(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 859 231 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
04.08.2021 Bulletin 2021/31

(21) Application number: **18935928.4**

(22) Date of filing: **25.09.2018**

(51) Int Cl.:
F25B 1/00 *(2006.01)* ***F24F 11/86*** *(2018.01)*
F25B 13/00 *(2006.01)* ***F24F 140/00*** *(2018.01)*

(86) International application number:
PCT/JP2018/035477

(87) International publication number:
WO 2020/065730 (02.04.2020 Gazette 2020/14)

(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
Designated Validation States:
KH MA MD TN

(71) Applicant: **Toshiba Carrier Corporation**
Kawasaki-Shi,
Kanagawa 212-8585 (JP)

(72) Inventors:
- **NAGAI, Hiroyuki**
  Fuji-shi, Shizuoka 416-8521 (JP)
- **MIURA, Ken**
  Fuji-shi, Shizuoka 416-8521 (JP)
- **IMATO, Naoki**
  Fuji-shi, Shizuoka 416-8521 (JP)

(74) Representative: **Gramm, Lins & Partner**
Patent- und Rechtsanwälte PartGmbB
Theodor-Heuss-Straße 1
38122 Braunschweig (DE)

(54) **AIR CONDITIONING DEVICE**

(57) A second electric expansion valve in each of one or more indoor units in an operating state of indoor units is opened, and the second electric expansion valve in each of one or more indoor units in an operation stopped state of the indoor units is fully closed. When a refrigeration circulation amount in a refrigeration cycle is insufficient, an opening degree of the second electric expansion valve in each of the one or more indoor units in the operation stopped state is gradually increased.

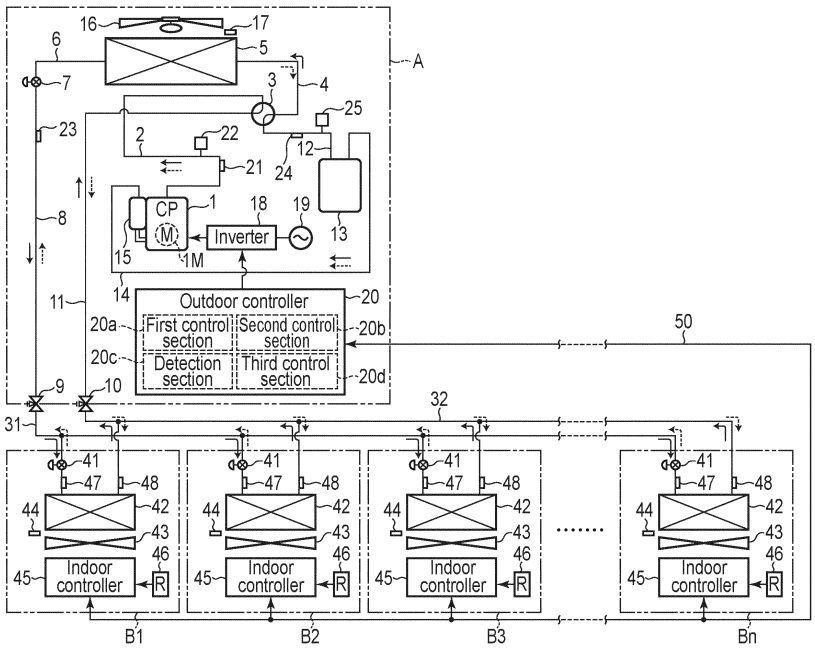

FIG. 1

EP 3 859 231 A1

Description

Technical Field

[0001] Embodiments described herein relate generally to a multi-type air conditioning apparatus comprising at least one outdoor unit and a plurality of indoor units.

Background Art

[0002] A multi-type air conditioning apparatus comprising at least one outdoor unit and a plurality of indoor units comprises a heat pump type refrigeration cycle in which a refrigerant discharged from a compressor passes through a four-way valve, an outdoor heat exchanger, a pressure reducing unit and each indoor heat exchanger and returns to the compressor.

Summary of Invention

Technical Problem

[0003] In the air conditioning apparatus, during a heating operation, a part of the refrigerant may accumulate in the indoor heat exchanger of the stopped indoor unit, and a refrigerant circulation amount in the refrigeration cycle may become insufficient.

[0004] Embodiments described herein aim to provide an air conditioning apparatus which can solve a shortage of a refrigerant circulation amount in a refrigeration cycle.

Solution to Problem

[0005] An air conditioning apparatus of claim 1 comprises: an outdoor unit including a compressor, an outdoor heat exchanger and a first electric expansion valve; a plurality of indoor units each including a second electric expansion valve and an indoor heat exchanger; a refrigeration cycle in which a refrigerant discharged from the compressor flows into each of the indoor heat exchangers, the refrigerant flowing out of each of the indoor heat exchangers flows into the outdoor heat exchanger through each of the second electric expansion valves and the first electric expansion value, and the refrigerant flowing out of the outdoor heat exchanger returns to the compressor, during a heating operation; and a controller which controls operations of the outdoor unit and each of the indoor units. The controller opens the second electric expansion valve in each of one or more indoor units in an operating state of the indoor units, and fully closes the second electric expansion valve in each of one or more indoor units in an operation stopped state of the indoor units. Furthermore, when a refrigerant circulation amount in the refrigeration cycle is insufficient, the controller gradually increases an opening degree of the second electric expansion valve in each of the one or more indoor units in the operation stopped state.

