

DESCRIPTION

AIR CONDITIONER

TECHNICAL FIELD

The present invention relates to an air conditioner.

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BACKGROUND ART

Conventionally, an air conditioner including a refrigerant circuit in which a compressor, a condenser, an electric valve, and an evaporator are connected is known. Patent Document 1 (JP 2015-124958 A) describes an air conditioner that reduces the number of rotations of a fan of an indoor unit when a low pressure exceeds an upper limit during a cooling operation under high ambient air.

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SUMMARY OF THE INVENTION

<Technical Problem>

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However, Patent Document 1 (JP 2015-124958 A) does not describe that a refrigerant liquid rapidly accumulating in the condenser is allowed to escape from the condenser when the high pressure rapidly increases during a cooling operation under high ambient air. An object of the present disclosure is to allow a refrigerant liquid rapidly accumulating in a condenser to escape from the condenser.

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<Solution to Problem>

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An air conditioner according to a first aspect of the present disclosure includes a plurality of indoor units that each has an expansion valve and an evaporator, and is individually operated to be turned on or off, an outdoor unit that has a compressor and a condenser, and is connected to the plurality of indoor units, and a control device that controls an opening degree of the expansion valve, in which the control device increases the opening degree of the expansion valve of the indoor unit that is operating, at a time of operating capacity decrease when an entire operating capacity of the plurality of indoor units decreases by a predetermined rate in a predetermined period.

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Therefore, the present disclosure allows the refrigerant liquid rapidly accumulating in the condenser to escape from the condenser.

An air conditioner according to a second aspect of the present disclosure includes a plurality of indoor units that each has an expansion valve and an evaporator, and is individually operated to be turned on or off, an outdoor unit that has a compressor and a condenser, and is connected to the plurality of indoor units, and a control device that controls an opening degree

of the expansion valve, in which the control device increases the opening degree of the expansion valve of the indoor unit that is operating, at a time of operating capacity decrease when an entire operating capacity of the plurality of indoor units decreases by a predetermined rate in a predetermined period and when a high pressure is equal to or higher than a first predetermined value.

In the air conditioner according to a third aspect of the present disclosure, the control device increases the opening degree of the expansion valve in accordance with a differential pressure between the high pressure and a low pressure at the time of operating capacity decrease.

In the air conditioner according to a fourth aspect of the present disclosure, the control device increases the opening degree of the expansion valve in accordance with a degree of subcooling at an outlet of the condenser at the time of operating capacity decrease.

In the air conditioner according to a fifth aspect of the present disclosure, the control device controls the opening degree of the expansion valve such that a degree of superheating at an outlet of the evaporator becomes a target degree of superheating during the normal operation different from a time of operating capacity increase or decrease.

In the air conditioner according to a sixth aspect of the present disclosure, the control device sets the opening degree of the expansion valve to a fully open state at the time of operating capacity decrease.

In the air conditioner according to a seventh aspect of the present disclosure, the control device decreases the operating capacity of the compressor when the high pressure of the air conditioner is equal to or higher than a second pressure.

In the air conditioner according to an eighth aspect of the present disclosure, the control device stops the compressor when the high pressure is equal to or higher than a third pressure.

The air conditioner according to a ninth aspect of the present disclosure is an apparatus exclusive for cooling, and does not have a container that adjusts a refrigerant amount.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a refrigerant system diagram of an air conditioner.

FIG. 2 is a flowchart of an electric valve control during a normal operation.

FIG. 3 is a flowchart of a compressor capacity control during the normal operation.

FIG. 4 is a flowchart of a high-pressure protection control during the normal operation.

FIG. 5 is a flowchart of the electric valve control at a time of refrigerant accumulation.

FIG. 6 is a time chart of the electric valve control at the time of refrigerant accumulation.

FIG. 7 is a flowchart of the electric valve control at a time of high pressure rise.

FIG. 8 is a time chart of the electric valve control at the time of high pressure rise.

5 FIG. 9 is a flowchart of the electric valve control at a time of operating capacity decrease.

FIG. 10 is a time chart of the electric valve control at the time of operating capacity decrease.

10 FIG. 11 is a flowchart of the compressor capacity control at a time of operating capacity increase.

FIG. 12 is time chart of the compressor capacity control at the time of operating capacity increase.

