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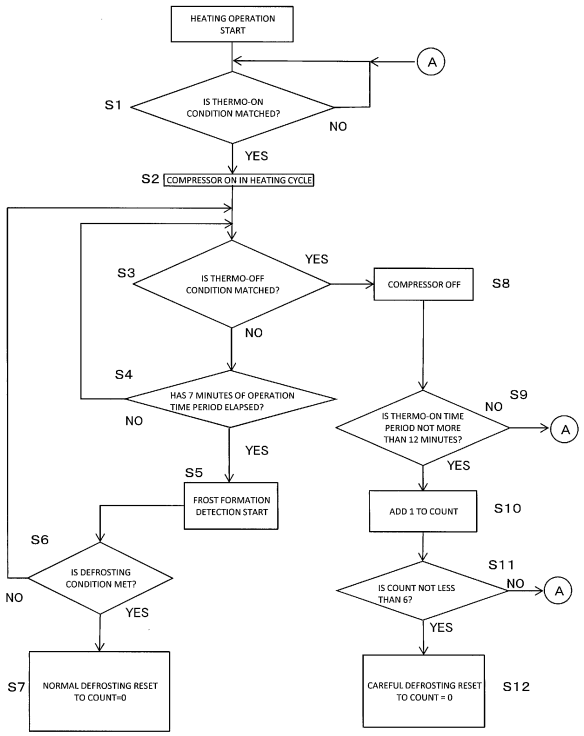
(54) AIR CONDITIONER

(57) When thermo-OFF is performed during heating operation, the operation time period of immediate preceding thermo-ON operation is confirmed. When the operation time period is not more than a specified time period, the number of operations of thermo-ON is counted. Every time thermo-ON and thermo-OFF are repeated, the number of operations of thermo-ON is counted. When the count of the number of operations reaches a predetermined number of times, defrosting operation is forcibly performed. When thermo-OFF and the thermo-ON are repeated in a short cycle, defrosting of an outdoor heat exchanger can be performed. As described above, by forcibly performing defrosting operation upon coming into a situation in which thermo-OFF and thermo-ON are repeated in a short cycle, it is made possible to eliminate an adverse effect that defrosting of the outdoor heat exchanger cannot be performed in such a situation.

FIG. 3



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Description

Technical Field

[0001] The present invention relates to an air conditioner which performs defrosting operation when frost formation on an outdoor heat exchanger is detected during heating operation.

Background Art

[0002] In an air conditioner including an indoor unit and an outdoor unit, frost is formed on an outdoor heat exchanger during heating operation, thereby adversely affecting heat exchanging. Accordingly, detection of frost formation on the outdoor heat exchanger is performed by detecting temperature of the outdoor heat exchanger. Upon detection of frost formation, defrosting operation is performed.

[0003] Meanwhile, when heating operation is started and a compressor is operated, refrigerant circulates forming a refrigeration cycle. At the beginning of driving of the compressor, the outdoor heat exchanger is rapidly cooled since drawing pressure of the compressor is large. For that reason, if judgment whether or not defrosting operation is to be performed is made based on the temperature of the outdoor heat exchanger, erroneous detection of frost formation occurs every time the compressor operates, thus causing defrosting operation to be performed. In order to avoid such unnecessary operation, Patent Literature 1 describes that a masking time period is set such that defrosting operation will not be performed for a predetermined time period after operation of the compressor.

Citation list

Patent Literature

[0004] Patent Literature 1: Japanese Patent Laid-Open No. 10-267475

Summary of Invention

Technical Problem

[0005] During the masking time period after operation of the compressor, defrosting operation will not be performed. Meanwhile, when the room temperature reaches a set temperature, "thermo-OFF" for stopping the compressor is performed, and when the temperature decreases after a while, "thermo-ON" for operating the compressor is performed. If the thermo-OFF and the thermo-ON are repeated in a short cycle, defrosting operation will not be performed since a masking time period is set. As a result of that, frost will not be removed even if frost forms on the outdoor heat exchanger, and the outdoor heat exchanger will freeze, disabling heating operation.

[0006] In view of what has been described above, it is an objective of the present invention to provide an air conditioner which enables defrosting of an outdoor heat exchanger when thermo-OFF and thermo-ON are repeated in a short cycle.

Solution to Problem

[0007] An air conditioner of the present invention includes a frost formation detecting section for detecting frost formation on an outdoor heat exchanger during heating operation, and a control apparatus for performing defrosting operation upon detection of frost formation, wherein the control apparatus invalidates detection of frost formation during a predetermined masking time period from start of heating operation, and validates detection of frost formation after elapse of the masking time period. Moreover, the control apparatus forcibly performs defrosting operation when thermo-OFF for stopping the compressor during heating operation and thermo-ON for operating the stopped compressor are repeatedly performed.

[0008] When thermo-OFF and thermo-ON are repeated before elapse of a masking time period, defrosting operation will not be performed since detection of frost formation is invalidated. In such a situation, defrosting operation is forcibly performed.

[0009] The control apparatus performs defrosting operation when thermo-ON, in which operation time period of thermo-ON is not more than a specified time period which is set to be not less than the masking time period, is performed for a predetermined number of times. That is, the control apparatus checks if an operation time period of immediately preceding thermo-ON is not more than a specified time period when starting thermo-ON, makes a count when it is not more than specified time period, and performs defrosting operation when the count reaches the predetermined number of times. The repeating of thermo-OFF and thermo-ON in a short cycle is judged based on the operation time period of thermo-ON.

Advantageous Effects of Invention

[0010] According to the present invention, by forcibly performing defrosting operation upon coming into a situation in which thermo-OFF and thermo-ON are repeated in a short cycle, it is made possible to eliminate an adverse effect that defrosting of the outdoor heat exchanger cannot be performed in such a situation.

Brief Description of Drawings

[0011]

[Figure 1] Figure 1 is a schematic configuration diagram of a refrigeration cycle of an air conditioner of the present invention.

[Figure 2] Figure 2 is a control block diagram of the

air conditioner.

[Figure 3] Figure 3 is a flowchart when defrosting operation of a first embodiment is performed.

[Figure 4] Figure 4 is a flowchart when defrosting operation of a second embodiment is performed.

[Figure 5] Figure 5 is a flowchart when defrosting operation of a third embodiment is performed.

[Figure 6] Figure 6 is a flowchart when defrosting operation of a fourth embodiment is performed.

