



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
14.03.2012 Bulletin 2012/11

(51) Int Cl.:
F25B 47/02 ^(2006.01) **F25B 13/00** ^(2006.01)

(21) Application number: **11174744.0**

(22) Date of filing: **20.07.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(72) Inventor: **Nakaya, Noritaka**
Kariya-shi, Aichi-ken,, 448-8650 (JP)

(74) Representative: **Winter, Konrad Theodor**
Winter, Brandl, Fűrnis, Hübner,
Röss, Kaiser, Polte - Partnerschaft
Patent- und Rechtsanwaltskanzlei
Bavariaring 10
80336 München (DE)

(30) Priority: **03.08.2010 JP 2010174596**

(71) Applicant: **AISIN SEIKI KABUSHIKI KAISHA**
Kariya-shi, Aichi-ken 448-8650 (JP)

(54) **Idle defrosting operation determining device for air conditioning apparatus**

(57) An air conditioning apparatus (1) includes a refrigeration cycle including a compressor (11), an indoor heat exchanger (16), a pressure reducer (17) and an outdoor heat exchanger (15), that constitute a fluid circuit for circulating a cooling medium, the outdoor heat exchanger serving as an evaporator when a heating operation is performed and as a condenser when a defrosting operation is performed, and an idle defrosting operation determining device (20) including a temperature detect-

ing device (21) detecting a pipe temperature (T) of the outdoor heat exchanger, a low temperature integrated value calculating means (20) calculating a low temperature integrated value (A), a high temperature integrated value calculating means (20) calculating a high temperature integrated value (B), and a determining means (20) determining whether or not the idle defrosting operation is carried out based on a relationship between the low temperature integrated value and the high temperature integrated value.

FIG. 3A

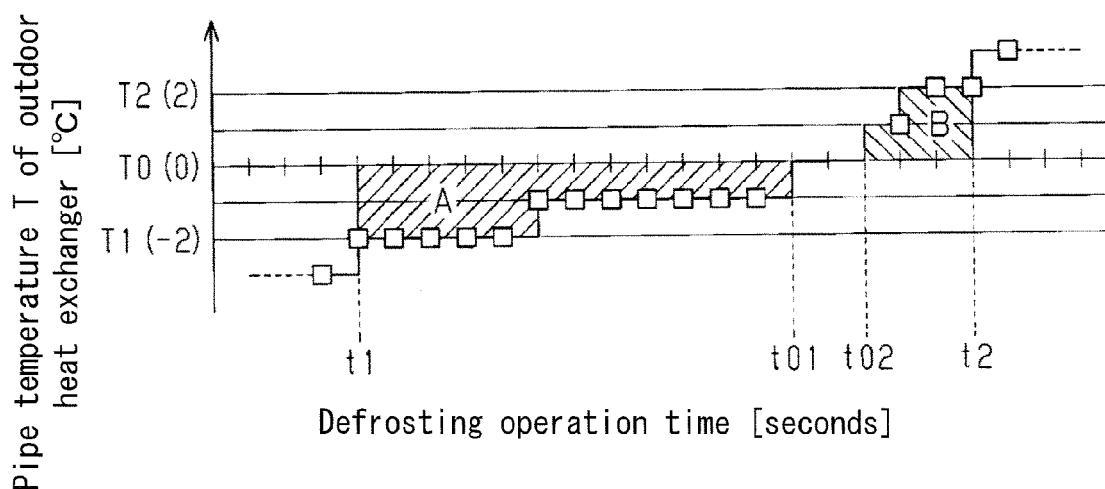
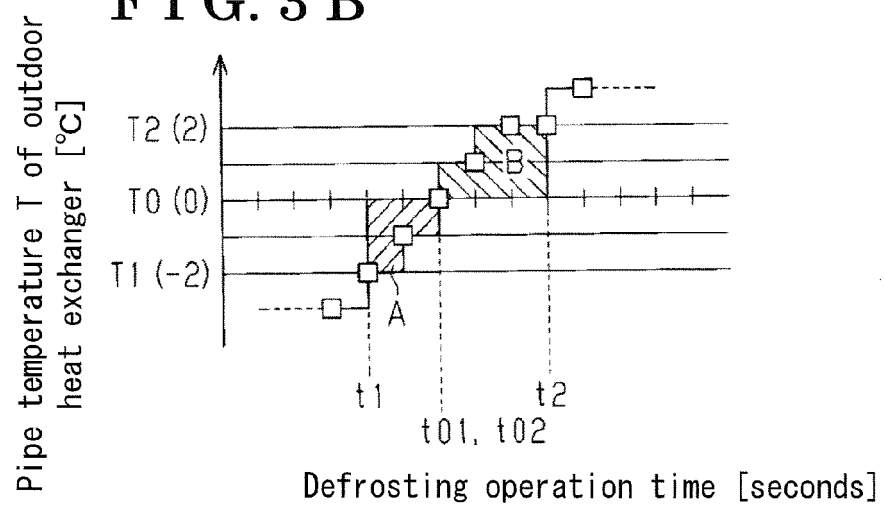


FIG. 3 B



Description

TECHNICAL FIELD

[0001] This disclosure generally relates to an idle defrosting operation determining device for an air conditioning apparatus for determining whether or not an idle defrosting operation, which is considered to be an unnecessary defrosting operation while a heating operation of the air conditioning apparatus is carried out, is executed.

BACKGROUND DISCUSSION

[0002] Generally, under a cold weather condition (e.g. during winter), an outdoor heat exchanger may be frosted while an air conditioning apparatus operates a heating operation, which may result in decreasing a heating performance of the air conditioning apparatus while being in operation. Accordingly, generally, the air conditioning apparatus such as a heat pump and the like is configured so as to carry out an inverse cycle operation (which corresponds to a cooling operation) and the like while the air conditioning apparatus is in operation in order to execute a defrosting operation for defrosting the outdoor heat exchanger (for melting frost formed on the outdoor heat exchanger). However, in a case where the defrosting operation is continued for a period of time that is more than necessary even if the frost does not actually form on the outdoor heat exchanger, a temperature within a room is not adjusted while the defrosting operation is carried out, which may result in causing discomfort to a user and further, which may result in consuming unnecessary energy. Accordingly, there have been suggested several methods of avoiding an execution of the defrosting operation while the frost does not form on the outdoor heat exchanger (i.e. an idle defrosting operation).

