillatory wave sensing units installed on a refrigerant pipe; and
   a control unit determining amounts of frost formed in sections of the refrigerant pipe based on differences of wave forms between the oscillatory waves generated from the oscillatory wave generating units and the oscillatory waves sensed by the oscillatory wave sensing units.

7. The cooling system according to claim 6, wherein the plurality of oscillatory wave generating units sequentially generates the oscillatory waves.

8. The cooling system according to claim 6, wherein:

   the refrigerant pipe is divided into plural sections; and
   the plurality of oscillatory wave generating units are respectively installed at ends of the sections and the plurality of oscillatory wave sensing units are respectively installed at the other ends of the sections.

9. The cooling system according to claim 6, wherein the control unit performs the defrosting operation when the amount of frost in at least one section of the sections is more than a reference amount.

10. A method of controlling a cooling system, comprising:

    generating an oscillatory wave by operating an oscillatory wave generating unit installed at one end of a refrigerant pipe;
    sensing the oscillatory wave by an oscillatory wave sensing unit installed at the other end of the refrigerant pipe; and
    determining an amount of frost formed on the refrigerant pipe based on a difference of wave forms between the generated oscillatory wave and the sensed oscillatory wave.

11. The method according to claim 10, wherein the determination of the amount of frost includes calculating a phase difference between the generated oscillatory wave and the sensed oscillatory wave.

12. The method according to claim 10, wherein the determination of the amount of frost includes calculating an amplitude difference between the generated oscillatory wave and the sensed oscillatory wave.

13. The method according to claim 10, further comprising determining whether or not it is a defrosting time point based on the amount of the frost formed on the refrigerant pipe.

14. The method according to claim 13, further comprising:

    performing a defrosting operation, when it is determined that it is the defrosting time point;
    determining an amount of frost remaining on the refrigerant pipe by generating an oscillatory wave and sensing the oscillatory wave; and
    determining whether or not it is a defrosting operation ending time point based on the amount of the remaining frost.

15. The method according to claim 10, further comprising:

    generating oscillatory waves by operating a plurality of oscillatory wave generating units;

sensing the oscillatory waves by a plurality of oscillatory wave sensing units corresponding to the plurality of oscillatory wave generating units; and

determining amounts of frost formed in sections of a refrigerant pipe based on differences of wave forms between the generated oscillatory waves and the sensed oscillatory waves.