Description of Embodiments

(First Embodiment)

[0012] Figure 1 shows an air conditioner of a first embodiment. The air conditioner of a heat pump type is configured such that an outdoor unit 1 and an indoor unit 2 are connected by piping and wiring. The outdoor unit 1 includes a compressor 3, a four-way valve 4, an outdoor heat exchanger 5, an expansion valve 6, and an outdoor fan 7. The indoor unit 2 includes an indoor heat exchanger 8 and an indoor fan 9. The compressor 3, the four-way valve 4, the outdoor heat exchanger 5, the expansion valve 6, and the indoor heat exchanger 8 are connected by piping to form a refrigerant circuit. To connect the piping of the indoor unit 2 and the piping of the outdoor unit 1, a two-way valve 10 and a three-way valve 11 are provided in the outdoor unit. The two-way valve 10 is interposed in the piping connecting the expansion valve 6 and the indoor heat exchanger 8, and the three-way valve 11 is interposed in the piping connecting the four-way valve 4 and the indoor heat exchanger 8.

[0013] Driving the compressor 3 causes the refrigerant to circulate the refrigerant circuit. A refrigeration cycle for heating or cooling is formed by the refrigerant circulating around the refrigerant circuit. In a cooling cycle, the refrigerant circulates in the order from the compressor 3, the four-way valve 4, the outdoor heat exchanger 5, the expansion valve 6, and the indoor heat exchanger 8. In a heating cycle, the refrigerant circulates in the order from the compressor 3, the four-way valve 4, the indoor heat exchanger 8, the expansion valve 6, and the outdoor heat exchanger 5.

[0014] Then, as shown in Figure 2, the air conditioner includes a control apparatus 12 which controls the refrigeration cycle to perform air conditioning operations such as cooling, heating, and dehumidification. Moreover, the air conditioner includes a room temperature detector 13, an outside air temperature detector 14, an outdoor heat exchanger temperature detector 15 for detecting temperature of the outdoor heat exchanger 5, and an indoor heat exchanger temperature detector 16 for detecting temperature of the indoor heat exchanger 8. Each of the temperature detectors 13 to 16 uses a temperature sensor such as a thermistor.

[0015] The control apparatus 12 controls each of a rotational frequency (operational frequency) of the compressor 3, an opening of the expansion valve 6, a rotational frequency of the outdoor fan 7, and a rotational frequency of the indoor fan 9 based on the temperature detected by each of the temperature detectors 13 to 16 according to an instructed operation mode. Note that the control apparatus 12 is made up of an indoor control section provided in the indoor unit 2, and an outdoor control section provided in the outdoor unit 1. The indoor control section and the outdoor control section are connected so as to be communicable with each other, and control the operations of the indoor unit 2 and the outdoor unit 1 in cooperation with each other. The outdoor control section transmits detection signals, which are inputted from a plurality of temperature detectors 14 and 15, altogether to the indoor control section, and the indoor control section manages detected temperature information.

[0016] Here, when heating operation is performed, the temperature of the outdoor heat exchanger 5 becomes lower than the outside air temperature, and frost forms on the surface of the outdoor heat exchanger 5. Accordingly, in order to detect frost formation on the outdoor heat exchanger 5, a frost formation detecting section is made up by the outside air temperature detector 14 and the outdoor heat exchanger temperature detector 15. The frost formation detecting section performs operation of detecting frost formation during air conditioning operation. When the difference between the outside air temperature and the temperature of the outdoor heat exchanger 5 becomes not less than a predetermined temperature, the frost formation detecting section detects that frost is formed on the outdoor heat exchanger 5.

[0017] The control apparatus 12 judges appropriateness of defrosting operation based on the output of the frost formation detecting section. That is, the control apparatus 12 judges that a defrosting condition is met when the difference between the outside air temperature and the temperature of the outdoor heat exchanger 5 is not less than a predetermined value, and that the defrosting condition is unmet when the difference between the outside air temperature and the temperature of the outdoor heat exchanger 5 is less than a predetermined value. The control apparatus 12 performs defrosting operation if a detection result meets the defrosting condition. Reverse defrosting is performed as the defrosting operation. During heat operation, the compressor is stopped and the operation is switched to cooling operation. Note that detection of frost formation may be performed based on the temperature of the outdoor heat exchanger 5. When the temperature of the outdoor heat exchanger 5 becomes not more than a specified temperature below freezing point, it is judged that the defrosting condition is fulfilled.

[0018] When operation is started and the compressor 3 starts to operate, the temperature of the outdoor heat exchanger 5 significantly decreases in the beginning of the start of operation. For that reason, the detection result meets the defrosting condition even though frost is not formed on the outdoor heat exchanger 5. Accordingly, a masking time period, during which detection of frost for-

mation is invalidated for a predetermined time period from the start of heating operation, is set. The control apparatus 12 does not perform defrosting operation during a period from the start of operation until the masking time period has elapsed. When the masking time period elapses, the control apparatus 12 judges necessity of defrosting operation based on the output of the frost formation detecting section.

[0019] Moreover, during heating operation, when the room temperature reaches a set temperature, thermo-OFF for stopping the compressor 3 is performed. When the room temperature decreases after a while, thermo-ON for operating the compressor 3 is performed. When thermo-ON is performed as well, the control apparatus 12 invalidates detection of frost formation during a masking time period from the start of operation of the compressor 3. When the masking time period elapses, the control apparatus 12 validates detection of frost formation.

[0020] By the way, if thermo-ON is performed repeatedly while the masking time period has not elapsed, the defrosting operation will not be performed during this period even if frost is formed on the outdoor heat exchanger 5. When thermo-ON continues at a short cycle, frost formed on the outdoor heat exchanger 5 grows, and the outdoor heat exchanger 5 will be frozen. Accordingly, the control apparatus 12 forcibly performs defrosting operation when thermo-OFF and thermo-ON are repeatedly performed.

[0021] The control apparatus 12 checks if the operation time period of immediately preceding thermo-ON is not more than a specified time period when thermo-OFF is started. The specified time period is set to be not less than the masking time period. For example, when the masking time period is 7 minutes, the specified time period is set to be 12 minutes. The control apparatus 12 performs defrosting operation when thermo-ON, whose operation time period is not more than the specified time period, is performed for a predetermined number of times.

[0022] When heating operation is started, as shown in Figure 3, the control apparatus 12 confirms if the room temperature matches a thermo-ON condition (S1). The thermo-ON condition is a case in which the room temperature is lower than the set temperature. When the room temperature is lower than the set temperature and matches the thermo-ON condition, the compressor 3 starts operating in a heating cycle (S2). Note that when the room temperature is not less than the set temperature, the compressor 3 remains to be stopped. At this time, the indoor fan 9 is driven and air blowing operation is performed.

[0023] Upon performing thermo-ON, the control apparatus 12 confirms if the room temperature matches the thermo-OFF condition (S3). The thermo-OFF condition is a case in which the room temperature is not less than the set temperature. When the room temperature is lower than the set temperature, and does not match the thermo-OFF condition, the control apparatus 12 checks operation time period from the start of heating operation. The control apparatus 12 confirms if the operation time period has exceeded a specified time period (7 minutes) (S4). During this period, frost formation detection is invalidated. When operation time period has exceeded the masking time period, the control apparatus 12 validates frost formation detection and starts detection (S5).