[0003] For example, disclosed in JP2004-232942A is a defrosting control method for an air conditioner which is configured so that a defrosting operation of an outdoor heat exchanger is executed for a predetermined period of time on the basis of a temperature changes of an indoor heat exchanger obtained every predetermined time, a temperature difference between a temperature of the indoor heat exchanger and an indoor temperature, and a predetermined elapsed time of a mask time from a start of a heating operation. In a case where the defrosting operation is continuously executed for plural times based on the mask time while a decrease of the temperature of the indoor heat exchanger is equal to or lower than a predetermined value, the defrosting control method disclosed in JP2004-232942A sets the temperature difference between the temperature of the indoor heat exchanger and the indoor temperature to be a value lower than an initially set value in order to switch an operation condition to a low ambient temperature operation condition and carry out the defrosting operation, so that an idle defrosting operation may be prevented from being carried out even while a heating operation is executed under

a condition that an ambient air temperature is low.

[0004] Disclosed in JP2002-130876A is a controller for an air conditioner which is configured so as to time a duration time during which a temperature of a cooling pipe is found in approximately a freezing point as a defrosting operation time (i.e. a freezing point approximate time) in a case where the defrosting operation is ended on the basis of the temperature of the cooling pipe of an outdoor heat exchanger while a defrosting operation is executed. Then, the controller for the air conditioner disclosed in JP2002-130876A changes a defrosting operation prohibiting time for prohibiting a next (following) defrosting operation depending on a length of a duration time of the defrosting operation when the cooling pipe temperature is found approximately in the freezing point. Accordingly, the defrosting operation may be executed in response to, for example, an environment (e.g. outside weather conditions).

[0005] Accordingly, in sum, there exist two general types of the method of avoiding the idle defrosting operation (i.e. a determining method of the idle defrosting operation). One is the method based on a detection of the temperature inside of the room, as disclosed in JP2004-232942A. The other one is the method based on a detection of the cooling pipe temperature at an outdoor apparatus.

[0006] According to the controller for the air conditioner disclosed in JP2002-130876A, the controller actually executes an idle defrosting operation determination when the cooling pipe temperature of the outdoor heat exchanger exceeds the freezing point and reaches a predetermined heating resetting temperature and then, the controller stops the defrosting operation. In a case where a relatively low temperature (e.g. two degrees, 2 .) is used as the heating resetting temperature, the defrosting operation may be stopped even if the frost remains on the outdoor heat exchanger. Accordingly, in this case, the idle defrosting operation determination may not be sufficiently accurate. On the other hand, in a case where a relatively high temperature (e.g. ten degrees, 10) is set as the heating resetting temperature, the defrosting operation may be continued more than necessary even if the frost does not actually remain on the outdoor heat exchanger, because the cooling pipe temperature takes time to reach the heating resetting temperature after the defrosting operation is started.

[0007] Additionally, as the idle defrosting operation determining method at the outdoor apparatus such as the method disclosed in JP2002-130876A, there exist several known determining methods. For example, there exists an idle defrosting operation determining method, which is executed by estimating whether or not frost is formed on the outdoor heat exchanger on the basis of a temperature rising tendency (a derivative value) of a pipe temperature of the outdoor heat exchanger. Furthermore, there exists an idle defrosting operation determining method, which is executed by timing a duration time during which a pipe temperature of an outdoor heat ex-

changer increases from the freezing point after a defrosting operation is executed. However, the detection accuracy of the above-mentioned method may fluctuate depending on a setting of the pipe temperature, which is used for the determination. Furthermore, the above-described methods may need relatively longer time from when the pipe temperature reaches a predetermined set temperature and when the idle defrosting operation determination ends.

[0008] A need thus exists to provide an idle defrosting operation determining device for an air conditioning apparatus which is configured so as to promptly and accurately execute a determination of whether or not an idle defrosting operation is carried out.

SUMMARY

[0009] According to an aspect of this disclosure, an air conditioning apparatus includes a refrigeration cycle including a compressor, an indoor heat exchanger, a pressure reducer and an outdoor heat exchanger, that are connected to constitute a fluid circuit through which a cooling medium is circulated, the outdoor heat exchanger serving as an evaporator for evaporating the cooling medium in a case where a heating operation is performed and as a condenser for condensing the cooling medium in a case where a defrosting operation is performed, and an idle defrosting operation determining device including a temperature detecting device detecting a pipe temperature of the outdoor heat exchanger, a low temperature integrated value calculating means calculating a low temperature integrated value of a temperature difference between a freezing point temperature and the pipe temperature relative to time in a case where the pipe temperature, which is detected while the defrosting operation is carried out, falls within a temperature range from a predetermined low temperature lower than the freezing point temperature and the freezing point temperature, a high temperature integrated value calculating means calculating a high temperature integrated value of a temperature difference between the freezing point temperature and the pipe temperature relative to the time in a case where the pipe temperature, which is detected while the defrosting operation is carried out, falls within a temperature range from a predetermined high temperature higher than the freezing point temperature and the freezing point, and a determining means determining whether or not the idle defrosting operation is carried out on the basis of a magnitude relationship between the calculated low temperature integrated value and the calculated high temperature integrated value.

[0010] Accordingly, a determination of whether or not the idle defrosting operation is performed may be promptly executed while avoiding deterioration in a determination accuracy.

[0011] According to another aspect of this disclosure, the freezing point temperature refers to a freezing point of water.

[0012] According to a further aspect of this disclosure, the freezing point of water fluctuates depending on an atmospheric pressure.

[0013] According to a further aspect of this disclosure, the temperature detecting device processes the pipe temperature of the outdoor heat exchanger as an integer value.

[0014] According to a further aspect of this disclosure, the temperature detecting device obtains the pipe temperature of the outdoor heat exchanger as the integer value in a manner where a numeral after a decimal point is rounded down in a case where the pipe temperature indicates a positive value and the numeral after the decimal point is rounded up in a case where the pipe temperature indicates a negative value.

[0015] According to a further aspect of this disclosure, the temperature detecting device measures the pipe temperature of the outdoor heat exchanger every predetermined time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The foregoing and additional features and characteristics of this disclosure will become more apparent from the following detailed description considered with the reference to the accompanying drawings, wherein:

[0017] Fig. 1 is a circuit diagram of an air conditioning apparatus according to an embodiment;

[0018] Fig. 2 is a graph illustrating changes in pipe temperature of an outdoor heat exchanger while a defrosting operation is being executed;

[0019] Figs. 3A and 3B are enlarged and elaborate graphs illustrating the changes in the pipe temperature of the outdoor heat exchanger while the defrosting operation is being executed;

[0020] Fig. 4 is a table comparing an idle defrosting operation determining method according to the embodiment and a known idle defrosting operation determining method; and

[0021] Fig. 5 is a flowchart illustrating a control process executed by the idle defrosting operation determining method according to the embodiment.