Brief Description of Drawings

[0006]

FIG. 1 is an illustration showing a configuration of one embodiment.
FIG. 2 is a flowchart showing control of one embodiment.
FIG. 3 is a Mollier diagram showing a change of a refrigerant temperature TL in one embodiment.

Mode for Carrying Out the Invention

[0007] One embodiment will be described hereinafter with reference to the accompanying drawings.

[0008] As shown in FIG. 1, a four-way valve 3 is connected to the discharge port of a compressor 1 via a high-pressure side pipe 2, and one end of an outdoor heat exchanger 5 is connected to the four-way valve 3 via a gas side pipe 4. One end of a pressure reducing unit, for example, an electric expansion value (first electric expansion value) 7 is connected to the other end of the outdoor heat exchanger 5 via a liquid side pipe 6, and a packed valve 9 is connected to the other end of the electric expansion value 7 via a liquid side pipe 8. The electric expansion value 7 is a pulse motor valve (PMV) whose opening degree Qo changes according to the number of input driving pulse signals. The opening degree Qo can be changed continuously from a minimum opening degree Qomin (fully closed) corresponding to 0 driving pulse signals pls to a maximum opening degree Qomax (fully open) corresponding to 3000 driving pulse signals pls.

[0009] One ends of a plurality of indoor heat exchangers 42 are connected to the packed valve 9 via a liquid side crossover pipe 31 and a plurality of electric expansion valves (second electric expansion valves) 41, and the other ends of the indoor heat exchangers 42 are connected to a packed valve 10 via a gas side crossover pipe 32. Each electric expansion valve 41 is a pulse motor valve (PMV) whose opening degree Qi changes according to the number of input driving pulse signals. The opening degree Qi can be changed continuously from a minimum opening degree Qimin (fully closed) corresponding to 0 driving pulse signals pls to a maximum opening degree Qimax (fully open) corresponding to 1500 driving pulse signals pls.

[0010] The four-way valve 3 is connected to the packed valve 10 via a gas side pipe 11, and the inflow port of an accumulator 13 is connected to the four-way valve 3 via a low-pressure side pipe 12. A suction cup 15 of the compressor 1 is connected to the outflow port of the accumulator via a low-pressure side pipe 14.

[0011] According to these pipe connections, a heat pump type refrigeration cycle is formed.

[0012] The compressor 1 is a hermetic compressor in which a motor 1M operated by the output of an inverter 18 is accommodated in a hermetically-closed case, and

sucks in a refrigerant flowing out of the accumulator 13 and compresses and discharges the sucked refrigerant. The inverter 18 converts the voltage of an AD power supply 19 into a DC voltage, and converts the DC voltage into a frequency F (referred to as an output frequency F) according to a command from an outdoor controller 20 and an AC voltage having a level corresponding to the frequency F and outputs them. The speed of the motor 1M, that is, the capacity of the compressor 1 changes according to the value of the output frequency F.

[0013] During a cooling operation, as indicated by solid arrows, the refrigerant discharged from the compressor 1 flows into each indoor heat exchanger 42 thorough the four-way valve 3, the outdoor heat exchanger 5, the electric expansion valve 7 and each electric expansion valve 41. The refrigerant flowing out of each indoor heat exchanger 42 is sucked into the compressor 1 through the four-way valve 3 and the accumulator 13. The outdoor heat exchanger 5 functions as a condenser, and each indoor heat exchanger 42 functions as an evaporator.

[0014] During a heating operation, the flow path of the four-way valve 3 is switched, and as indicated by dashed arrows, the refrigerant discharged from the compressor 1 flows into each indoor heat exchanger 42 through the four-way valve 3. The refrigerant flowing out of each indoor heat exchanger 42 is sucked into the compressor 1 through the electric expansion valve 7, the outdoor heat exchanger 5, the four-way valve 3 and the accumulator 13. Each indoor heat exchanger 42 functions as a condenser, and the outdoor heat exchanger 5 functions as an evaporator.

[0015] An outdoor fan 16 which sucks in outdoor air and supplies it to the outdoor heat exchanger 5 is disposed close to the external heat exchanger 5. An outdoor air temperature sensor 17 which detects an outdoor air temperature To is disposed in the flow path of the outdoor air sucked in by the outdoor fan 16. A temperature sensor 21 which detects a high-pressure side refrigerant temperature TD and a pressure sensor 22 which detects a high-pressure side refrigerant pressure PD are attached to the high-pressure side pipe 2 located between the discharge port of the compressor 1 and the four-way valve 3. A temperature sensor 23 which detects a refrigerant temperature TL is attached to the liquid side pipe 8 located between the electric expansion valve 7 and the packed valve 9. A temperature sensor 24 which detects a low-pressure side refrigerant temperature TS and a pressure sensor 25 which detects a low-pressure side refrigerant pressure PS are attached to the low-pressure side pipe 12 located between the four-way valve 3 and the accumulator 13.

[0016] An indoor fan 43 which sucks in indoor air and supplies it to each indoor heat exchanger 42 is disposed close to each indoor heat exchanger 42. An indoor air temperature sensor 44 which detects an indoor temperature Ta is disposed in the flow path of the indoor air sucked in by the indoor fan 43.