[0024] During heating operation, the control apparatus 12 validates frost forming detection and confirms if the detection result meets the defrosting condition (S6). When the detection result meets the defrosting condition, the control apparatus 12 performs normal defrosting operation (S7). Moreover, a count to be described below of the number of operations of thermo-ON is reset.

[0025] When the room temperature matches the thermo-OFF condition, the control apparatus 12 causes the compressor 3 to stop (S8). Then, the control apparatus 12 checks the operation time period of thermo-ON (S9). When the operation time period is not more than the specified time period (12 minutes), the control apparatus 12 adds 1 to the count of the number of operations of thermo-ON, and stores the count in a memory (S10). The control apparatus 12 confirms if the count of the number of operations reaches a predetermined number of times, for example, 6 times (S11) .

[0026] When the operation time period of thermo-ON is longer than the specified time period, or the count is less than the predetermined number of times, the control apparatus 12 confirms if the room temperature matches the thermo-ON condition (S1) while continuing thermo-OFF.

[0027] When the room temperature further decreases due to thermo-OFF and the thermo-ON condition is fulfilled, the control apparatus 12 causes the compressor 3 to operate (S2). The room temperature increases due to thermo-ON. When the room temperature becomes higher than the set temperature, the thermo-OFF condition is fulfilled (S3), and the compressor stops (S8). The control apparatus 12 checks the operation time period of immediately preceding thermo-ON (S9). When the operation time period is not more than the specified time period (12 minutes), the control apparatus 12 adds 1 to the count of the number of operations of thermo-ON (S10), and confirms if the count reaches the predetermined number of times (S11).

[0028] Note that the operation time period of thermo-ON may exceed the masking time period even if it is not more than the specified time period. However, when thermo-OFF and thermo-ON are repeated after the start of heating operation, the control apparatus 12 invalidates frost formation detection. Therefore, even if the operation time period of thermo-ON exceeds the masking time period, the control apparatus 12 does not judge the necessity of defrosting operation. However, when the operation time period of thermo-ON exceeds the specified time period, the control apparatus 12 validates frost formation detection, and judges the necessity of defrosting opera-

tion. When a detection result by the frost formation detecting section meets the defrosting condition, the control apparatus 12 performs normal defrosting operation. At this time, the count is reset. When defrosting is unnecessary, thermo-ON is continued, and the control apparatus 12 confirms if the room temperature matches the thermo-OFF condition. At this time, the count will not be reset.

[0029] When the count reaches the predetermined number of times, the control apparatus 12 forcibly starts defrosting operation (S12). Moreover, the control apparatus 12 resets the count of the number of operations of thermo-ON to be 0. In this defrosting operation, "careful defrosting" will be performed. That is, a heating cycle, in which the rotational frequency of the compressor 3 is increased and the indoor fan 9 is stopped, is carried out. When the temperature of the indoor heat exchanger 8 becomes a predetermined temperature, for example, 54°C, operation is switched from the heating cycle to the cooling cycle. As a result of this, since heat is accumulated in the indoor heat exchanger 8, and high temperature refrigerant flows to the outdoor heat exchanger 5 after switching to the cooling cycle, it is possible to surely and quickly perform defrosting. Upon completion of defrosting operation, the control apparatus 12 switches the operation to the heating cycle and continues the heating operation.

[0030] Thus, since defrosting operation is forcibly performed when thermo-OFF and thermo-ON are repeated in a short cycle, it is possible to eliminate a situation that defrosting cannot be performed even though frost is formed on the outdoor heat exchanger 5. Particularly, in a situation in which heating operation is performed at low load when the outside air temperature is low, it is often the case that thermo-OFF and thermo-ON are repeated in a short cycle. Although, in such a situation, there is a risk that frost is formed on the outdoor heat exchanger 5, and the outdoor heat exchanger 5 freezes, defrosting of the outdoor heat exchanger 5 is surely performed, enabling heating operation to be stably continued.

(Second Embodiment)

[0031] The cycle of thermo-ON varies depending on the outside air temperature. Since efficiency of heating operation decreases as the outside air temperature decreases, when the room temperature decreases, it takes more time for the room temperature to become a set temperature. As a result of this, the operation time period of thermo-ON increases. On the contrary, when the outside air temperature is not so low, the operation time period of thermo-ON decreases. Accordingly, the air conditioner counts the number of operations of thermo-ON based on a specified time period according to the outside air temperature, and judges the necessity of frosting operation. Note that other components are the same as those of the first embodiment.

[0032] The control apparatus 12 determines a specified time period according to the outside air temperature. When the outside air temperature becomes higher, a shorter specified time period is set, and when the outside air temperature becomes lower, a longer specified time period is set. For example, the specified time period is set to 7 minutes when the outside air temperature is not less than -5°C and is set to 12 minutes when the outside air temperature is lower than -5°C.

[0033] The control apparatus 12 monitors the outside air temperature based on the output of the outside air temperature detector 14 during heating operation. As shown in Figure 4, when thermo-OFF is performed (S8) after heating operation is started, the control apparatus 12 confirms the outside air temperature (S20), and sets a specified time period according to the outside air temperature. When the outside air temperature is not less than -5°C, the control apparatus 12 checks the operation time period of immediately preceding thermo-ON (S21) based on the short specified time period (7 minutes). When the outside air temperature is lower than -5°C, the control apparatus 12 checks the operation time period of immediately preceding thermo-ON (S22) based on the long specified time period (12 minutes). When the operation time period is not more than the specified time period, the control apparatus 12 adds 1 to the count of thermo-ON (S10), and confirms if the count reaches the predetermined number of times (S11). When the operation time period is longer than the specified time period, the control apparatus 12 does not increase the count, and confirms if the room temperature matches the thermo-ON condition (S1).

[0034] When the outside air temperature is low, if the number of operations of thermo-ON is counted in a short specified time period, the number of operation will not be counted when the operation time period of thermo-ON exceeds the specified time period. As a result of this, the time period until which the necessity of defrosting operation is judged becomes longer, and frost formed on the outdoor heat exchanger 5 grows during that period, disabling to remove the frost. Accordingly, by changing the specified time period to a longer time period when the outside air temperature is low, it is made possible to surely perform counting even if the operation time period becomes longer when the outside air temperature is low, and reduce the time period until defrosting is performed. Therefore, it is possible to perform defrosting of the outdoor heat exchanger 5 before frost has grown.

[0035] Moreover, when the outside air temperature is high, the operation time period of thermo-ON is normally short. When the operation time period of thermo-ON becomes longer, there is possibility that frost has been formed on the outdoor heat exchanger 5. In this case, the operation time period will exceed the specified time period. If the specified time period is set to be a short time period according to the outside air temperature, frost formation detection becomes valid since the operation time period of thermo-ON exceeds the specified time period. Since frost formation is detected when frost is

formed, it is possible to perform defrosting.