FIG. 1

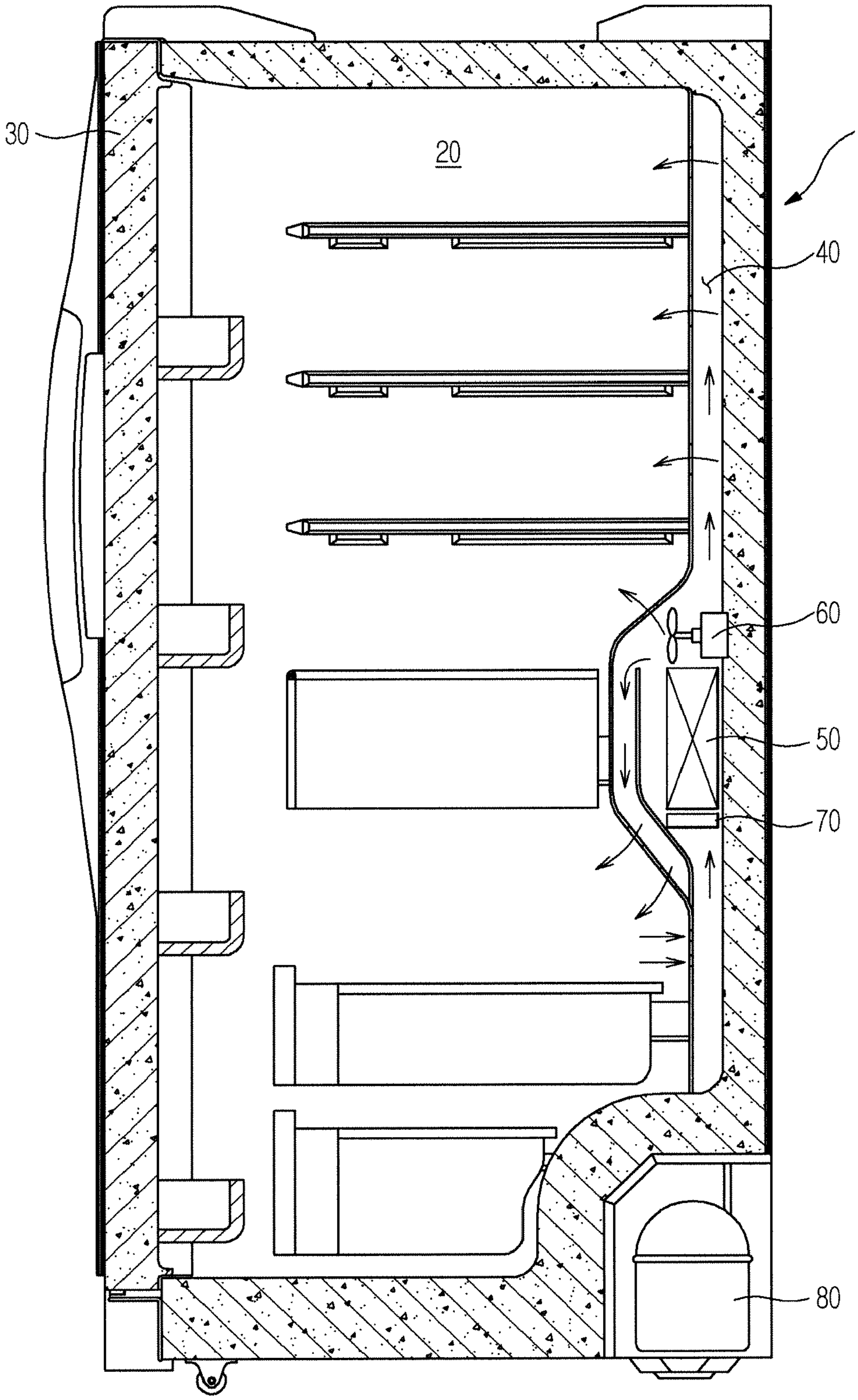


FIG. 2

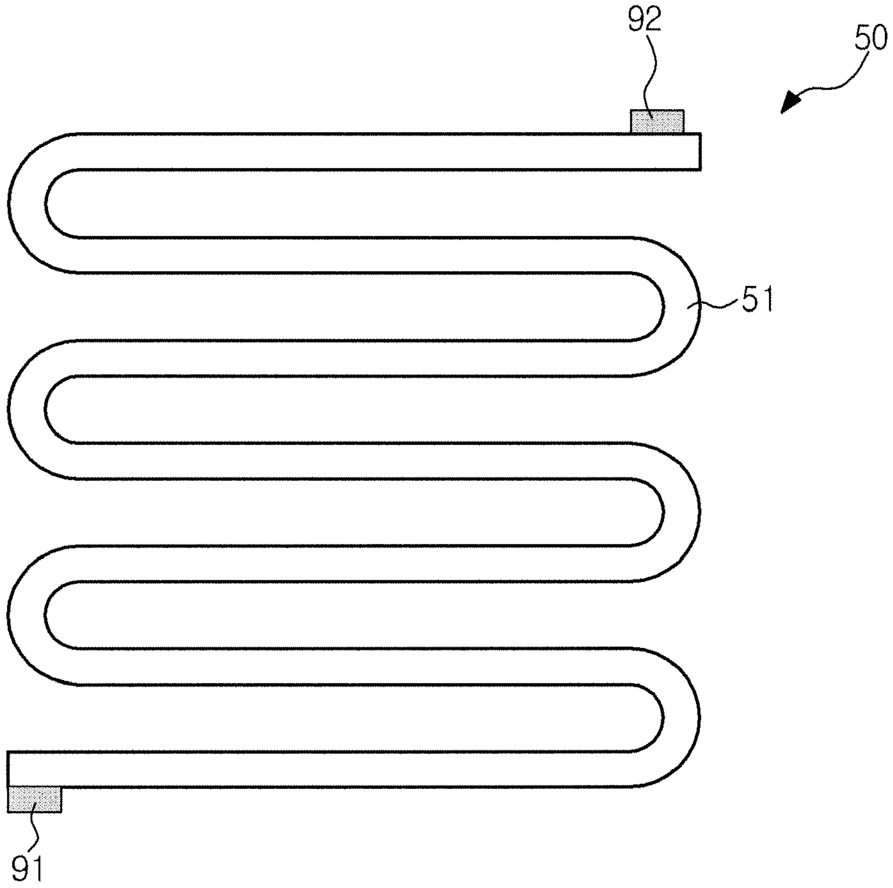


FIG. 3

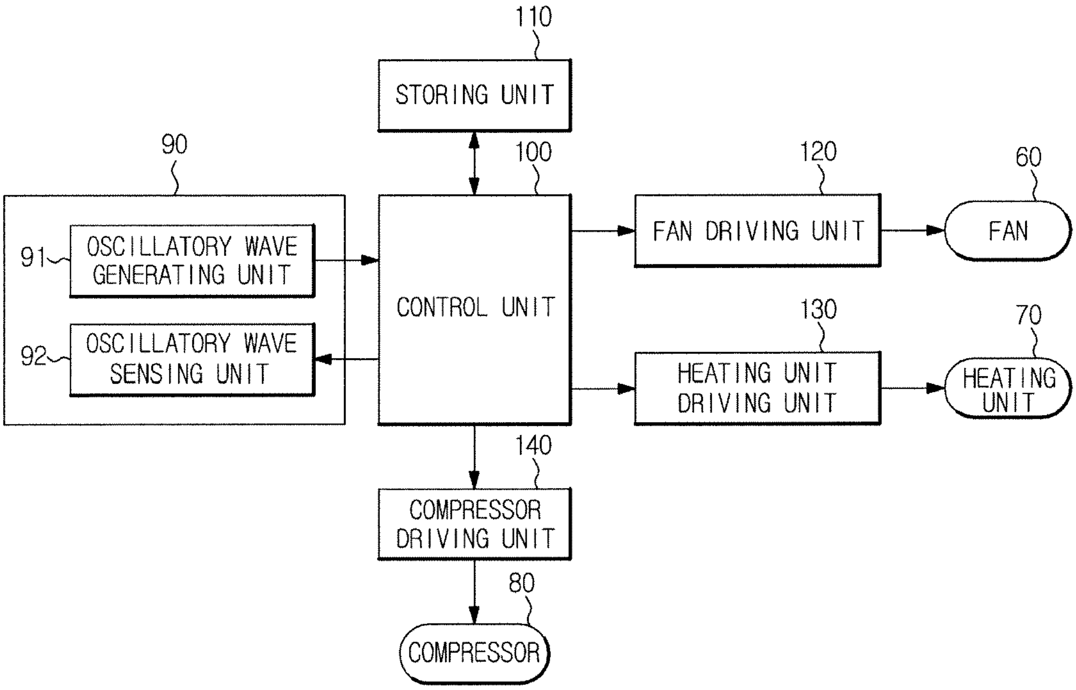

110
STORING UNIT
100
CONTROL UNIT
90
91
OSCILLATORY WAVE GENERATING UNIT
92
OSCILLATORY WAVE SENSING UNIT
120
FAN DRIVING UNIT
60
FAN
130
HEATING UNIT DRIVING UNIT
70
HEATING UNIT
140
COMPRESSOR DRIVING UNIT
80
COMPRESSOR