[0017] A temperature sensor 47 which detects a temperature TC2 of the refrigerant flowing out of each indoor heat exchanger 42 during the heating operation is attached to the other end of each indoor heat exchanger 42. A temperature sensor 48 which detects a temperature TC1 of the refrigerant flowing into each indoor heat exchanger 42 during the heating operation is attached to one end of each indoor heat exchanger 42. The detection signals of these temperature sensors 47 and 48 are transmitted to each indoor controller 45. A remote control type operator (so-called remote control) 46 for allowing the user to set various operation conditions such as a cooling operation, a dehumidifying operation, a heating operation, an air blowing operation, a target indoor temperature Tas, an operation start and an operation stop is connected to each indoor controller 45.

[0018] The compressor 1, the four-way valve 3, the outdoor heat exchanger 5, the electric expansion valve 7, the packed valves 9 and 10, the accumulator 13, the outdoor fan 16, the inverter 18, the outdoor controller 20, the respective pipes and the respective sensors described above are accommodated in an outdoor unit A. The indoor heat exchanger 42, the outdoor fan 43, the indoor controller 45, the operator 46, the respective pipes and the respective sensors described above are accommodated in each of N indoor units B1, B2, ... , Bn. These outdoor unit A and indoor units B1, B2, ... , Bn constitute a multi-type air conditioning apparatus. In addition, the outdoor controller 20 and each indoor controller 45 are interconnected by a signal line 50 for data transmission.

[0019] The outdoor controller 20 controls the operations of the outdoor unit A and each of the indoor units B1 to Bn by coordinating with each of the indoor controllers 45, and includes a first control section 20a, a second control section 20b, a detection section 20c and a third control section 20d as main functions.

[0020] The first control section 20a executes superheat degree control in which the opening degree Qo of the electric expansion valve 7 is controlled such that a superheat degree SH of the refrigerant in the outdoor heat exchanger (evaporator 5) is set to a target value SHs during the heating operation. The superheat degree SH of the refrigerant corresponds to the difference between the detection temperature TL of the temperature sensor 23 and the detection temperature TS of the temperature sensor 24.

[0021] During the heating operation, the second control section 20b executes subcooling degree control in which the opening degree Qi of the electric expansion valve 41 of each of one or more indoor units in an operating state is operated such that a subcooling degree SC of the refrigerant in the indoor heat exchanger (condenser) 42 of each of the indoor units is set to a target value SCs, and fully closes the electric expansion valve 41 of each of one or more indoor units in an operation stopped state. The difference between a condensation temperature TG of the refrigerant in each indoor heat exchanger 42 and the detection temperature TC2 of each temperature sensor 47 can be obtained as the subcooling de-

gree SC of the refrigerant in each indoor heat exchanger 42. The condensation temperature TG can be obtained by conversion from the refrigerant pressure PD detected by the pressure sensor 22 of the high-pressure side pipe 2. In addition, when the difference between the target indoor temperature Tas of the operator 46 and the detection temperature Ta of the indoor temperature sensor 44 in the indoor unit in the operating state increases and the heating load increases in association with the execution of the subcooling degree control, the second control section 20b reduces the target value SCs with respect to the subcooling degree SC and changes the opening degree Qo of the electric expansion value 7 in the increasing direction, and increases the refrigerant flow amount into the indoor heat exchanger 42 and increases the heating capacity. Furthermore, when the difference between the target indoor temperature Tas of the operator 46 and the detection temperature Ta of the indoor temperature sensor 44 in the indoor unit in the operating state decreases and the heating load decreases in association with the execution of the subcooling degree control, the second control section 20b increases the target value SCs with respect to the subcooling degree SC and changes the opening degree Qo of the electric expansion valve 7 in the decreasing direction, and reduces the refrigerant flow amount into the indoor heat exchanger 42 and reduces the heating capacity.

[0022] The detection section 20c detects the refrigerant circulation amount in the heat pump type refrigeration cycle during the heating operation, more specifically, the detection section 20c detects a shortage rate X (%) of the refrigerant circulation amount.

[0023] When the refrigerant circulation amount detected in the detection section 20c is insufficient, more specifically, when the shortage rate X detected in the detection section 20c is greater than or equal to a threshold value Xs (for example, 30%) and cannot be ignored, the third control section 20d gradually increases the opening degree Qi of the electric expansion valve 41 in each of the one or more indoor units in the operation stopped state from the fully closed state. More specifically, when the shortage rate X detected in the detection section 20c is greater than or equal to the threshold value Xs and the opening degree Qo of the electric expansion valve 7 operated by the superheat degree control of the first control section 20a is greater than or equal to a set value Qos (that is, when the increase of the superheat degree SH associated with the shortage of the refrigerant circulation amount cannot be suppressed by the superheat degree control), the third control section 20d gradually increases the opening degree Qi of the electric expansion valve 41 in each of the one or more indoor units in the operation stopped state by a certain opening degree ΔQ from the fully closed state to an upper limit of a predetermined opening degree Qis (for example, 10% of the maximum opening degree Qimax). The set value Qos corresponds to, for example, an opening degree of 2/3 of the maximum opening degree Qomax. The predetermined opening Qis set as the upper limit prevents unnecessary refrigerant inflow due to excessive opening of the electric expansion valve 41.