(Third Embodiment)

[0036] In the above described embodiments, when thermo-OFF and thermo-ON are repeated in a short cycle, defrosting operation is forcibly performed. However, even in such a situation, there is a case in which no frost is formed on the outdoor heat exchanger 5. In such a case, defrosting operation is unnecessary. Therefore, the air conditioner performs frost formation detection before performing forcible defrosting operation. That is, heating operation is performed such that frost formation detection becomes valid in thermo-ON for a predetermined number of times. Note that, other components are the same as those of the first or second embodiment.

[0037] The control apparatus 12 performs thermo-ON such that the operation time period exceeds the specified time period when performing heating operation by thermo-ON for the predetermined number of times (6 times). As shown in Figure 5, when the number of operations of thermo-ON becomes 5 times (S30), the control apparatus 12 confirms if the room temperature matches the thermo-ON condition (S31) while continuing thermo-ON.

[0038] If the thermo-ON condition is fulfilled, the control apparatus 12 performs the 6th thermo-ON. The compressor 3 operates in the heating cycle (S32). At this time, the control apparatus 12 forcibly performs heating operation for a time period longer than the specified time period, for example, 13 minutes. Since, as a result of this, the operation time period exceeds the specified time period, the control apparatus 12 validates frost formation detection, and judges the necessity of defrosting operation (S33). That is, the control apparatus 12 confirms if a detection result by the frost formation detecting section meets the defrosting condition (S6) after completion of defrosting operation. If the detection result meets the defrosting condition, the control apparatus 12 performs defrosting operation by "careful defrosting", and resets the count (S12). When the detection result does not meet the defrosting condition, the control apparatus 12 resets the count (S34), and confirms if the room temperature matches the thermo-ON condition (S1) while continuing thermo-OFF.

[0039] In this way, although detection of frost formation is not performed while thermo-OFF and thermo-ON are repeated in a short cycle, defrosting operation will be performed as needed by forcibly judging the necessity of defrosting operation. When frost is not formed on the outdoor heat exchanger 5, defrosting operation will not be performed, thereby preventing unnecessary defrosting operation from being performed.

(Fourth Embodiment)

[0040] In the above described embodiments, when thermo-OFF and thermo-ON are repeated in a short cycle, detection of frost formation is invalidated. Here, when heating operation is performed by thermo-ON, the operation time period of thermo-ON becomes longer if the room temperature is hard to be increased. In such a case, frost forms on the outdoor heat exchanger 5, the efficiency of heating operation may have deteriorated. Accordingly, the air conditioner is configured to perform defrosting operation by detecting frost formation on the outdoor heat exchanger 5 when the operation time period of thermo-ON becomes long. Note that other components are the same as those of the first to third embodiments.

[0041] The control apparatus 12 validates detection of frost formation when the operation time period of thermo-ON exceeds the specified time period, and judges the necessity of defrosting operation. As shown in Figure 6, when thermo-OFF is performed, the control apparatus 12 checks the operation time period of immediately preceding thermo-ON (S9). When the operation time period is not more than the specified time period (12 minutes), the control apparatus 12 adds 1 to the count of the number of operations of thermo-ON (S10) and confirms if the count reaches a predetermined number of times, for example, 6 times (S11) .

[0042] When the operation time period of thermo-ON is longer than the specified time period, the control apparatus 12 resets the count (S40), validates frost formation detection, and starts frost formation detection (S41). The control apparatus 12 confirms if the detection result meets the defrosting condition (S42). When the detection result meets the defrosting condition, the control apparatus 12 performs normal defrosting operation (S43). When the detection result does not meet the defrosting condition, the control apparatus 12 confirms if the room temperature matches the thermo-ON condition (S1). When the room temperature matches the thermo-ON condition, the control apparatus 12 performs thermo-ON and operates the compressor 3 in a heating cycle (S2).

[0043] In this way, when thermo-ON is prolonged, frost formation detection is performed. If frost is formed on the outdoor heat exchanger 5, the defrosting operation is performed. Therefore, even if thermo-ON and thermo-OFF are being repeated, it is possible to surely perform defrosting of the outdoor heat exchanger 5 when defrosting is necessary.

[0044] As so far described, the air conditioner of the present invention comprises a frost formation detecting section for detecting frost formation on an outdoor heat exchanger 5 during heating operation, and a control apparatus 12 for performing defrosting operation upon detection of frost formation, wherein the control apparatus 12 invalidates detection of frost formation during a predetermined masking time period from start of heating operation, and validates the detection of frost formation after elapse of the masking time period, and the control apparatus 12 forcibly performs defrosting operation when thermo-OFF for stopping a compressor during heating operation and thermo-ON for operating the stopped compressor are repeatedly performed.

[0045] When operation is performed from thermo-ON

to thermo-OFF in a short cycle, frost formation detection will not be performed due to the masking time period. However, by forcibly performing defrosting operation when thermo-ON and thermo-OFF are repeatedly performed in a short cycle, it is possible to prevent a situation in which frost formed on the outdoor heat exchanger during that period grows and the outdoor heat exchanger 5 freezes.

[0046] The control apparatus 12 performs defrosting operation when thermo-ON, in which operation time period of thermo-ON is not more than a specified time period which is set to be not less than the masking time period, is performed for a predetermined number of times. This makes it possible to surely perform defrosting when thermo-ON is repeated in a shorter time period than the masking time period.

[0047] The control apparatus 12 checks if an operation time period of immediately preceding thermo-ON is not more than a specified time period when starting thermo-ON, to make a count when not more than the specified time period, and performs defrosting operation when the count reaches a predetermined number of times. As a result of this, when the operation time period of thermo-ON is longer than the specified time period, it will be excluded from counting. In this case, normal frost formation detection and defrosting operation become possible, enabling defrosting.

[0048] The control apparatus 12 determines the specified time period according to the outside air temperature so that the specified time period is made shorter when the outside air temperature is higher, and the specified time period is made longer when the outside air temperature is lower. Since, as a result of this, the operation time period of thermo-ON is affected by the outside air temperature, it is possible to surely count thermo-ON in a short cycle by determining a specified time period according to the outside air temperature, thus enabling to perform forcible defrosting operation as soon as possible.

[0049] The control apparatus 12 resets the count when thermo-ON whose operation time period is longer than the specified time period is performed. Since this causes frost formation detection to be validated, defrosting operation can be performed as needed.

[0050] Note that the present invention will not be limited to the above described embodiments and, as a matter of course, many modifications and alterations can be made to the above described embodiments within the scope of the present invention. When thermo-OFF and thermo-ON are repeated during heating operation, determination may be made on whether or not forcible defrosting operation is performed. That is, when thermo-OFF and thermo-ON are being repeated, the control apparatus 12 judges the possibility of frost formation based on a detection result of the frost formation detecting section. Then, the control apparatus 12 determines the necessity of forcible defrosting operation based on the possibility of frost formation. When there is no possibility of frost formation, it is judged that defrosting operation is not necessary. In this case, frost formation detection is performed when the operation time period of thermo-ON exceeds the masking time period. Moreover, when there is possibility of frost formation, it is judged that defrosting operation is necessary, and operation according to each of the above described embodiments is performed.