DESCRIPTION OF EMBODIMENT

15 Hereinafter, an embodiment of an air conditioner 100 according to the present disclosure will be described with reference to the drawings. A specific configuration of the air conditioner 100 according to the present disclosure is not limited to the following embodiment, and can be changed without departing from the gist of the disclosure.

<Air conditioner>

20 (1) Overall configuration

An overall configuration of the air conditioner 100 will be described with reference to FIG. 1. The broken lines in FIG. 1 represent electric signal lines. Hereinafter, an upstream side or a downstream side is defined according to a flow direction of a refrigerant.

25 The air conditioner 100 is a device that cools a room in a building or the like by a vapor compression refrigeration cycle. The air conditioner 100 is an apparatus exclusive for cooling. The air conditioner 100 includes an outdoor unit 10, four indoor units 20a, 20b, 20c, and 20d, connection pipes 41 and 42, and a controller 50 as a control device.

(1-1) Outdoor unit

30 The outdoor unit 10 is provided outside a building. The outdoor unit 10 includes a compressor 11, an outdoor heat exchanger 12 as a condenser, and an outdoor fan 13. The compressor 11, the outdoor heat exchanger 12, and the outdoor fan 13 are housed in an outdoor casing (not shown).

The compressor 11 sends out a low-pressure refrigerant gas to be in a high pressure state. A suction pipe 31 is connected to a low pressure side of the compressor 11. A low

pressure sensor 61 is provided near the compressor 11 of the suction pipe 31. A discharge pipe 32 is connected to a high pressure side of the compressor 11. A high pressure sensor 62 and a high pressure cutoff switch 82 are provided near the compressor 11 of the discharge pipe 32.

5 The outdoor heat exchanger 12 exchanges heat between air and the refrigerant, and condenses the refrigerant gas into a refrigerant liquid. The upstream side of the outdoor heat exchanger 12 is connected to the discharge pipe 32. The downstream side of the outdoor heat exchanger 12 is connected to a liquid pipe 33. An outdoor heat exchanger outlet temperature sensor 71 is provided near the outdoor heat exchanger 12 of the liquid pipe 33. That is, the
10 outdoor heat exchanger outlet temperature sensor 71 is provided at an outlet of the outdoor heat exchanger 12.

 The outdoor fan 13 is driven by an electric motor (not shown) and blows air toward the outdoor heat exchanger 12. An outdoor suction air temperature sensor 74 is provided on a suction side of the outdoor fan 13. Specifically, the outdoor suction air temperature sensor
15 74 is provided at an air suction port of the outdoor casing.

 The low pressure sensor 61 detects the refrigerant gas sucked by the compressor 11, that is, a low pressure LP of the air conditioner 100. The high pressure sensor 62 detects the refrigerant gas compressed by the compressor 11, that is, a high pressure HP of the air conditioner 100. The outdoor heat exchanger outlet temperature sensor 71 detects a
20 temperature of the refrigerant liquid at the outlet of the outdoor heat exchanger 12 (outdoor heat exchanger outlet temperature T_{co}). The outdoor suction air temperature sensor 74 detects an indoor suction air temperature T_b of the outdoor unit 10.

 The high pressure cutoff switch 82 stops the air conditioner 100 when the high pressure HP of the air conditioner 100 is equal to or higher than a predetermined value HP_m .

25 (1-2) Indoor unit

 The indoor unit 20a is provided in a room in a building. The indoor unit 20a is connected to the outdoor unit 10 by connection pipes (the liquid pipe 33 and the suction pipe 31). The indoor unit 20a includes an electric valve 21a as an expansion valve, an indoor heat exchanger 22a as an evaporator, an indoor fan 23a, and a remote controller (not shown). The
30 electric valve 21a, the indoor heat exchanger 22a, and the indoor fan 23a are housed in an indoor casing (not shown).

 The electric valve 21a expands the refrigerant liquid into a gas-liquid mixed refrigerant. The electric valve 21a is electrically driven, and is operated to increase or decrease an opening degree. The upstream side of the electric valve 21a is connected to the

connection pipe 41.

The indoor heat exchanger 22a exchanges heat between air and the refrigerant, and evaporates the gas-liquid mixed refrigerant into the refrigerant gas. The downstream side of the indoor heat exchanger 22a is connected to the connection pipe 42. An indoor heat exchanger outlet temperature sensor 72a is provided at the outlet of the indoor heat exchanger 22a.