DETAILED DESCRIPTION

[0022] An embodiment of an idle defrosting operation determining device for an air conditioning apparatus will be described below with reference to the attached drawings. Illustrated in Fig. 1 is a circuit diagram of a heat pump-type air conditioning apparatus 1 (which will be hereinafter referred to simply as the air conditioning apparatus 1). The air conditioning apparatus 1 configures a refrigeration cycle. As illustrated in Fig. 1, the air conditioning apparatus 1 includes a compressor 11, a four-way valve 14, an outdoor heat exchanger 15, an indoor heat exchanger 16, an electronic expansion valve 17 (i.e. a pressure reducer) and a cooling pipe 18. More specifically, the compressor 11, the indoor heat exchanger 16,

the electronic expansion valve 17 and the outdoor heat exchanger 15 are connected so as to constitute a fluid circuit through which a cooling medium is circulated, thereby forming the refrigeration cycle. The cooling pipe 18 is used for circulating a coolant medium to the compressor 11 and the like. Furthermore, the air conditioning apparatus 1 includes a control device 20, which is configured so as to control actuation of the compressor 11, the four-way valve 14, the electronic expansion valve 17 and the like. The control device 20 is configured with a microcomputer as a core and serves as an idle defrosting operation determining device. Furthermore, the control device 20 is electrically connected to a temperature sensor 21, which serves as a temperature detecting device and which is provided on a surface of the cooling pipe 18 located in the vicinity of an outlet 15a of the outdoor heat exchanger 15. More specifically, the temperature sensor 21 is provided at a portion of the cooling pipe 18 used as a pipe extending between the outlet 15a of the outdoor heat exchanger 15 and the electronic expansion valve 17 within an outdoor apparatus. The temperature sensor 21 is configured so as to detect a pipe temperature T (i.e. a surface temperature) of the cooling medium discharged from the outdoor heat exchanger 15 while a defrosting operation is executed. A resolution of the pipe temperature T detected by the temperature sensor 21 is set to one degree (1 .) (however, generally, a number(s) after the decimal point is ignored, more specifically, a number in a plus value is ignored after the decimal point but a number in a minus value is rounded up). The control device 20 obtains the pipe temperature T every one second. For example, in a case where an actual temperature is -0.9 degrees (-0.9 .), the temperature sensor 21 detects the temperature as zero degree (0 .). In a case where the actual temperature is -3.5 degrees (-3.5 .), the temperature sensor 21 detects the temperature as -3 degrees (-3 .). On the other hand, in a case where the actual temperature is 0.9 degrees (0.9 .), the temperature sensor 21 detects the temperature as zero degree (0 .). Furthermore, in a case where the actual temperature is 1.6 degrees (1.6 .), the temperature sensor 21 detects the temperature as one degree (1 .).

[0023] An air conditioning operation executed by the air conditioning apparatus 1 will be described below with reference to Fig. 1. A flow of the cooling medium in a case where a cooling operation is executed is indicated by a solid arrow line. On the other hand, a flow of the cooling medium in a case where a heating operation is executed is indicated by a dashed arrow. In the case of cooling operation, the cooling medium discharged from the compressor 11 passes through the four-way valve 14 and then is let to the outdoor heat exchanger 15, which serves as a condenser. A heat of the cooling medium is removed by air (ambient air) at the outdoor heat exchanger 15, so that the cooling medium is condensed and liquefied. Then, the cooling medium is depressurized at the electronic expansion valve 17 and is vaporized at the indoor heat exchanger 16, which serves as an evapora-

tor, in a manner where the cooling medium removes a heat of the air remaining within a room. The cooling medium then is returned to the compressor 11 via the four-way valve 14. Accordingly, an inside of the room is cooled through the above-mentioned process.

[0024] On the other hand, in the case of the heating operation, the cooling medium discharged from the compressor 11 passes through the four-way valve 14 and is condensed and liquefied at the indoor heat exchanger 16, which serves as a condenser, in a manner where the cooling medium emits the heat into the air remaining within the room. Then, the cooling medium is depressurized at the electronic expansion valve 17 and is vaporized at the outdoor heat exchanger 15, which serves as an evaporator, in a manner where the cooling medium absorbs the heat of the air remaining outside of the room. The cooling medium then is returned to the compressor 11 via the four-way valve 14. Accordingly, the inside of the room is heated through the above-mentioned process.

[0025] In a case where a satisfaction of a predetermined defrosting operation starting condition is detected by the control device 20 while the heating operation is executed, the defrosting operation (i.e. an inverse cycle operation) for circulating the cooling medium as is the case of the cooling operation is started. Appropriate conditions by which a formation of the frost on the outdoor heat exchanger 15 is expected, such as, for example, a duration time of the heating operation (i.e. an elapsed time since a previous defrosting operation), the pipe temperature T of the outdoor heat exchanger 15, an ambient air temperature and the like may be adapted as the defrosting operation starting condition.

[0026] While the defrosting operation is carried out, a cycle is inverted, so that the outdoor heat exchanger 15 functions as the condenser. Accordingly, in the defrosting operation, the cooling medium having high temperature is led to the outdoor heat exchanger 15, so that the pipe temperature T at the outdoor heat exchanger 15 increases. Additionally, in this case, the pipe temperature T detected by the temperature sensor 21 corresponds to a pipe temperature at a downstream side of the outdoor heat exchanger 15 in the flow of the cooling medium while the defrosting operation is executed. For example, in a case where the pipe temperature T at a period of time when the defrosting operation is started is -10 degrees (-10 .), the pipe temperature T gradually increases after the defrosting operation is started. Then, when the pipe temperature T is increased to reach approximately the freezing point T₀, the frost melts and is accordingly removed in the case where the frost is formed on the outdoor heat exchanger 15. In the case where the control device 20 detects a satisfaction of a predetermined defrosting operation ending condition in accordance with the continuous defrosting operation, the defrosting operation is ended. Appropriate conditions by which a defrosting of the outdoor heat exchanger 15 is estimated, such as, for example, a duration time of the defrosting operation (i.e. an elapsed time since a previous heating oper-

ation), the pipe temperature T of the outdoor heat exchanger 15, the ambient air temperature and the like may be adapted as the defrosting operation ending condition. In this embodiment, the freezing point refers to a freezing point of water and changes in response to the atmospheric pressure.