Reference Signs List

[0051]

1	Outdoor unit
2	Indoor unit
3	Compressor
4	Four-way valve
5	Outdoor heat exchanger
6	Expansion valve
7	Outdoor fan
8	Indoor heat exchanger
9	Indoor fan
12	Control apparatus
13	Room temperature detector
14	Outside air temperature detector
15	Outdoor heat exchanger temperature detector
16	Indoor heat exchanger temperature detector

Claims

1. An air conditioner comprising a frost formation detecting section for detecting frost formation on an outdoor heat exchanger during heating operation, and a control apparatus for performing defrosting operation upon detection of frost formation, wherein
the control apparatus invalidates detection of frost formation during a predetermined masking time period from start of heating operation, and validates the detection of frost formation after elapse of the masking time period, the air conditioner being configured such that
the control apparatus forcibly performs defrosting operation when thermo-OFF for stopping the compressor during heating operation and thermo-ON for operating the stopped compressor are repeatedly performed.

2. The air conditioner according to claim 1, wherein
the control apparatus performs defrosting operation when thermo-ON, in which operation time period of thermo-ON is not more than a specified time period which is set to be not less than the masking time period, is performed for a predetermined number of times.

3. The air conditioner according to claim 1 or 2, wherein
the control apparatus checks if an operation time period of immediately preceding thermo-ON is not more than a specified time period when starting thermo-

OFF, makes a count when it is not more than the specified time period, and performs defrosting operation when the count reaches a predetermined number of times.

4. The air conditioner according to any of claims 1 to 3, wherein
the control apparatus determines the specified time period according to outside air temperature so that the specified time period is made shorter when the outside air temperature is higher, and the specified time period is made longer when the outside air temperature is lower.

5. The air conditioner according to claim 3 or 4, wherein the control apparatus resets the count when thermo-ON whose operation time period is longer than a specified time period is performed.

FIG. 1

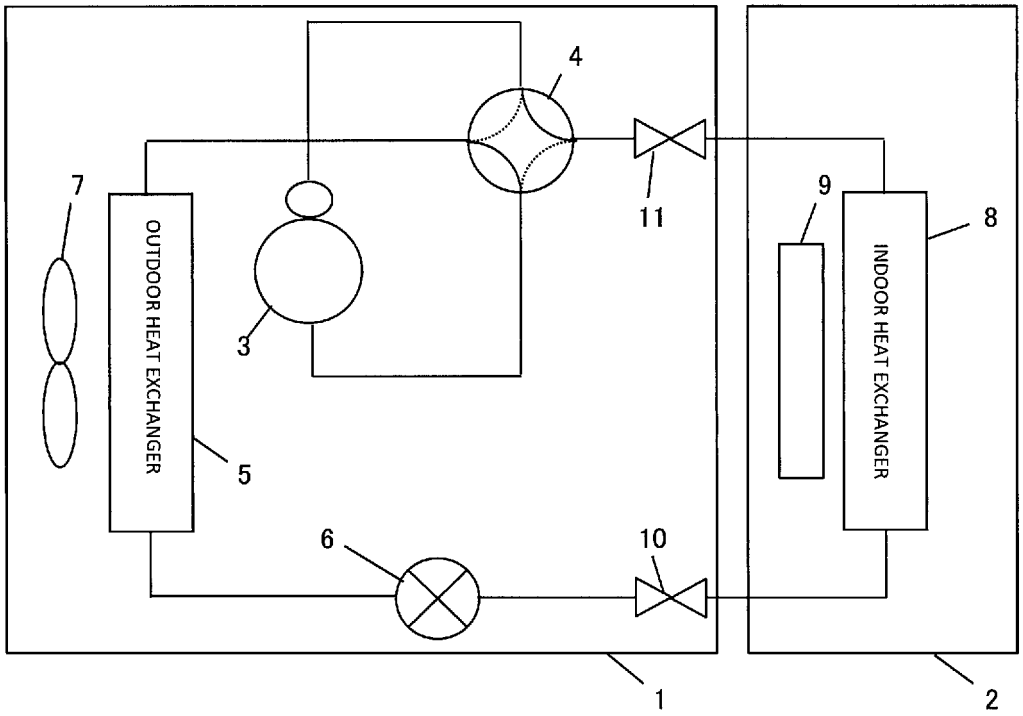

4
7
OUTDOOR HEAT EXCHANGER
11
9
8
INDOOR HEAT EXCHANGER
3
5
6
10
1
2

FIG. 2

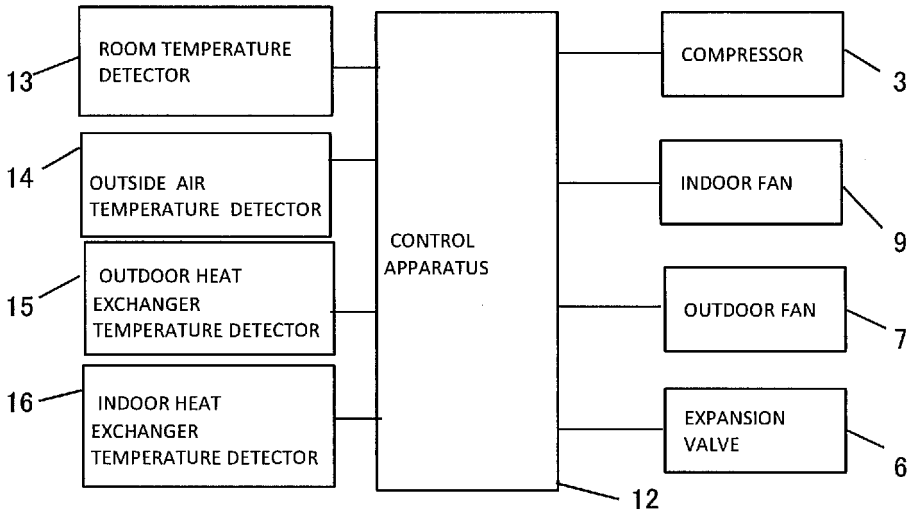

13
ROOM TEMPERATURE DETECTOR
14
OUTSIDE AIR TEMPERATURE DETECTOR
15
OUTDOOR HEAT EXCHANGER TEMPERATURE DETECTOR
16
INDOOR HEAT EXCHANGER TEMPERATURE DETECTOR
CONTROL APPARATUS
12
COMPRESSOR
3
INDOOR FAN
9
OUTDOOR FAN
7
EXPANSION VALVE
6