FIG. 4

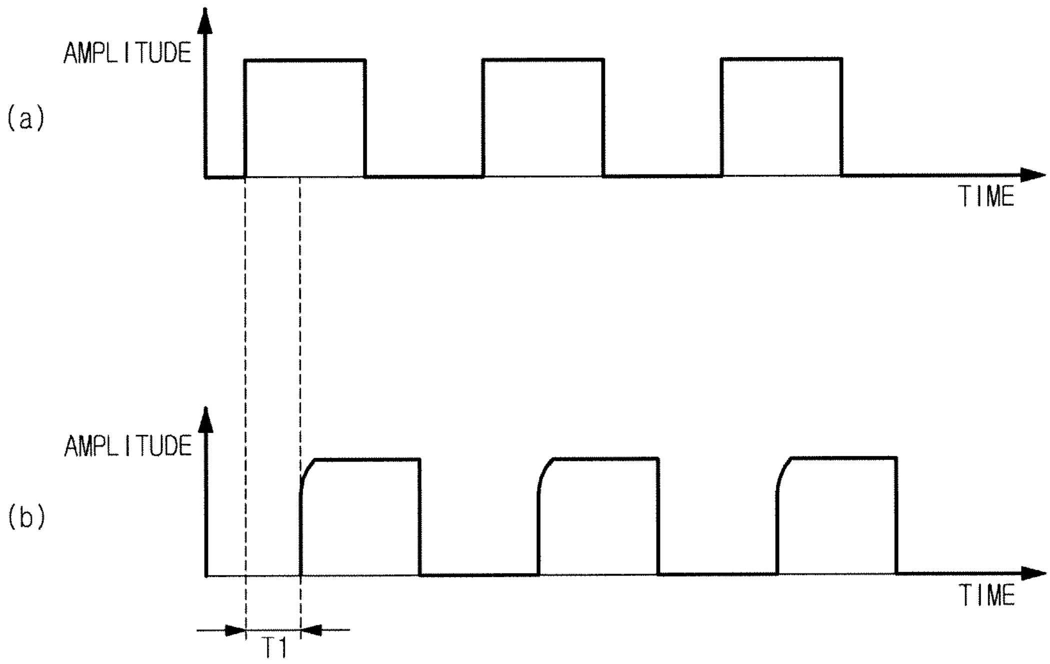


FIG. 5

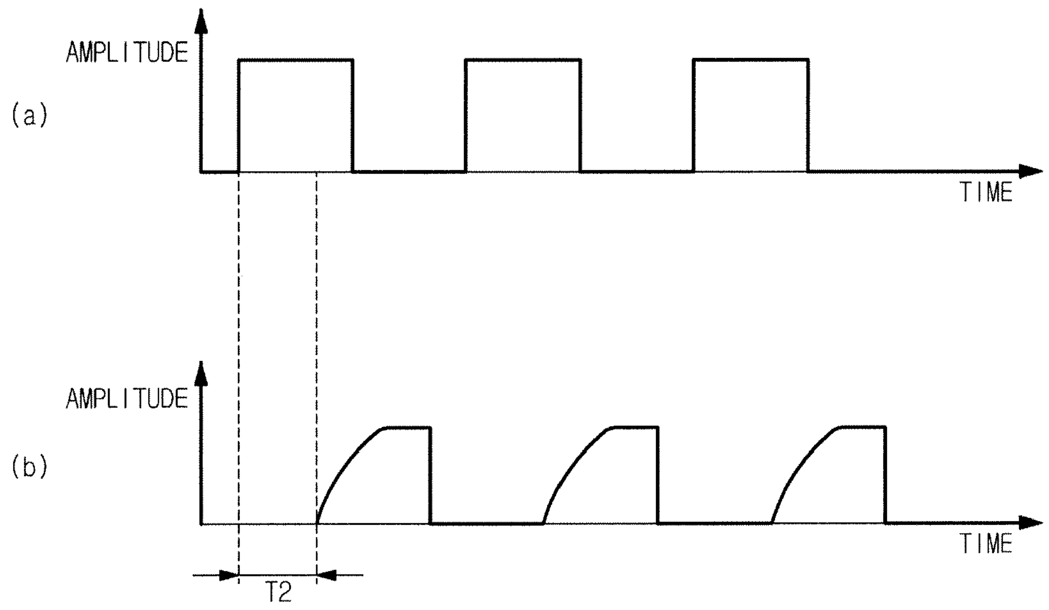


FIG. 6

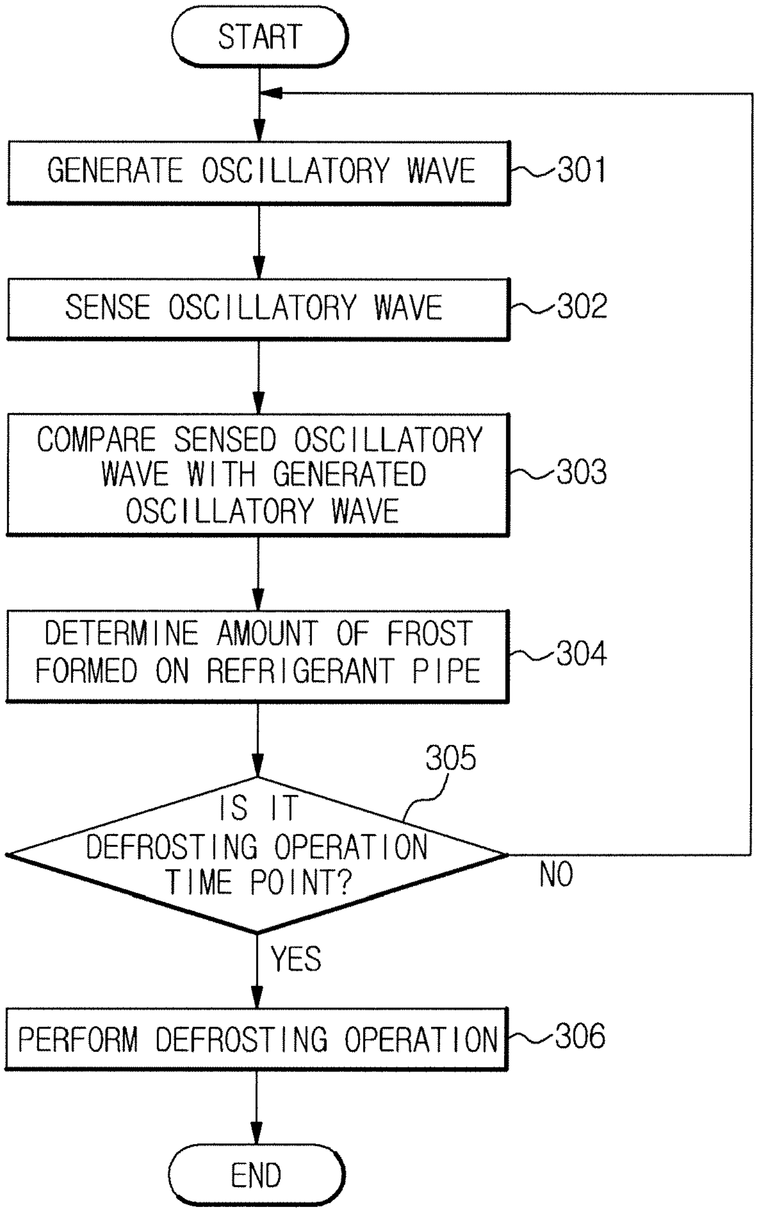

START
GENERATE OSCILLATORY WAVE
301
SENSE OSCILLATORY WAVE
302
COMPARE SENSED OSCILLATORY WAVE WITH GENERATED OSCILLATORY WAVE
303
DETERMINE AMOUNT OF FROST FORMED ON REFRIGERANT PIPE
304
305
IS IT DEFROSTING OPERATION TIME POINT?
NO
YES
PERFORM DEFROSTING OPERATION
306
END