[0024] The shortage rate X of the refrigerant circulation amount can be detected using one or more elements of the condensation temperature TG of the refrigerant in the condenser, an evaporation temperature TU of the refrigerant in the evaporator (indoor heat exchanger 42), the temperature TC2 (detection temperature of the temperature sensor 47) of the refrigerant flowing out of the evaporator, and the temperature TL (detection temperature of the temperature sensor 23) flowing into the condenser. The evaporator temperature TU can be obtained by conversion from the detection pressure PS of the pressure sensor 25 in the low-pressure side pipe 12.

[0025] For example, when the refrigerant in the heat pump type refrigeration cycle circulates properly without accumulating in any of the indoor units B1 to Bn and there is no shortage of the refrigeration circulation amount, the liquid side crossover pipe 31 and the liquid side pipes 8 and 9 are filled with the liquid refrigerant, and the liquid refrigerant flows into the outdoor heat exchanger (evaporator) 5. When the refrigerant accumulates in any of the indoor units B1 to Bn and the refrigerant circulation amount in the heat pump type refrigeration cycle becomes insufficient, the liquid refrigerant and the gas refrigerant coexist and flow through the liquid side crossover pipe 31 and the liquid side pipes 8 and 7, and the so-called gas-liquid two-phase refrigerant flows into the outdoor heat exchanger 5.

[0026] When the gas-liquid two-phase refrigerant flows into the outdoor heat exchanger 5, the superheat degree SH of the refrigerant in the outdoor heat exchanger 5 increases, and in order to suppress the increase of the superheat degree SH, the superheat degree control is executed and the opening degree Qo of the electric expansion valve 7 is changed in the increasing direction. However, when the increase of the opening degree Qo of the electric expansion valve 7 continues and the opening degree Qo reaches the maximum opening degree Qomax of the electric expansion valve 7, the increase of the superheat degree SH cannot be suppressed, and the temperature TS of the refrigerant sucked into the compressor 1 increases. When the refrigerant temperature TS increases, the temperature TD (and the pressure PD) of the refrigerant discharged from the compressor 1 increases, and due to high-pressure protection control of the indoor controller 20 against the increase of the refrigerant temperature TD, the output frequency F of the inverter 18 decreases. When the output frequency F decreases, the capacity of the compressor 1 decreases, and the heating capacity in the indoor unit in the operating state decreases accordingly.

[0027] The state of the heat pump type refrigeration cycle when the liquid refrigerant flows into the outdoor heat exchanger 5 is indicated by a solid line in the Mollier diagram of FIG. 3, and the state of the heat pump type refrigeration cycle when the gas-liquid two-phase refrig-

erant flows into the outdoor heat exchanger 5 is indicated by a dashed line in the same Mollier diagram. The refrigerant temperature TL is close to the condensation temperature TG when the liquid refrigerant flows in. On the other hand, the refrigerant temperature TL is a value TL' far from the condensation temperature TG and close to the evaporation temperature TU when the gas-liquid two-phase refrigerant flows in.

[0028] Therefore, the detection section 20c detects where the actual refrigerant temperature TL detected by the temperature sensor 23 is located between the refrigerant temperature TL and the refrigerant temperature TL' in the Mollier diagram as the shortage rate X (%) of the refrigerant circulation amount. That is, the shortage rate is 0% when the actual refrigerant temperature TL is located at the same position as the refrigerant temperature TL in the Mollier diagram, the shortage rate X is 50% when the actual refrigerant temperature TL is located at the middle position between the refrigerant temperature TL and the refrigerant temperature TL' in the Mollier diagram, and the shortage rate X is 100% when the actual refrigerant temperature TL is located at the same position as the refrigerant temperature TL' in the Mollier diagram.

[0029] Next, control executed by the outdoor controller 20 will be described with reference to a flowchart of FIG. 2. Steps S1, S2, and the like in the flowchart are referred to simply as S1, S2, and the like.

[0030] During the heating operation, the outdoor controller 20 controls the opening degree of the electric expansion valve 7 such that the superheat degree SH of the refrigerant in the outdoor heat exchanger (evaporator) 5 is set to the target value SHs (S1). Simultaneously, the outdoor controller 20 controls the opening degree of the electric expansion valve 41 of each of one or more indoor units in the operating state, for example, the indoor units B1 and B2 such that the subcooling degree SC of the refrigerant in the indoor heat exchanger 42 in each of the indoor units is set to the target value Cs, and fully closes the electric expansion valve 41 of each of one or more indoor units in the operation stopped state, for example, the indoor units B3 to Bn (S2).

[0031] Then, the outdoor controller 20 detects the shortage rate X of the refrigerant circulation amount in the heat pump type refrigeration cycle (S3), and determines whether the detected shortage rate X is greater than or equal to the threshold value Xs or not (S4). When the detected shortage rate X is not greater than or equal to the threshold value Xs (NO in S4), the outdoor controller 20 repeats the processes from S1.