FIG. 3

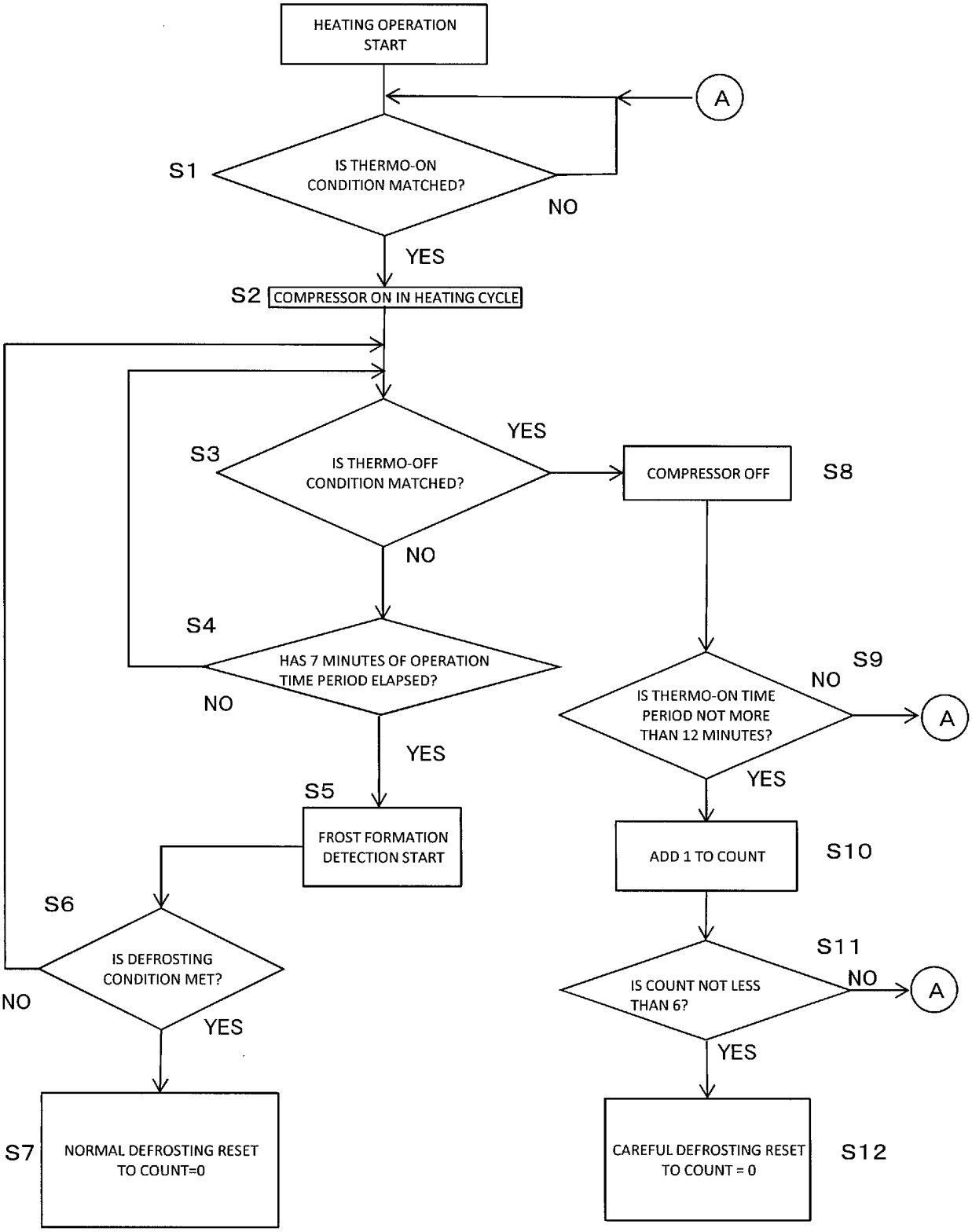

HEATING OPERATION START
A
S1
IS THERMO-ON CONDITION MATCHED?
NO
YES
S2
COMPRESSOR ON IN HEATING CYCLE
S3
IS THERMO-OFF CONDITION MATCHED?
YES
COMPRESSOR OFF
S8
NO
S4
HAS 7 MINUTES OF OPERATION TIME PERIOD ELAPSED?
NO
YES
S9
IS THERMO-ON TIME PERIOD NOT MORE THAN 12 MINUTES?
NO
A
YES
S5
FROST FORMATION DETECTION START
ADD 1 TO COUNT
S10
S6
IS DEFROSTING CONDITION MET?
NO
YES
S11
IS COUNT NOT LESS THAN 6?
NO
A
YES
S7
NORMAL DEFROSTING RESET TO COUNT=0
CAREFUL DEFROSTING RESET TO COUNT = 0
S12