FIG. 7

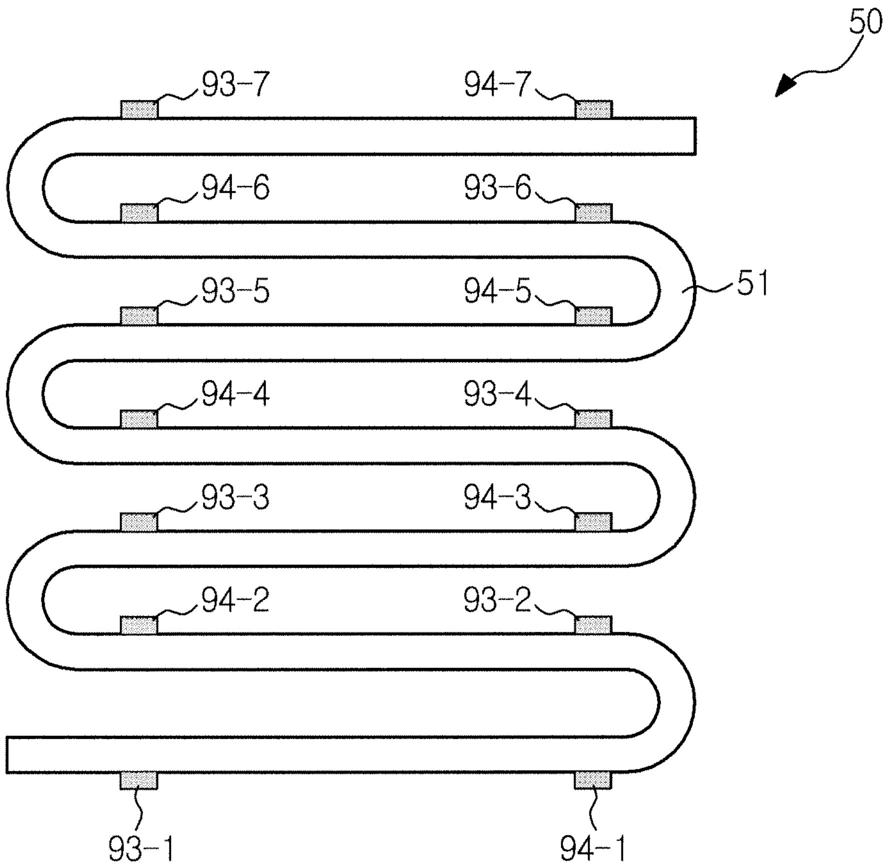