[0032] When the detected shortage rate X is greater than or equal to the threshold value Xs (YES in S4), the outdoor controller 20 determines whether the opening degree Qo of the electric expansion valve 7 adjusted by the superheat degree control is greater than or equal to the set value Qos or not (S5). When the opening degree Qo is not greater than or equal to the set value Qos (NO in S5), the outdoor controller 20 repeats the processes from S1.

[0033] When the opening degree Qo is greater than or equal to the set value Qos (YES in S5), on the condition that the opening degree Qi of the electric expansion valve 41 of each of the indoor units B3 to Bn in the operation stopped state is less than the predetermined opening degree Qis (YES in S6), the outdoor controller 20 increases the opening degree Qi of the electric expansion valve 41 of each of the indoor units B3 to Bn by the predetermined opening degree ΔQ (S7). When each fully closed electric expansion valve 41 is opened, the stagnant refrigerant accumulating and liquefied in the indoor heat exchanger 42 of each of the indoor units B3 to Bn flows out to the liquid side crossover pipe 31 and the liquid side pipe 8.

[0034] In association with the increase of the opening degree, the outdoor controller 20 starts a time count t (S8), and determines whether the time count t has reached a certain time ts (for example, 300 seconds) or not (S9). When the time count t is less than the certain time ts (NO in S9), the outdoor controller 20 holds the increased opening degree Qi of the electric expansion valve 41 (S10) and continues the time count t (S8). Then, when the time count t reaches the certain time ts (YES in S9), the outdoor controller 20 detects the shortage rate X of the refrigerant circulation amount again (S3) through the processes of S1 and S2.

[0035] When the detected shortage rate X is greater than or equal to the threshold value Xs regardless of the increase of the opening degree (YES in S4) and the opening degree Qo of the electric expansion valve 7 is greater than or equal to the set value Qos (YES in S5), on the condition that the opening degree Qi of the electric expansion valve 41 of each of the indoor units B3 to Bn in the operation stopped state is less than the predetermined opening degree Qis (YES in S6), the outdoor controller 20 increases the opening degree Qi of the electric expansion valve 41 of each of the indoor units B1 to Bn by the predetermined opening degree ΔQ again (S7). When the opening degree Qi of each fully closed electric expansion valve 41 is further increased, the stagnant refrigerant accumulating and liquefied in the indoor heat exchanger 42 of each of the indoor units B3 to Bn further flows out to the liquid side crossover pipe 31 and the liquid side pipe 8.

[0036] In association with the increase of the opening degree, the outdoor controller 20 starts the time count t over again (S8), and determines whether the time count t has reached the certain time ts or not (S9). When the time count t is less than the certain time ts (NO in S9), the outdoor controller 20 holds the increased opening degree Qi of the electric expansion valve 41 (S10), and continues the time count t (S8). When the time count t reaches the certain time ts (YES in S9), the outdoor controller 20 repeats the detection of the shortage rate X of the refrigerant circulation amount through the processes of S1 and S2 (S3).

[0037] When the opening degree Qi of the electric expansion valve 41 in each of the indoor units B3 to Bn in

the operation stopped state reaches the set value Qis in S6 (YES in S6), the outdoor controller 20 starts the time count t over again without executing the process of increasing the opening degree of S7 (S8).

[0038] As described above, when the refrigerant circulation amount is insufficient, the electric expansion valve 41 of each of the indoor units B3 to Bn in the operation stopped state is opened from the fully closed state and the opening degree Qi is gradually increased at intervals of the certain time ts, and this gradually promotes the outflow of the stagnant refrigerant accumulating in the indoor heat exchanger 42 in each of the outdoor units B3 to Bn. According to the outflow, the gas-liquid two-phase state of the refrigerant in the liquid side crossover pipe 31 and the liquid side pipes 8 and 7 is gradually dissolved.

[0039] When the gas-liquid two-phase refrigerant does not flow into the outdoor heat exchanger 5, an unnecessary increase of the superheat degree SH of the refrigerant in the outdoor heat exchanger 5 can be prevented, and an unnecessary increase of the opening degree Qo of the electric expansion valve 7 due to the superheat degree control can be prevented. In accordance with this, an unnecessary increase of the temperature TS of the refrigerant sucked into the compressor 1 can be avoided, and an unnecessary increase of the temperature TD (and the pressure PD) of the refrigerant discharged from the compressor 1 can be avoided, and consequently, an unnecessary decrease of the output frequency F of the inverter 18 due to the high-pressure protection control can be avoided. As a result, an unnecessary decrease of the heating capacity in the indoor unit in the operating state can be prevented.

[0040] When the opening degree Qi of the electric expansion valve 41 is significantly increased at once, a large amount of refrigerant flows into each of the indoor units B3 to Bn in the operation stopped state at once. However, since the opening degree Qi of the electric expansion valve 41 is gradually increased at intervals of the certain time ts, a large amount of refrigerant does not flow into each of the indoor units B3 to Bn in the operation stopped state at once, and a stable and efficient energy-saving operation of the pump-type refrigeration cycle can be achieved.

[Modification Example]

[0041] In the above-described embodiment, the ratio of the value of the refrigerant temperature TL to the value of the condensation temperature TG is detected as the shortage rate (%) of the refrigerant circulation amount. However, it is not limited to this, and basically, one or more elements of the condensation temperature TG, the evaporation temperature TU, the refrigerant temperature TC2 and the refrigerant temperature TL may be used for detection.