FIG. 4

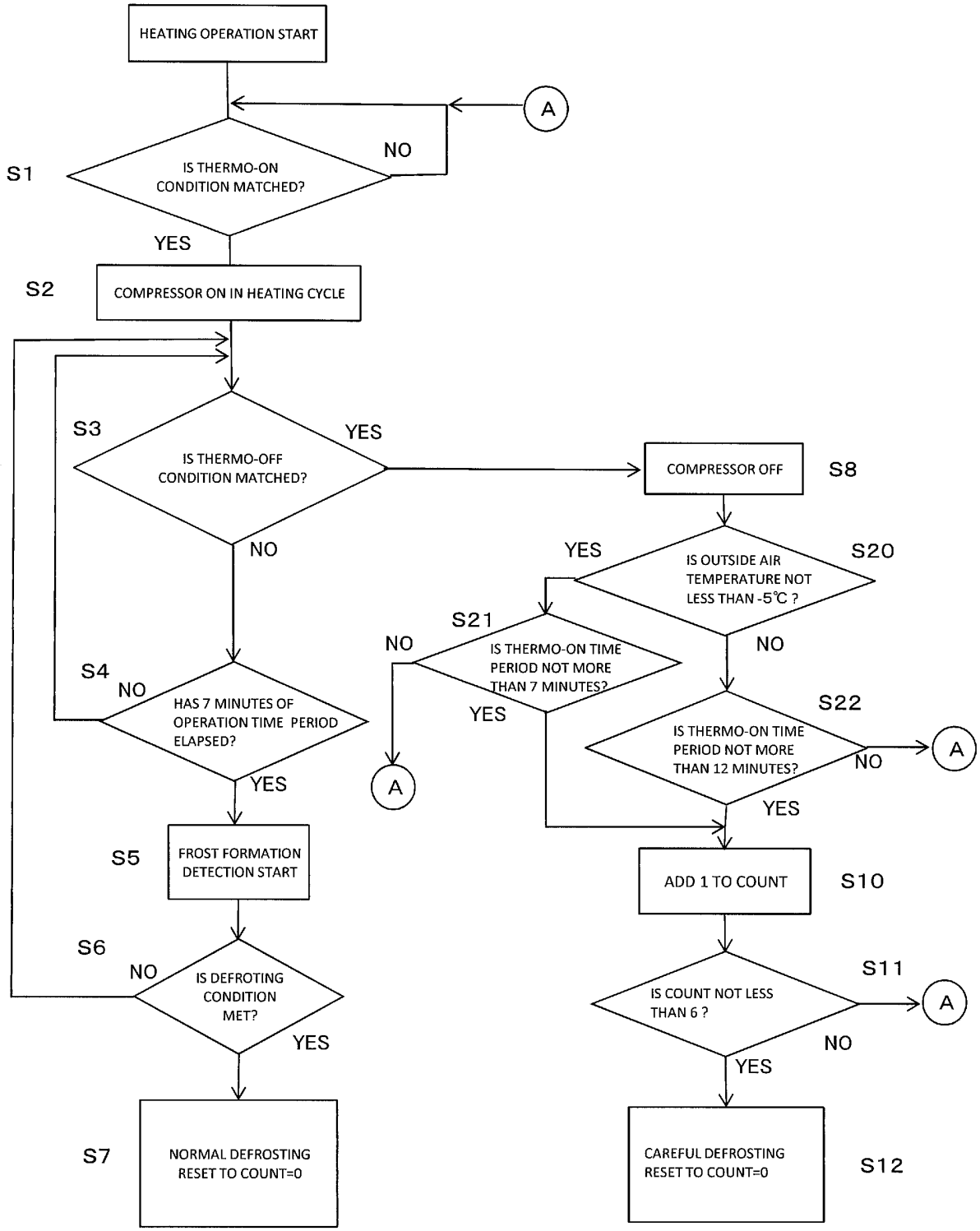

HEATING OPERATION START
A
S1
IS THERMO-ON CONDITION MATCHED?
NO
YES
S2
COMPRESSOR ON IN HEATING CYCLE
S3
IS THERMO-OFF CONDITION MATCHED?
YES
NO
COMPRESSOR OFF
S8
S4
NO
HAS 7 MINUTES OF OPERATION TIME PERIOD ELAPSED?
YES
S5
FROST FORMATION DETECTION START
S6
NO
IS DEFROTING CONDITION MET?
YES
S7
NORMAL DEFROSTING RESET TO COUNT=0
YES
IS OUTSIDE AIR TEMPERATURE NOT LESS THAN -5℃ ?
S20
NO
S21
NO
IS THERMO-ON TIME PERIOD NOT MORE THAN 7 MINUTES?
YES
A
S22
IS THERMO-ON TIME PERIOD NOT MORE THAN 12 MINUTES?
NO
A
YES
ADD 1 TO COUNT
S10
S11
IS COUNT NOT LESS THAN 6 ?
A
NO
YES
CAREFUL DEFROSTING RESET TO COUNT=0
S12

FIG. 5

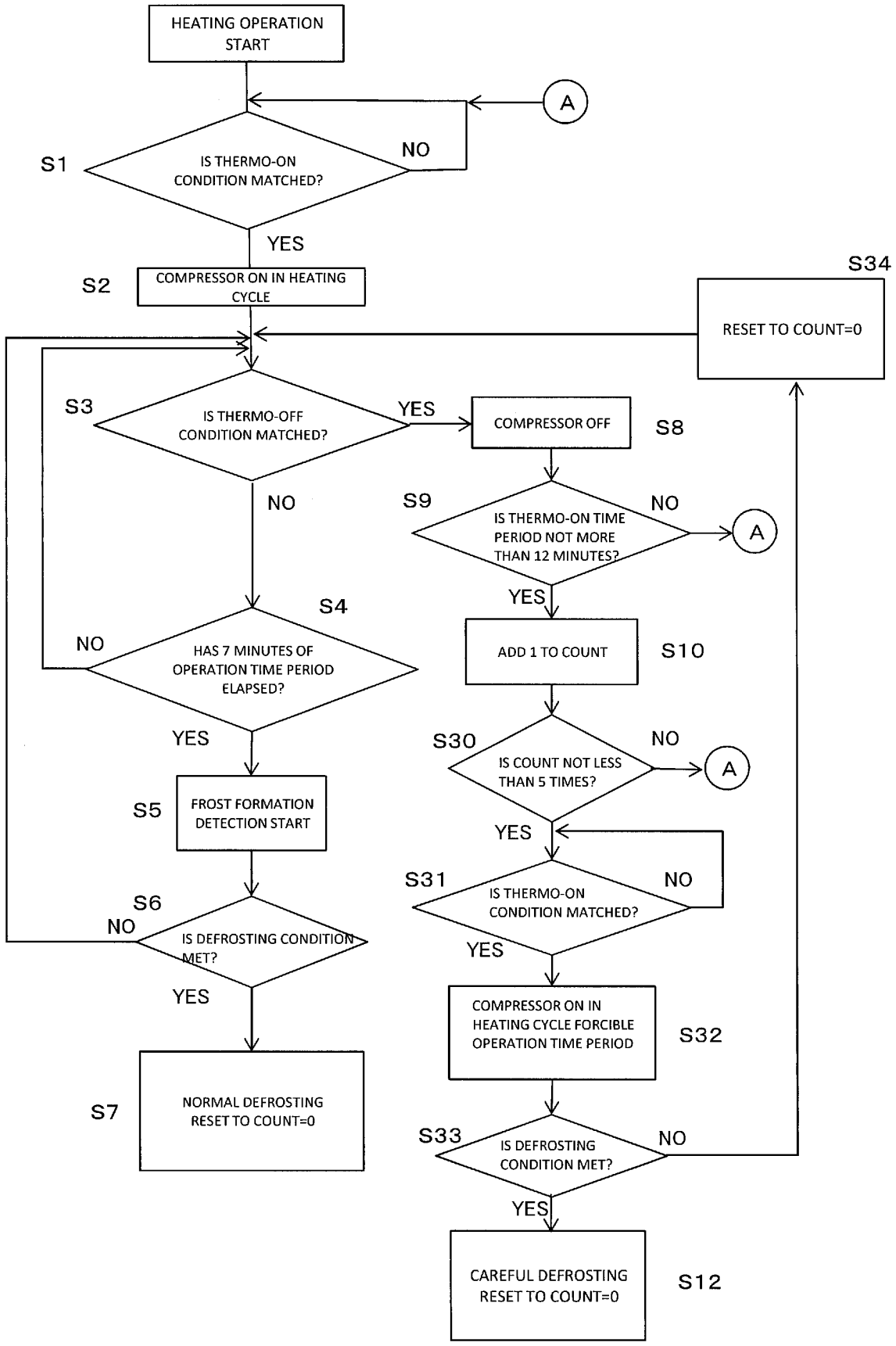
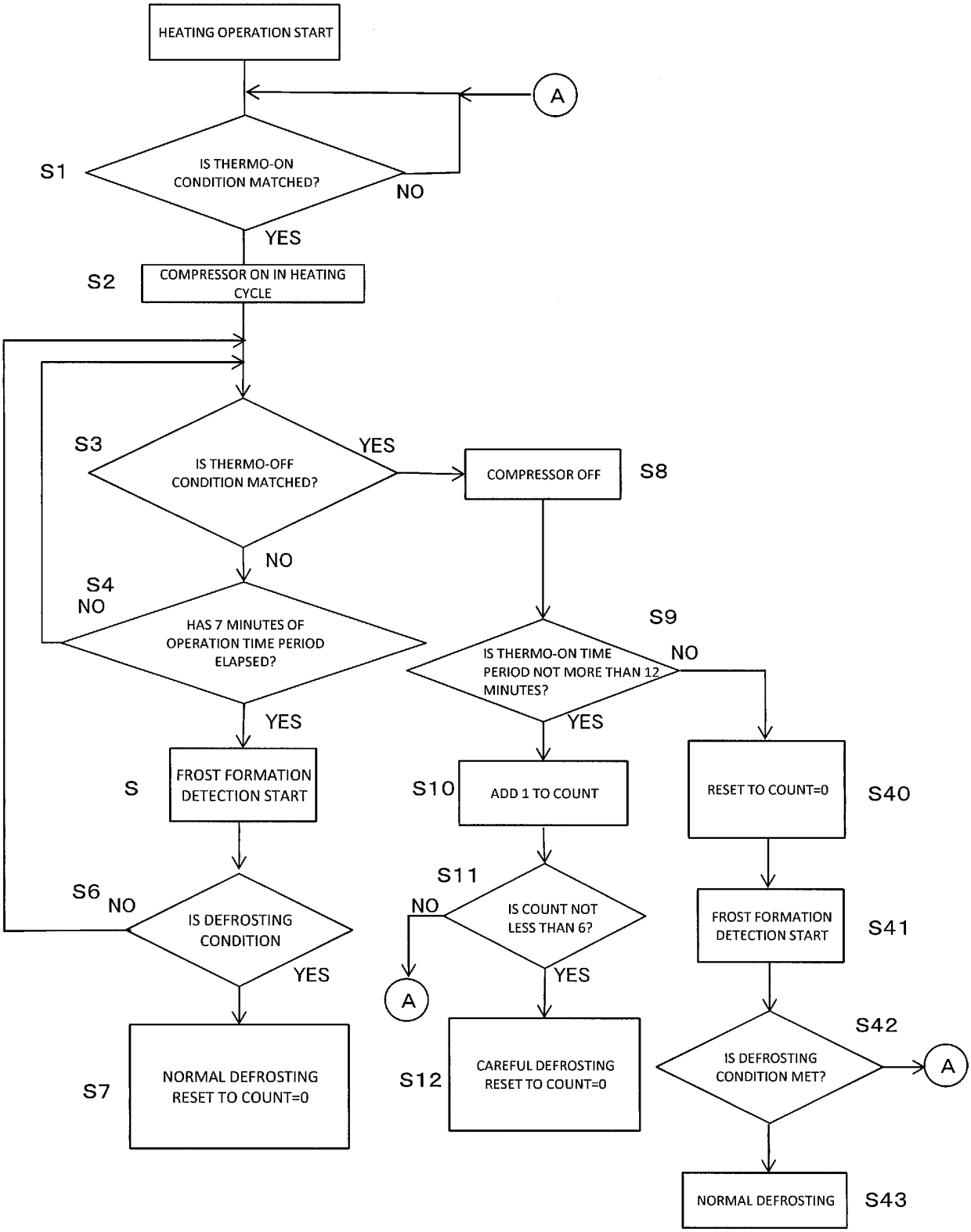