[0027] Test results of the pipe temperature at the outdoor heat exchanger 15 in the case where the frost is formed on the outdoor heat exchanger 15 and in the case where the frost is not formed on the outdoor heat exchanger 15 will be described below with reference to Fig. 2. As indicated by a solid line in Fig. 2, in the case where the frost is actually formed on the outdoor heat exchanger 15 when the defrosting operation is started, a temperature rising tendency of the pipe temperature T becomes slower (becomes diminished) after the pipe temperature T increases up to approximately a freezing point temperature T_0 (i.e. zero degree (0 .)) because of the following reasons: in a case where the pipe temperature T of the outdoor heat exchanger 15 falls within a temperature range, which is lower than the freezing point temperature T_0 , the pipe temperature T increases while showing a predetermined tendency. Then, in the case where the pipe temperature T reaches approximately the freezing point temperature T_0 , some of the frost or ice formed on a surface of the outdoor heat exchanger 15 starts melting (i.e. some of the frost or the ice starts melting from an upper stream side of the cooling water while the defrosting operation is executed) and then, the frost or the ice formed on the surface of the outdoor heat exchanger 15 is turned to be in a saturation state, so that the heat (i.e. a heat capacity) of the cooling medium having the high temperature flowing through the cooling pipe 18 is used as a heat of fusion instead of being used for increasing the pipe temperature T . After the frost or the ice formed on the surface of the outdoor heat exchanger 15 almost melts and the pipe temperature T of the outdoor heat exchanger 15 exceeds the freezing point temperature T_0 , the pipe temperature T again starts rising at a predetermined tendency, so that the temperature rising tendency becomes relatively rapid (prominent).

[0028] As indicated by a dashed line in Fig. 2, in the case where the frost is not formed on the outdoor heat exchanger 15 at the point of time when the defrosting operation is executed, the pipe temperature T continues to rise at predetermined tendencies within the low temperature range and a high temperature range across the freezing point temperature T_0 .

[0029] The temperature rising tendency of the pipe temperature T of the outdoor heat exchanger 15 while the defrosting operation is carried out is considered to follow the above-mentioned phenomena. However, in the case where the frost is actually formed on the outdoor heat exchanger 15, it is confirmed that a timing of changes in the temperature rising tendency of the pipe temperature T approximately to the freezing point temperature T_0 fluctuates depending on pipe temperature T or a circulation of the cooling medium at the point of time when

the defrosting operation (i.e. the inverse cycle operation) is started, and other factor(s). Therefore, upon a determination whether or not an idle defrosting operation is executed, the control device 20 (i.e. a low temperature integrated value calculating means, a high temperature integrated value calculating means) calculates an integrated value of a temperature difference between the freezing point temperature T_0 and the pipe temperature T relative to time at each of the low temperature range (e.g. -2 to 0 degrees) and the high temperature range (e.g. 0 to 2 degrees) across the freezing point temperature T_0 , at which the changes in the temperature rising tendency of the pipe temperature T is substantially recognized, as each of a lower temperature integrated value A and a high temperature integrated value B . Then, the control device 20 compares the low temperature integrated value A with the high temperature integrated value B , so that the control device 20 (i.e. a determining means) is allowed to determine whether or not the idle defrosting operation is executed while the aforementioned fluctuation is absorbed (cleared). The fluctuation is cleared by comparing the low temperature integrated value A and the high temperature integrated value B because, in the case of a frost formed state where the temperature rising tendency becomes slow (becomes diminished) (i.e. in a case where the idle defrosting operation is not executed), the low temperature integrated value A increases so as to become greater than the high temperature integrated value B . On the other hand, in the case of a frost non-formed state (i.e. in the case where the idle defrosting operation is executed), the low temperature integrated value A and the high temperature integrated value B tend to have the same value.

[0030] More specifically, the low temperature range, within which the pipe temperature T used for the calculation of the low temperature integrated value A falls (i.e. the temperature range where the temperature rising tendency becomes slow (becomes diminished) while the frost formed state), is set to a range from a predetermined low temperature T_1 (a negative quantity) and the freezing point temperature T_0 . A time when the pipe temperature T reaches the low temperature T_1 from the low temperature range, which is lower than the low temperature T_1 , is set to be t_1 . A time when the pipe temperature T reaches the freezing point temperature T_0 (i.e. a time when the freezing point temperature T_0 is detected for the first time) is set to be t_{01} . Furthermore, the high temperature range, within which the pipe temperature T used for the calculation of the high temperature integrated value B falls, is set to a range from the freezing point temperature T_0 and a predetermined high temperature T_2 (a positive quantity). A time when the pipe temperature T starts rising from the freezing point temperature T_0 (i.e. a time when the freezing point temperature T_0 is detected for the final time) is set to be t_{02} . Furthermore, a final time when the pipe temperature T reaches the high temperature T_2 (i.e. a time when the high temperature T_2 is detected for the final time) is set to be t_2 . In this case, each of the low

temperature integrated value A and the high temperature integrated value B is calculated by respective following formulas.

[0031]

$$A = \sum_{t=t1}^{t01} (T0 - T) * \Delta t$$

$$B = \sum_{t=t02}^{t12} (T - T0) * \Delta t$$

:where Δt represents a timing cycle (in this embodiment, one second) of the control device 20 times the pipe temperature T.

[0032] The idle defrosting operation is determined whether or not being executed on the basis of a relationship (i.e. a magnitude relationship) between the low temperature integrated value A and a value (= kB) obtained by multiplying the high temperature integrated value B by a predetermined adjustment coefficient k ($0 < k < 1$). More specifically, in a case where the low temperature integrated value A is greater than the value kB (i.e. $A > kB$), the temperature rising tendency of the pipe temperature T is considered to slow (diminish) within the low temperature range across the freezing point temperature T0. Therefore, in this case, the control device 20 determines that the idle defrosting operation is not carried out. On the other hand, in a case where the low temperature integrated value A is equal to or lower than the value kB (i.e. $A \leq kB$), the temperature rising tendency is considered not to slow (diminish) within the low temperature range across the freezing point temperature T0, and the control device 20 determines that the idle defrosting operation is carried out. Additionally, the adjustment coefficient is used in order to avoid a mis-determination where the control device 20 determines that the idle defrosting operation is not executed even if the frost is formed on the outdoor heat exchanger 15.

[0033] Accordingly, because the low temperature integrated value A and the high temperature integrated value B, which emphasize the temperature rising tendency of the outdoor heat exchanger 15 in the respective low temperature range and the high temperature range across the freezing point temperature T0, are used, the idle defrosting operation may be properly determined whether or not being executed even if the temperature (i.e. the high temperature T2) to be reached from the freezing point temperature T0 is low, in other words, even if the elapsed time since the pipe temperature T exceeds the freezing point temperature T0 is short. As a result, a time necessary for the control device 20 to determine whether or not the idle defrosting operation is executed may be shortened without degrading reliability of the idle

defrosting operation determining device for the air conditioning apparatus 1.