[0042] Since the shortage rate X (%) can also be viewed as a sufficiency rate Y (%) of an opposite concept, the sufficiency rate Y (%) of a concept opposite to the shortage rate X (%) may be detected. The sufficiency rate Y (%) approaches 0% as the shortage of the refrigerant circulation amount increases, and approaches 100% as the shortage of the refrigerant circulation amount decreases. That is, the sufficiency rate Y = 100% when the shortage rate X = 0%, the sufficiency rate Y = 50% when the shortage rate X = 50%, and the sufficiency rate Y = 0% when the shortage rate X is 100%.

[0043] In the above-described embodiment, when the shortage rate X of the refrigerant circulation amount is greater than or equal to the threshold value Xs and the opening degree Qo of the electric expansion valve 7 is greater than or equal to the set value Qos, the control for gradually increasing the opening degree Qi of the electric expansion valve 41 is started. However, the condition that the opening degree Qo of the electric expansion valve 7 is greater than or equal to the set value Qos may be omitted, and the control for gradually increasing the electric expansion valve 41 may be immediately started when the shortage rate X of the refrigerant circulation amount is greater than or equal to the threshold value Xs.

[0044] While certain embodiment and modification example have been described, they have been presented by way of example only, and are not intended to limit the scope of the invention. Indeed, the novel embodiment and modification example described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiment described herein may be made without departing from the spirit of the invention. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the invention.

Reference Signs List

[0045] A···Outdoor unit, B1 to Bn···Indoor units, 1···Compressor, 3···Four-way valve, 5···Outdoor heat exchanger, 7···Electric expansion valve, 16···Outdoor fan, 18 Invertor, 20···Outdoor controller, 41···Electric expansion valve, 42···Indoor heat exchanger, 43···Indoor fan, 45···Indoor controller, and 46···Operator.

Claims

1. An air conditioning apparatus comprising:

an outdoor unit including a compressor, an outdoor heat exchanger and a first electric expansion valve;

a plurality of indoor units each including a second electric expansion valve and an indoor heat exchanger;

a refrigeration cycle in which a refrigerant discharged from the compressor flows into each of the indoor heat exchangers, the refrigerant flowing out of each of the indoor heat exchangers

flows into the outdoor heat exchanger through each of the second electric expansion valves and the first electric expansion value, and the refrigerant flowing out of the outdoor heat exchanger returns to the compressor, during a heating operation; and
a controller which controls operations of the outdoor unit and each of the indoor units, **characterized in that**
the controller opens the second electric expansion valve in each of one or more indoor units in an operating state of the indoor units, and fully closes the second electric expansion valve in each of one or more indoor units in an operation stopped state of the indoor units, and
when a refrigerant circulation amount in the refrigeration cycle is insufficient, the controller gradually increases an opening degree of the second electric expansion valve in each of the one or more indoor units in the operation stopped state.

2. The air conditioning apparatus of claim 1, **characterized in that**

the controller detects a shortage rate of the refrigerant circulation amount in the refrigeration cycle, and
when the detected shortage rate is greater than or equal to a threshold value, the controller gradually increases the opening degree of the second electric expansion valve in each of the one or more indoor units in the operation stopped state.

3. The air conditioning apparatus of claim 1, **characterized in that**

the controller detects a shortage rate of the refrigerant circulation amount in the refrigeration cycle, and
when the detected shortage rate is greater than or equal to a threshold value, the controller gradually increases the opening degree of the second electric expansion valve in the one or more indoor units in the operation stopped state to an upper limit of a predetermined opening degree.

4. The air conditioning apparatus of claim 1, **characterized in that**

the controller controls an opening degree of the first electric expansion valve such that a superheat degree of the refrigerant in the outdoor heat exchanger is set to a target value, and
the controller controls the opening degree of the second electric expansion valve in the one or more indoor units in the operating state of the indoor units such that a subcooling degree of the refrigerant in the indoor heat exchanger in each of the indoor units is set to a target value.

5. The air conditioning apparatus of claim 4, **characterized in that**

the controller detects a shortage rate of the refrigerant circulation amount in the refrigeration cycle, and
when the detected shortage rate is greater than or equal to a threshold value and the opening degree of the first electric expansion valve is greater than or equal to a set value, the controller gradually increases the opening degree of the second electric expansion valve in each of the one or more indoor units in the operation stopped state.

6. The air conditioning apparatus of claim 4, **characterized in that**

the controller detects a shortage rate of the refrigeration circulation amount in the refrigeration cycle, and
when the detected shortage rate is greater than or equal to a threshold value and the opening degree of the first electric expansion valve is greater than or equal to a set value, the controller gradually increases the opening degree of the second electric expansion valve in each of the one or more indoor units in the operation stopped state to an upper limit of a predetermined opening degree.