HEATING OPERATION START
A
S1
IS THERMO-ON CONDITION MATCHED?
NO
YES
S2
COMPRESSOR ON IN HEATING CYCLE
S34
RESET TO COUNT=0
S3
IS THERMO-OFF CONDITION MATCHED?
YES
COMPRESSOR OFF
S8
NO
S9
IS THERMO-ON TIME PERIOD NOT MORE THAN 12 MINUTES?
NO
A
YES
S4
NO
HAS 7 MINUTES OF OPERATION TIME PERIOD ELAPSED?
ADD 1 TO COUNT
S10
YES
S30
IS COUNT NOT LESS THAN 5 TIMES?
NO
A
S5
FROST FORMATION DETECTION START
YES
S31
IS THERMO-ON CONDITION MATCHED?
NO
S6
NO
IS DEFROSTING CONDITION MET?
YES
YES
COMPRESSOR ON IN HEATING CYCLE FORCIBLE OPERATION TIME PERIOD
S32
S7
NORMAL DEFROSTING RESET TO COUNT=0
S33
IS DEFROSTING CONDITION MET?
NO
YES
CAREFUL DEFROSTING RESET TO COUNT=0
S12

FIG. 6


HEATING OPERATION START
A
S1
IS THERMO-ON CONDITION MATCHED?
NO
YES
S2
COMPRESSOR ON IN HEATING CYCLE
S3
IS THERMO-OFF CONDITION MATCHED?
YES
COMPRESSOR OFF
S8
NO
S4
NO
HAS 7 MINUTES OF OPERATION TIME PERIOD ELAPSED?
S9
IS THERMO-ON TIME PERIOD NOT MORE THAN 12 MINUTES?
NO
YES
YES
S
FROST FORMATION DETECTION START
S10
ADD 1 TO COUNT
RESET TO COUNT=0
S40
S11
S6
NO
IS DEFROSTING CONDITION
NO
IS COUNT NOT LESS THAN 6?
FROST FORMATION DETECTION START
S41
YES
YES
A
S42
IS DEFROSTING CONDITION MET?
A
S7
NORMAL DEFROSTING RESET TO COUNT=0
S12
CAREFUL DEFROSTING RESET TO COUNT=0
NORMAL DEFROSTING
S43

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/078983

A. CLASSIFICATION OF SUBJECT MATTER
F24F11/02(2006.01)i, *F25B47/02*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24F11/02, F25B47/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2001-280666 A (Daikin Industries, Ltd.), 10 October 2001 (10.10.2001), paragraphs [0037], [0051] to [0071]; fig. 1 to 2 (Family: none)	1-2,4-5 3
Y A	JP 10-267475 A (Fujitsu General Ltd.), 09 October 1998 (09.10.1998), paragraphs [0020] to [0022]; fig. 2 (Family: none)	1-2,4-5 3
Y	JP 2-85629 A (Matsushita Refrigeration Co.), 27 March 1990 (27.03.1990), page 3, upper right column, line 3 to page 3, lower left column, line 15; fig. 1 to 3 (Family: none)	4-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 December 2015 (24.12.15)	12 January 2016 (12.01.16)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/078983

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 3-156268 A (Fujitsu General Ltd.), 04 July 1991 (04.07.1991), page 2, upper right column, line 20 to page 2, lower right column, line 14; fig. 3 (Family: none)	5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 10267475 A **[0004]**