[0034] In the case where the control device 20 determines that the idle defrosting operation is not executed, the control device 20 continues the defrosting operation until the satisfaction of the predetermined defrosting operation ending condition is detected. On the other hand, in the case where the control device 20 determines that the idle defrosting operation is executed, the control device 20 immediately stops the defrosting operation and executes a predetermined defrosting operation ending control in order to re-start the heating operation. Accordingly, a system control enhancing comfort for the user and energy saving may be achieved.

[0035] An example of determination of whether or not the idle defrosting operation is executed while the defrosting operation is performed will be described below with reference to Fig. 3 under a condition that the low temperature T1 is set to be -2 degrees (-2 .) and the high temperature T2 is set to be 2 degrees (2 .). Illustrated in Fig. 3A and 3B are graphs showing the changes in the pipe temperature T of the outdoor heat exchanger 15 while the defrosting operation is executed. Additionally, in this example, a value "0.8" is used as the adjustment coefficient. As described above, the temperature sensor 21 is configured so that the resolution thereof is set to one degree (1 .). Furthermore, the control device 20 obtains the pipe temperature T every one second. In other words, the calculation cycle is one second.

[0036] The case where the temperature rising tendency becomes slow (becomes diminished) at the low temperature range across the freezing point temperature T0 will be described below. As illustrated in Fig. 3A, when assuming that the pipe temperature T reaches (rises to) the freezing point temperature T0 (zero degree (0.)) through a process where the pipe temperature T remains to be -2 degrees (-2 .) for five seconds and -1 degree (-1 .) for seven seconds after the pipe temperature T reaches -2 degrees (-2 .) and the control device 20 starts calculating the low temperature integrated value A, in response to the defrosting operation, the low temperature integrated value A is calculated as follows:

[0037]

$$A = (0 - (-2)) * 5 + (0 - (-1)) * 7 = 17$$

[0038] Additionally, when assuming that the pipe temperature T remains to be 1 degree (1 .) for one second and 2 degrees (2 .) for tow seconds after the pipe temperature T starts rising from the freezing point temperature T0 and the control device 20 starts calculating the high temperature integrated value B in response to the defrosting operation, the high temperature integrated value B is calculated as follows:

[0039]

$$B = (1 - 0) * 1 + (2 - 0) * 2 = 5$$

[0040] Accordingly, a relationship that "A = 17 being greater than kB = 4 (i.e. A = 17 > kB = 4)" is established. Therefore, the control device 20 determines that the idle defrosting operation is not executed (i.e. the frost formed state) in the above-described manner.

[0041] A case where the temperature rising tendency is not slow (diminished) at the low temperature range across the freezing point temperature T0 will be described below. As illustrated in Fig. 3B, when assuming that the pipe temperature T reaches (rises to) the freezing point temperature T0 (zero degree (0.)) though a process where the pipe temperature T remains to be -2 degrees (-2.) for one second and -1 degree (-1.) for one second after the pipe temperature T reaches -2 degrees (-2.) and the control device 20 starts calculating the low temperature integrated value A in response to the defrosting operation, the low temperature integrated value A is calculated as follows:

[0042]

$$A = (0 - (-2)) * 1 + (0 - (-1)) * 1 = 3$$

[0043] Additionally, when assuming that the pipe temperature T remains to be 1 degree (1.) for one second and 2 degrees (2.) for two seconds after the pipe temperature T starts rising from the freezing point temperature T0 and the control device 20 starts calculating the high temperature integrated value B, the high temperature integrated value B is calculated as follows:

[0044]

$$B = (1 - 0) * 1 + (2 - 0) * 2 = 5$$

[0045] Accordingly, a relationship that "A = 3 being equal to or smaller than kB = 4 (i.e. A = 3 ≤ kB = 4)" is established. Therefore, the control device 20 determines that the idle defrosting operation is executed (i.e. the frost non-formed state) in the above-described manner.

[0046] Illustrated in Fig. 4 is a table data experimentally obtained in order to compare a relationship between the pipe temperature T (T2) of the outdoor heat exchanger 15 and the reliability when the determination of the idle defrosting operation is completed according to the idle defrosting operation determining device of this disclosure with a relationship between a pipe temperature of an outdoor heat exchanger and a reliability when a determination of an idle defrosting operation is completed according to a known idle defrosting operation determining device. In an experimental test, an idle defrosting operation determining device, which is configured so as to deter-

mine whether or not an idle defrosting operation is executed in a manner that the idle defrosting determining device estimates a formation of frost on an outdoor heat exchanger (15) on the basis of a temperature rising tendency (a derivative value) of a pipe temperature (T) of the outdoor heat exchanger, is adapted as the known idle defrosting operation determining device.

[0047] As shown in Fig. 4, according to the known idle defrosting operation determining device, in a case where the pipe temperature (T) of the outdoor heat exchanger (15) used for completing the determination of the idle defrosting operation whether or not being executed is set to 10 degrees (10.), the idle defrosting operation is correctly determined whether or not being executed. However, according to the known idle defrosting operation determining device, in a case where the pipe temperature (T) of the outdoor heat exchanger (15) is set to 2 degrees (2.), the idle defrosting operation is not correctly determined whether or not being executed. It is analyzed that, because the temperature rising tendency is not stable while the pipe temperature (T) is low, a mis-determination is likely to be induced. Therefore, in order to obtain a correct determination result, the high pipe temperature (T) at which the temperature rising tendency becomes stable needs to be used.

[0048] On the other hand, according to the idle defrosting operation determining device of this embodiment, the correct determination is obtained in the both cases where the pipe temperature T of the outdoor heat exchanger 15 to be used for completing the determination of the idle defrosting operation whether or not being executed is set to 10 degrees (10.) and 2 degrees (2.). The above-mentioned result is considered to be obtained because the determination executed by the control device 20 is less likely to be influenced by the circulation of the cooling medium, the ambient temperature and the like by comparing the low temperature integrated value A with the high temperature integrated value B across the freezing point temperature T0. Accordingly, the idle defrosting operation determining device of this embodiment may promptly and accurately determine whether or not the idle defrosting operation is executed.

[0049] A determination process of the control device 20 determining whether or not the idle defrosting operation is executed will be described below with reference to a flowchart illustrated in Fig. 5. The process is invoked when the pipe temperature T reaches the low temperature T1 after the defrosting operation is started in accordance with the detection of the satisfaction of the defrosting operation starting condition.