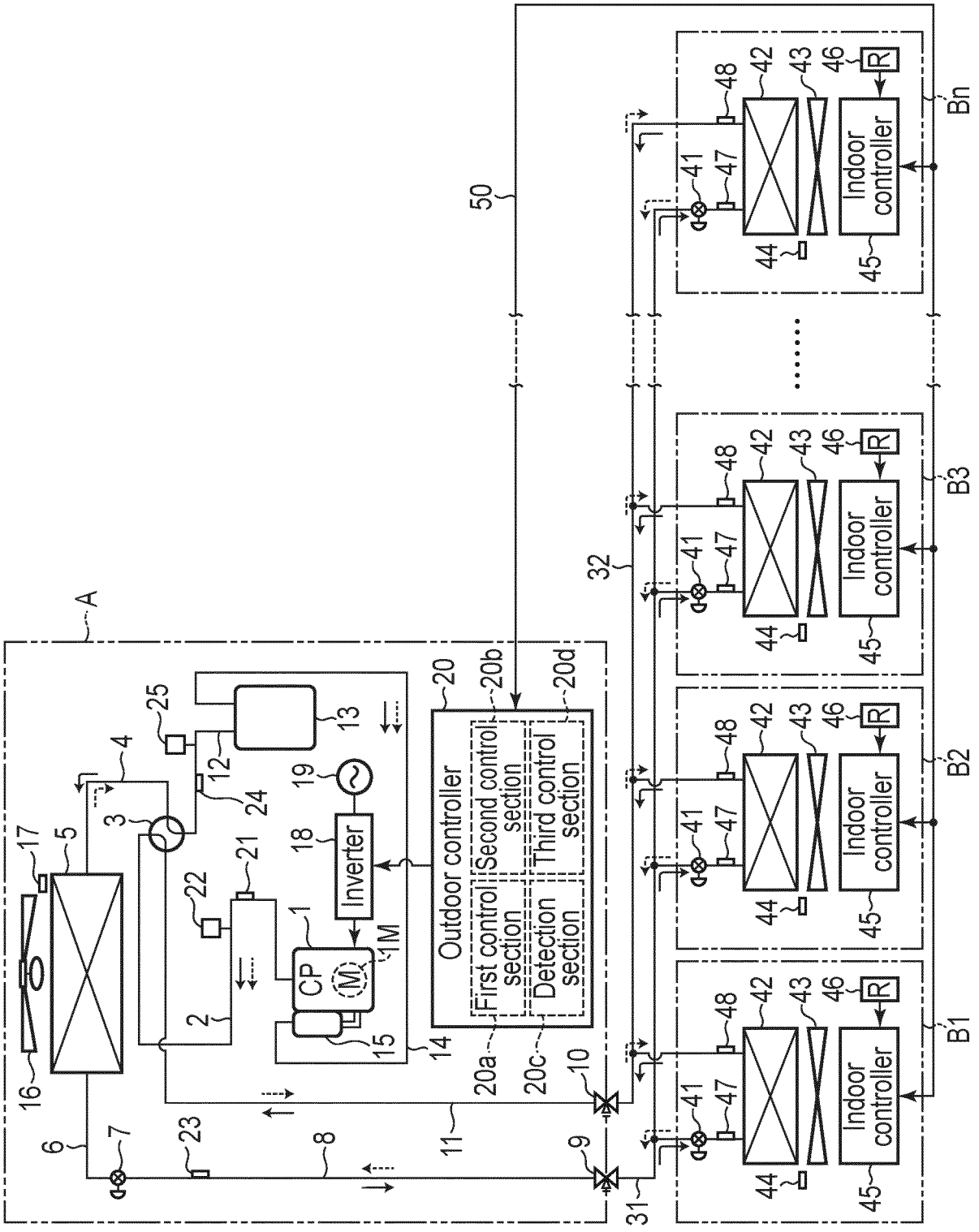
A
B1
B2
B3
Bn
Outdoor controller
First control section
Second control section
Third control section
Detection section
Inverter
CP
1M
Indoor controller
R
50
32
31