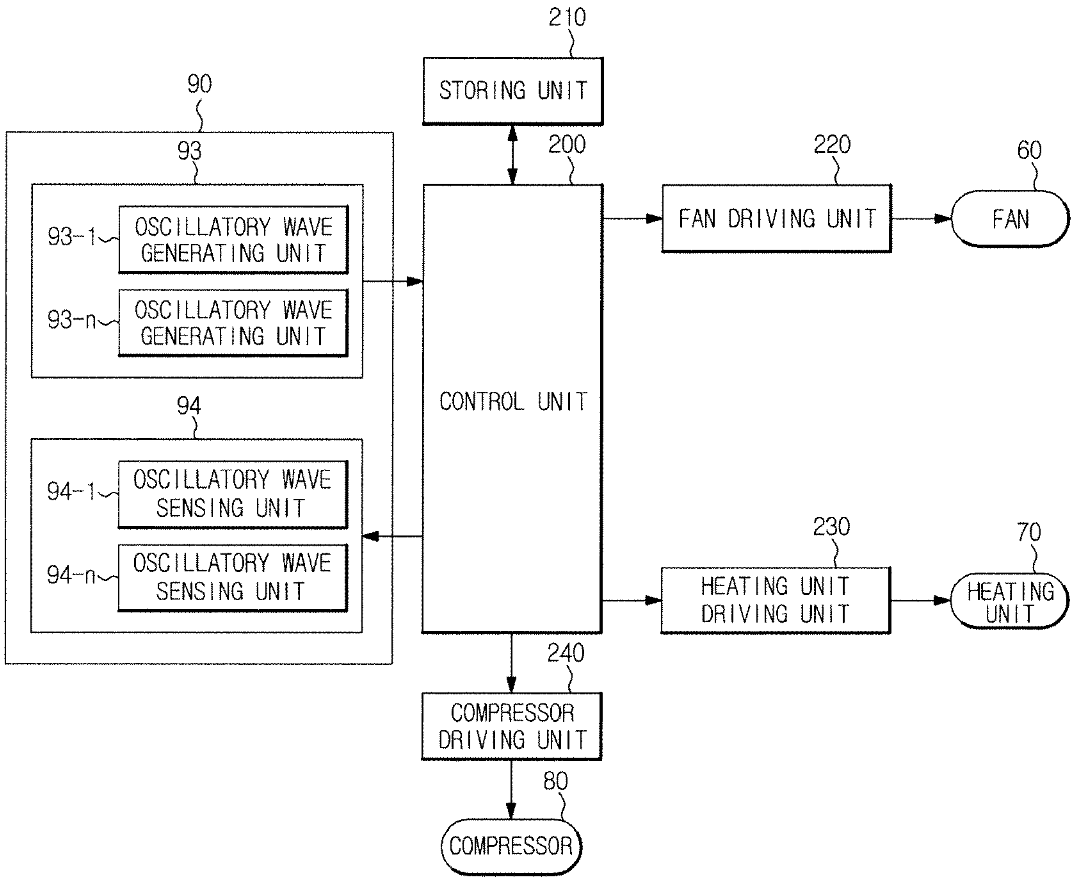
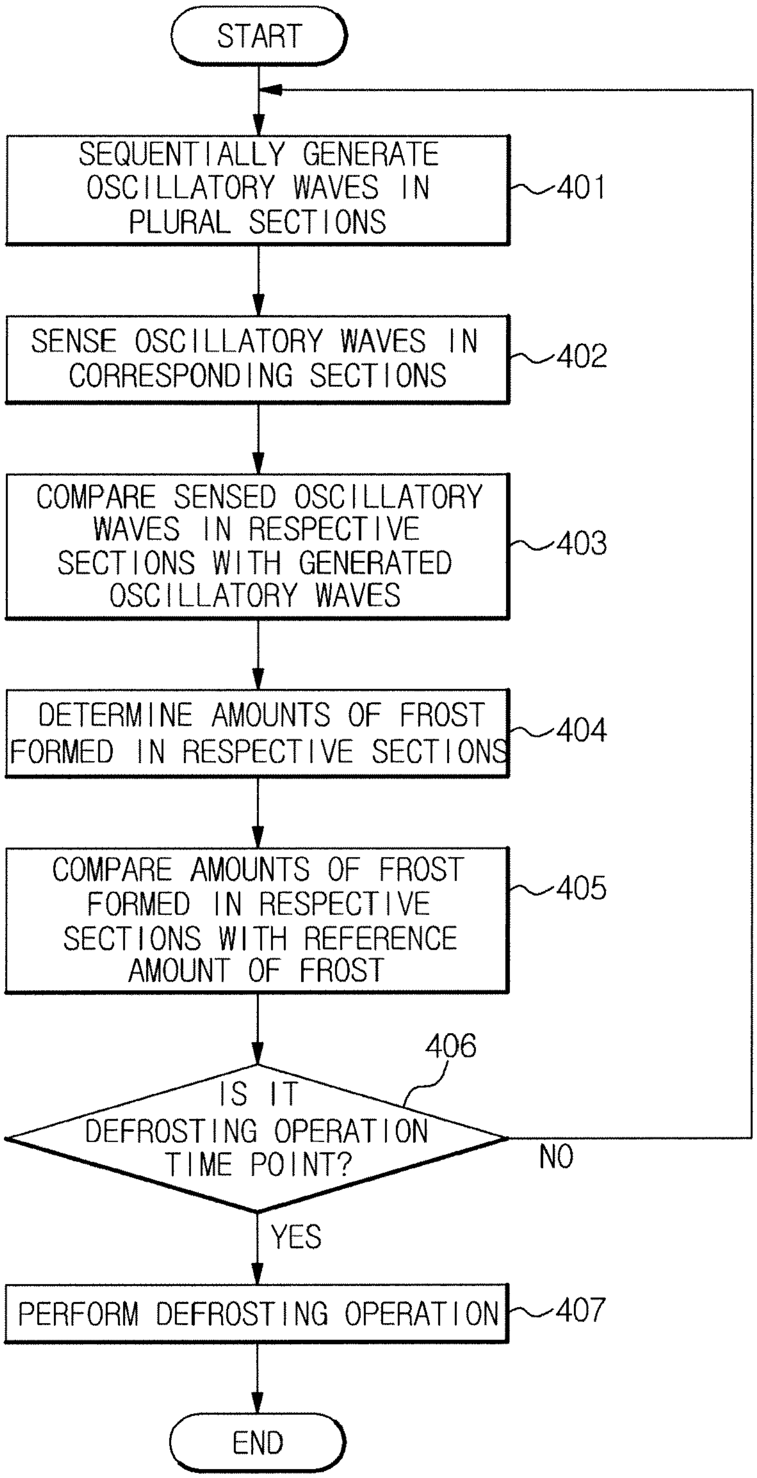