[0050] In the case where the process illustrated in Fig. 5 is started, the control device 20 calculates the low temperature integrated value A and the high temperature integrated value B in the above-mentioned manner as the pipe temperature T rises in accordance with the defrosting operation (S1). Then, the control device 20 determines whether or not the low temperature integrated value A is equal to or lower than the value kB, which is

obtained by multiplying the high temperature integrated value B by the adjustment coefficient k (S2). In the case where the control device 20 determines that the low temperature integrated value A is equal to or lower than the value kB (Yes in S2), the control device 20 determines that the idle defrosting operation is executed (S3). On the other hand, in the case where the control device 20 determines that the low temperature integrated value A is greater than the value kB, the control device 20 determines that the idle defrosting operation is not executed (S4). Then, the process is terminated. Additionally, in the case where the control device 20 determines that the idle defrosting operation is executed, the defrosting operation is ended. On the other hand, in the case where the control device 20 determines that the idle defrosting operation is not executed, the control device 20 continues the defrosting operation until the satisfaction of the defrosting operation ending condition is detected.

[0051] According to the embodiment, the following advantages and merits may be obtained. According to the embodiment, each of the low temperature integrated value A and the high temperature integrated value B, which are used for determining whether or not the idle defrosting operation is executed, represent the temperature difference relative to the freezing point temperature T0 additionally accumulated relative to the time at each of the low temperature range (the range from the low temperature T1 and the freezing point temperature T0) and the high temperature range (the range from the freezing point temperature T0 and the high temperature T2) across the freezing point temperature T0. Accordingly, for example, the fluctuation of changes in the temperature rising tendency of the outdoor heat exchanger 15 because of the influence of, for example, the circulation of the cooling medium may be absorbed (cleared), so that the idle defrosting operation may be determined whether or not being executed within a narrower temperature range (i.e. the high temperature T2 lower than a set temperature in the known idle defrosting operation determining device). As a result, the idle defrosting operation may be promptly and accurately determined whether or not being carried out.

[0052] According to this embodiment, a humidity sensor and the like does not need to be provided at the idle defrosting operation determining device in order to determine whether or not the idle defrosting operation is performed. As a result, a number of components used for the idle defrosting operation determining device may be reduced. Additionally, the idle defrosting operation determining device according to this embodiment may be modified as follows.

[0053] In the embodiment, the low temperature T1 is set to be -2 degrees (-2 .) and the high temperature T2 is set to be 2 degrees (2 .) as an example. For example, the low temperature T1 and the high temperature T2 do not need to be in the same level (i.e. the same absolute value). Furthermore, the adjustment coefficient k may be changed in response to a desired accuracy (the reliabil-

ity) of the determination of whether or not the idle defrosting operation is executed relative to the set low temperature T1 and the high temperature T2. More specifically, the adjustment coefficient k may be set to be a smaller value as the required accuracy of the determination of whether or not the idle defrosting operation is executed is lower in order to avoid the control device 20 from mis-determining that the idle defrosting operation is executed.

[0054] The calculation cycle Δt (one second) of the control device 20 obtaining the pipe temperature T is only an example.

Claims

1. An air conditioning apparatus (1) comprising:

a refrigeration cycle including a compressor (11), an indoor heat exchanger (16), a pressure reducer (17) and an outdoor heat exchanger (15), that are connected to constitute a fluid circuit through which a cooling medium is circulated, the outdoor heat exchanger (15) serving as an evaporator for evaporating the cooling medium in a case where a heating operation is performed and as a condenser for condensing the cooling medium in a case where a defrosting operation is performed; and

an idle defrosting operation determining device (20) including a temperature detecting device (21) detecting a pipe temperature (T) of the outdoor heat exchanger (15), a low temperature integrated value calculating means (20) calculating a low temperature integrated value (A) through a time-based summation or integration of a temperature difference between a freezing point temperature (T0) and the pipe temperature (T) in a case where the pipe temperature (T), which is detected while the defrosting operation is carried out, falls within a temperature range from a predetermined low temperature lower than the freezing point temperature (T0) and the freezing point temperature (T0), a high temperature integrated value calculating means (20) calculating a high temperature integrated value (B) through a time-based summation or integration of a temperature difference between the freezing point temperature (T0) and the pipe temperature (T) in a case where the pipe temperature (T), which is detected while the defrosting operation is carried out, falls within a temperature range from a predetermined high temperature higher than the freezing point temperature (T0) and the freezing point (T0), and a determining means (20) determining whether or not the idle defrosting operation is carried out on the basis of a magnitude relationship between the calculated low temperature integrated

value (A) and the calculated high temperature integrated value (B).