The indoor fan 23a is driven by an electric motor (not shown) and blows air toward the indoor heat exchanger 22a. An indoor suction air temperature sensor 73a is provided on the suction side of the indoor fan 23a. Specifically, the indoor suction air temperature sensor 73a is provided at the air suction port of the indoor casing.

The remote controller allows a user to input turn-on or turn-off of the indoor unit 20a or a set temperature T_s in the room.

The indoor heat exchanger outlet temperature sensor 72a detects a temperature of the refrigerant gas at the outlet of the indoor heat exchanger 22a (indoor heat exchanger outlet temperature T_{eo}). The indoor suction air temperature sensor 73a detects an indoor suction air temperature T_a of the indoor unit 20a.

The indoor units 20b, 20c, and 20d each have the same configuration as a configuration of the indoor unit 20a and a description thereof will be omitted. Hereinafter, any of the indoor units 20a, 20b, 20c, and 20d is simply referred to as the indoor unit 20. The same applies to the electric valve 21, the indoor heat exchanger 22, the indoor heat exchanger outlet temperature sensor 72, or the indoor suction air temperature sensor 73.

The controller 50 is configured to have a control board (not shown) provided in the outdoor unit 10 and a control board (not shown) provided in the indoor units 20a, 20b, 20c, and 20d, the control boards being communicably connected to each other by wire or wirelessly. Further, the controller 50 includes one or a plurality of CPUs, ROMs, RAMs, and the like.

The controller 50 is connected to the low pressure sensor 61, the high pressure sensor 62, the high pressure cutoff switch 82, the outdoor heat exchanger outlet temperature sensor 71, the electric valve 21, the indoor heat exchanger outlet temperature sensor 72, and the indoor suction air temperature sensor 73, and the remote controller of the indoor unit 20.

The controller 50 has a function of changing a rotation frequency of the compressor 11 and controlling an operating capacity Cap of the compressor 11. The controller 50 has a function of controlling the opening degree of the electric valve 21.

The controller 50 has a function of detecting an operating capacity TON of the indoor unit 20. Here, the indoor unit 20 has a capacity. The operating capacity TON indicates the

capacity of the indoor unit 20 that is operating (with thermo-ON). Note that the operating capacity TON excludes the capacity of the indoor unit 20 with thermo-OFF.

Here, it should be noted that the air conditioner 100 is not provided with a container that adjusts a refrigerant amount, such as a receiver and an accumulator.

5 (1-3) Connection pipe

The connection pipes 41 and 42 connect the outdoor unit 10 and the indoor units 20a, 20b, 20c, and 20d.

(2) Cooling operation

A cooling operation of the air conditioner 100 will be described with reference to FIG.

- 10 1. The cooling operation of only the indoor unit 20a will be described assuming that the indoor units 20b, 20c, and 20d are turned off to help make the description easier to understand.

The high-temperature and high-pressure refrigerant gas compressed by the compressor 11 flows toward the outdoor heat exchanger 12. In the outdoor heat exchanger 12, the high-temperature and high-pressure refrigerant gas is deprived of heat by air and condensed into the refrigerant liquid. The condensed refrigerant liquid flows toward the electric valve 21a.

The refrigerant liquid is expanded into a gas-liquid mixed refrigerant by the electric valve 21a. The gas-liquid mixed refrigerant flows toward the indoor heat exchanger 22a. In the indoor heat exchanger 22a, the gas-liquid mixed refrigerant is given heat by air and is evaporated into a refrigerant gas. The evaporated refrigerant gas is sucked into the compressor 11.

(3-1) Electric valve control during normal operation

An electric valve control S100 during the normal operation will be described with reference to FIG. 2. The normal operation is a cooling operation, which is controlled differently from operations at a time of refrigerant accumulation, at a time of high pressure rise, or at a time of operating capacity decrease to be described below. The electric valve control S100 during the normal operation of only the indoor unit 20a will be described assuming that the indoor units 20b, 20c, and 20d are turned off to help make the description easier to understand.

30 In step S101, the controller 50 detects the indoor heat exchanger outlet temperature T_{eo} by the indoor heat exchanger outlet temperature sensor 72a. In step S102, the controller 50 detects the low pressure LP by the low pressure sensor 61. In step S103, the controller 50 calculates the evaporation temperature T_e from the low pressure LP.