FIG. 8



210
STORING UNIT
90
93
200
220
60
93-1
OSCILLATORY WAVE GENERATING UNIT
FAN DRIVING UNIT
FAN
93-n
OSCILLATORY WAVE GENERATING UNIT
CONTROL UNIT
94
94-1
OSCILLATORY WAVE SENSING UNIT
230
70
94-n
OSCILLATORY WAVE SENSING UNIT
HEATING UNIT DRIVING UNIT
HEATING UNIT
240
COMPRESSOR DRIVING UNIT
80
COMPRESSOR

FIG. 9


START
SEQUENTIALLY GENERATE OSCILLATORY WAVES IN PLURAL SECTIONS
401
SENSE OSCILLATORY WAVES IN CORRESPONDING SECTIONS
402
COMPARE SENSED OSCILLATORY WAVES IN RESPECTIVE SECTIONS WITH GENERATED OSCILLATORY WAVES
403
DETERMINE AMOUNTS OF FROST FORMED IN RESPECTIVE SECTIONS
404
COMPARE AMOUNTS OF FROST FORMED IN RESPECTIVE SECTIONS WITH REFERENCE AMOUNT OF FROST
405
406
IS IT DEFROSTING OPERATION TIME POINT?
NO
YES
PERFORM DEFROSTING OPERATION
407
END