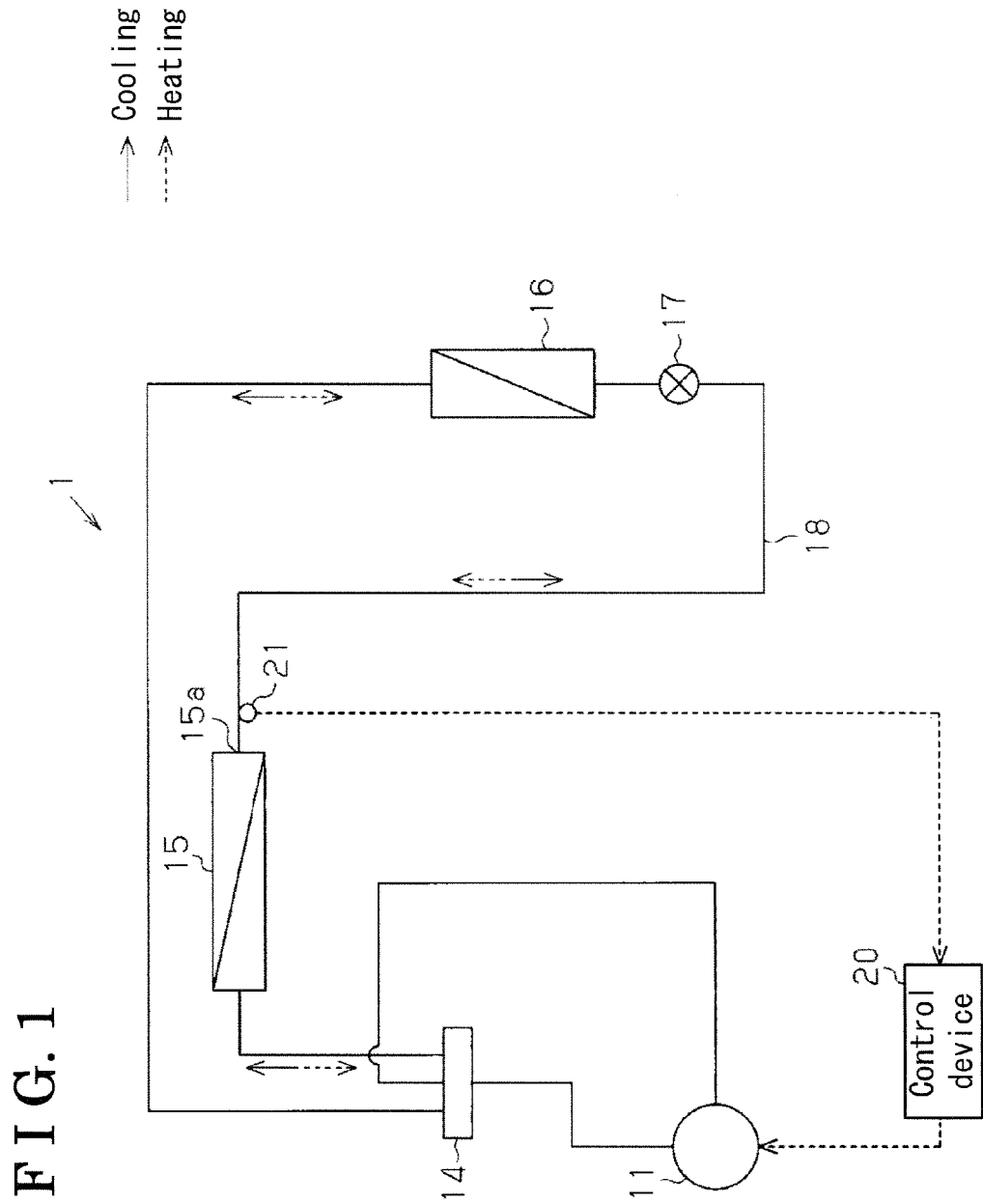
2. The idle defrosting operation determining device (20) for the air conditioning apparatus (1) according to Claim 1, wherein the freezing point temperature refers to a freezing point of water. 5
3. The idle defrosting operation determining device (20) for the air conditioning apparatus (1) according to Claim 2, wherein the freezing point of water fluctuates depending on an atmospheric pressure. 10
4. The idle defrosting operation determining device (20) for the air conditioning apparatus (1) according to Claim 1, wherein the temperature detecting device (21) processes the pipe temperature (T) of the outdoor heat exchanger (15) as an integer value. 15
5. The idle defrosting operation determining device (20) for the air conditioning apparatus (1) according to Claim 4, wherein the temperature detecting device (21) obtains the pipe temperature (T) of the outdoor heat exchanger (15) as the integer value in a manner where a numeral after a decimal point is rounded down in a case where the pipe temperature (T) indicates a positive value and the numeral after the decimal point is rounded up in a case where the pipe temperature (T) indicates a negative value. 20 25 30
6. The idle defrosting operation determining device (20) for the air conditioning apparatus (1) according to Claim 4, wherein the temperature detecting device (21) measures the pipe temperature (T) of the outdoor heat exchanger (15) every predetermined time. 35