FIG. 1

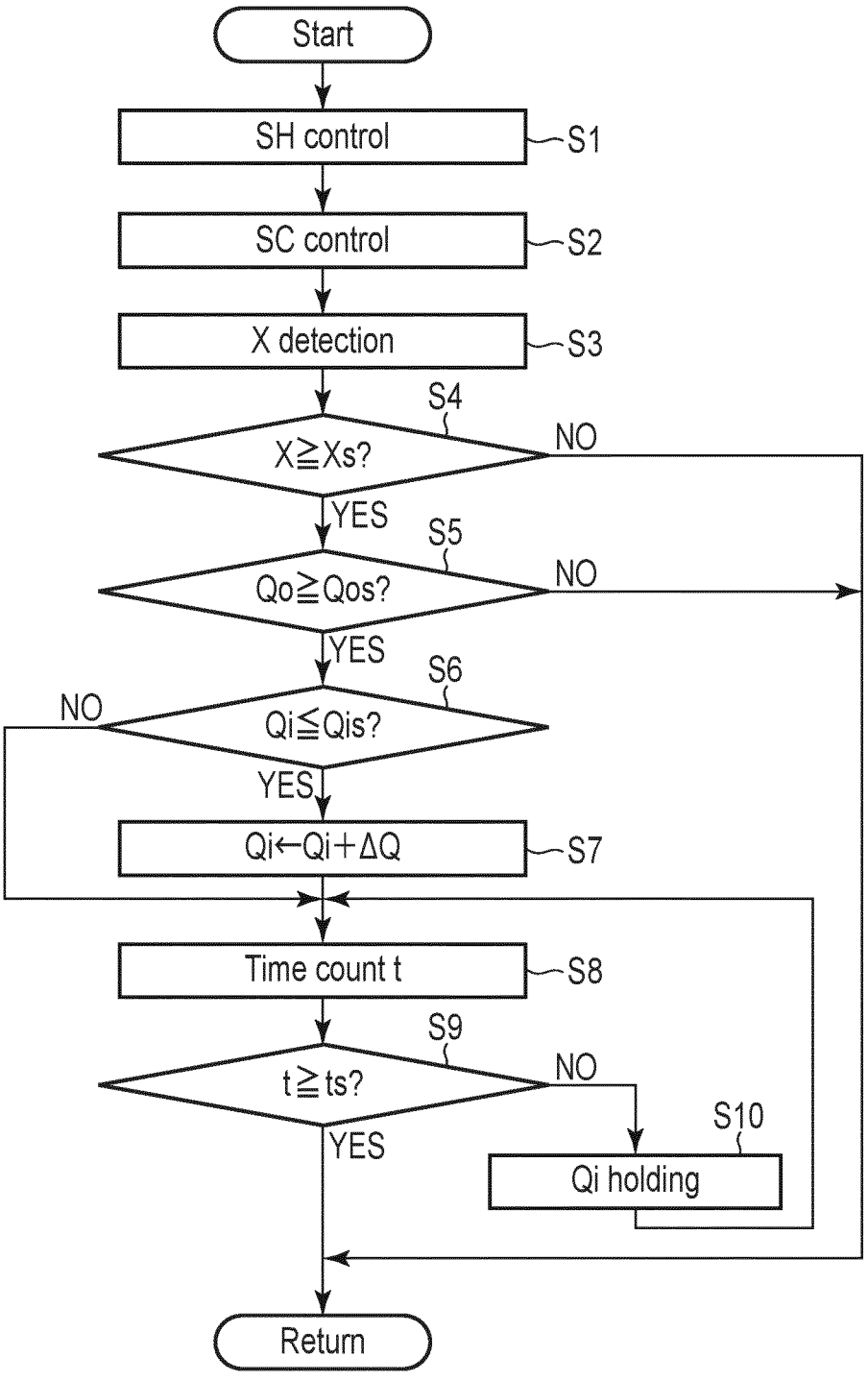
Start
SH control
S1
SC control
S2
X detection
S3
S4
X≧Xs?
NO
YES
S5
Qo≧Qos?
NO
YES
S6
NO
Qi≦Qis?
YES
Qi←Qi+ΔQ
S7
Time count t
S8
S9
t≧ts?
NO
S10
YES
Qi holding
Return

FIG. 2

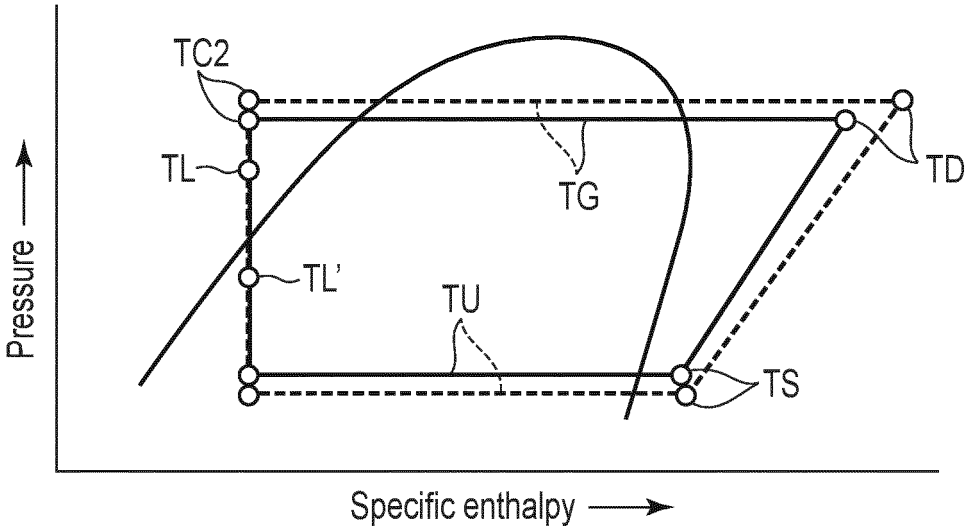

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/035477

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F25B1/00(2006.01)i, F24F11/86(2018.01)i, F25B13/00(2006.01)i, F24F140/00(2018.01)n

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)
Int. Cl. F25B1/00, F24F11/86, F25B13/00, F24F140/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2018
Registered utility model specifications of Japan 1996-2018
Published registered utility model applications of Japan 1994-2018

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	JP 5-312428 A (DAIKIN INDUSTRIES, LTD.) 22 November 1993, paragraphs [0031]-[0063], fig. 1-5 (Family: none)	1-6
Y	JP 2007-315750 A (SANYO ELECTRIC CO., LTD.) 06 December 2007, paragraphs [0007], [0020], [0021], [0055], fig. 1, 2 (Family: none)	1-6
Y	JP 2005-114184 A (HITACHI, LTD.) 28 April 2005, paragraphs [0015], [0016], fig. 3, 4 (Family: none)	2-6

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14.11.2018	27.11.2018
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)