40

45

50

55



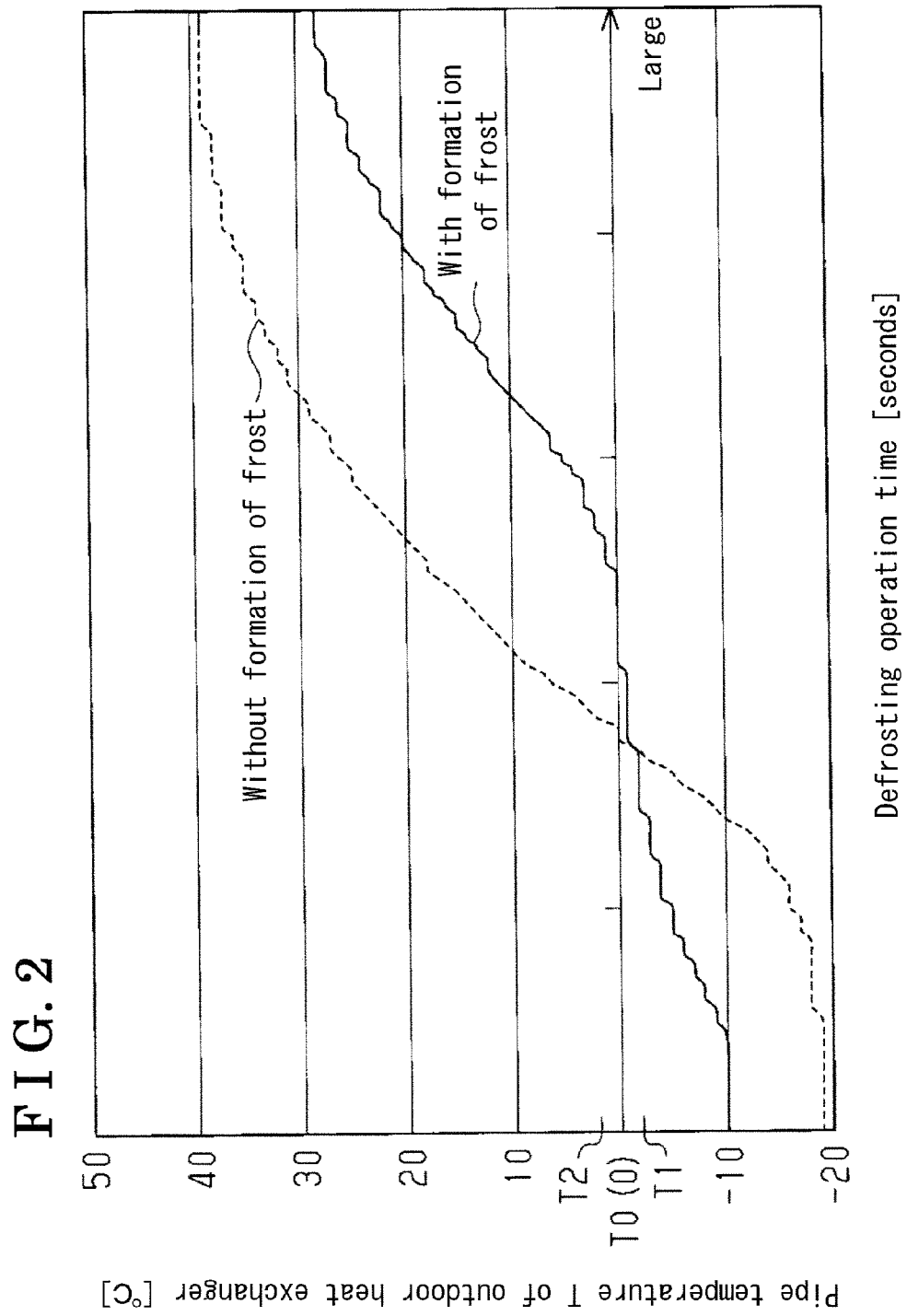


FIG. 3 A

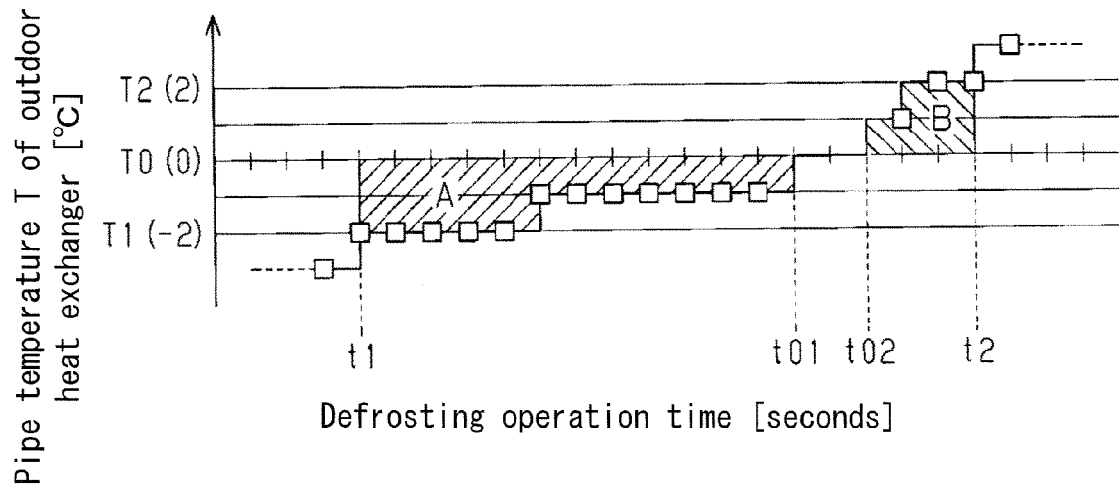


FIG. 3 B

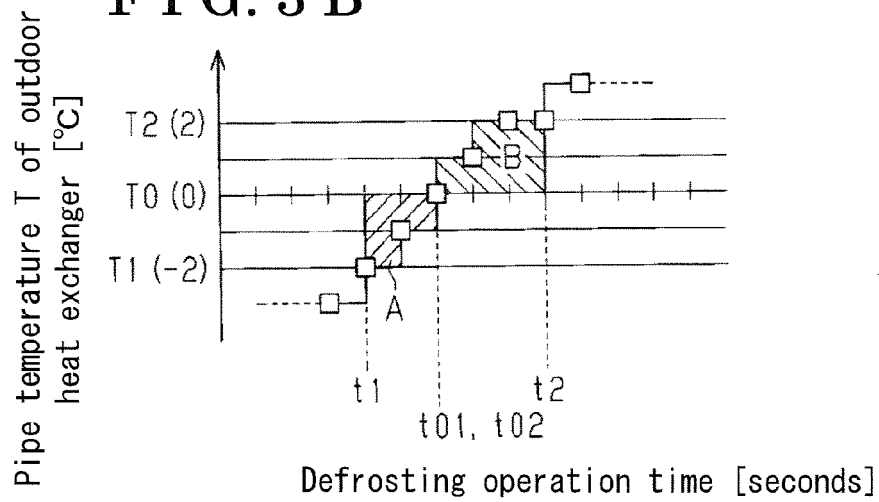
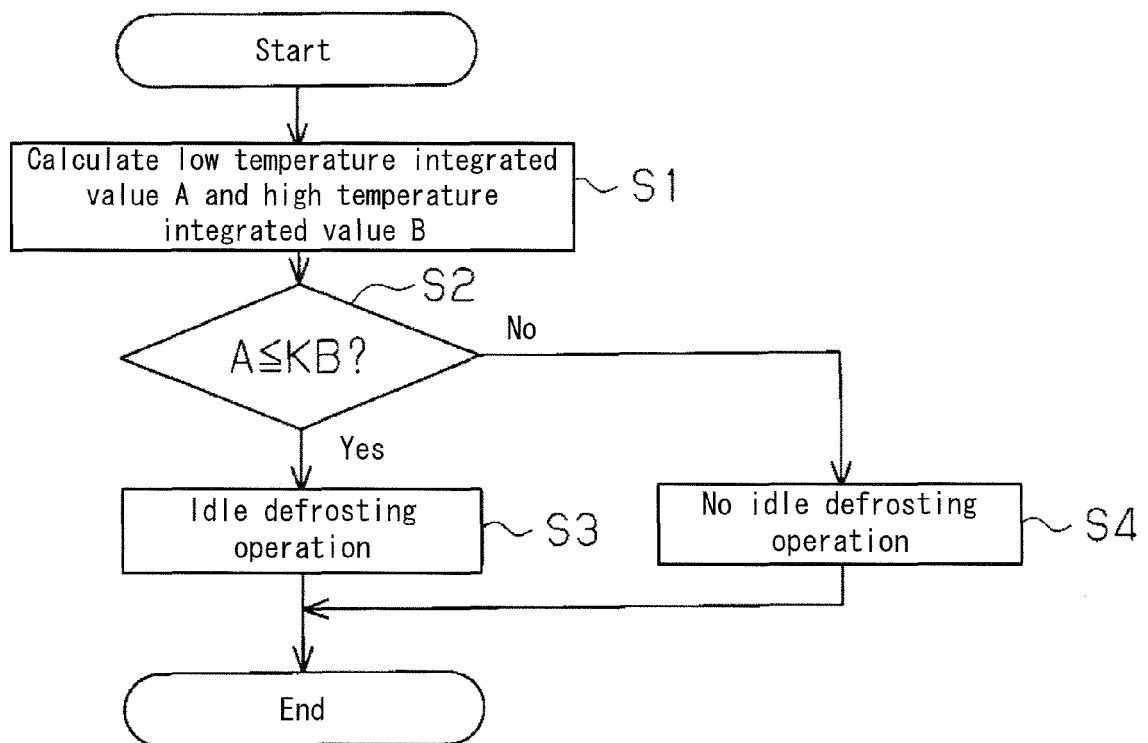


FIG. 4

	Determination ending pipe temperature	No mis- determination of idle defrosting operation
Known idle defrost determining device	2°C	×
	10°C	○
Idle defrost determining device of the embodiment	2°C	○
	10°C	○

FIG. 5



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2004232942 A [0003] [0005]
- JP 2002130876 A [0004] [0006] [0007]