In step S104, the controller 50 calculates a degree of superheating SH at the outlet of

the indoor heat exchanger 22a from the indoor heat exchanger outlet temperature T_{eo} and the evaporation temperature T_e . In step S105, when the degree of superheating SH is lower than a target degree of superheating SH_m set in advance, the controller 50 decreases the opening degree of the electric valve 21a. On the other hand, when the degree of superheating SH is higher than the target degree of superheating SH_m, the controller 50 increases the opening degree of the electric valve 21a.

This configuration allows the air conditioner 100 to operate such that the degree of superheating SH of the indoor heat exchanger 22a becomes the target degree of superheating SH_m during the normal operation. In this way, in the air conditioner 100, a wet operation or an overheat operation of the compressor 11 can be avoided.

(3-2) Compressor operating capacity control during normal operation

A compressor operating capacity control S200 during the normal operation will be described with reference to FIG. 3. The compressor operating capacity control S200 during the normal operation of only the indoor unit 20a will be described assuming that the indoor units 20b, 20c, and 20d are turned off to help make the description easier to understand.

In step S201, the controller 50 detects the indoor suction air temperature T_a by the indoor suction air temperature sensor 73a. In step S202, the controller 50 detects the set temperature T_s set by the remote controller.

In step S203, the controller 50 controls the operating capacity Cap of the compressor 11 on the basis of a difference (heat load) between the indoor suction air temperature T_a and the set temperature T_s . Specifically, when the difference between the indoor suction air temperature T_a and the set temperature T_s is large, the controller 50 increases the operating capacity Cap. When the difference between the indoor suction air temperature T_a and the set temperature T_s is small, the controller 50 decreases the operating capacity Cap.

With this configuration, the operating capacity Cap of the compressor 11 is controlled such that the indoor suction air temperature T_a approaches the set temperature T_s during the normal operation in the air conditioner 100. In this way, in the air conditioner 100, the capacity of the compressor 11 is controlled in a suitable manner for the heat load, and the indoor suction air temperature T_a can be promptly set to the set temperature T_s .

As a modification of the compressor operating capacity control S200 during the normal operation, the operating capacity Cap of the compressor 11 may be controlled such that the evaporation temperature T_e is constant at a target evaporation temperature T_{em} . Specifically, when the evaporation temperature T_e is higher than the target evaporation temperature T_{em} , the operating capacity Cap of the compressor 11 is controlled to increase.

On the other hand, when the evaporation temperature T_e is lower than the target evaporation temperature T_{em} , the operating capacity Cap of the compressor 11 is controlled to decrease. Here, the target evaporation temperature T_{em} is set to decrease as the operating capacity TON of the indoor unit 20 increases, whereas the target evaporation temperature T_{em} is set to increase as the operating capacity TON of the indoor unit 20 decreases.

(3-3) High-pressure protection control

A high-pressure protection control S300 will be described with reference to FIG. 4.

In step S301, the controller 50 detects the high pressure HP by the high pressure sensor 62. In step S302, the controller 50 determines whether the high pressure HP is higher than a predetermined value HP_n . Note that the predetermined value HP_n is less than the predetermined value HP_m set by the high pressure cutoff switch 82.

In step S302, when the high pressure HP is higher than the predetermined value HP_n , the processing proceeds to step S303. When the high pressure HP is equal to or lower than the predetermined value HP_n , the processing returns to S301. In step S303, the controller 50 decreases the operating capacity Cap of the compressor 11.

This configuration allows the high pressure HP to be decreased before the high pressure cutoff switch 82 is activated even when the high pressure HP rises in the air conditioner 100. This can avoid the air conditioner 100 to be stopped by the activation of the high pressure cutoff switch 82.

(3-4) Electric valve control at the time of refrigerant accumulation

An electric valve control S110 at the time of refrigerant accumulation will be described with reference to FIGS. 5 and 6. The electric valve control S110 is a control that secures a cooling capacity during the cooling operation under high ambient air.

(3-4-1) Processing

Processing of the electric valve control S110 will be described with reference to FIG. 5. The processing will be described assuming that the indoor units 20b, 20c, and 20d are turned off to help make the description easier to understand.

In step S111, the controller 50 detects the outdoor heat exchanger outlet temperature T_{co} by the outdoor heat exchanger outlet temperature sensor 71. In step S112, the controller 50 detects the high pressure HP by the high pressure sensor 62. In step S113, the controller 50 calculates a condensation temperature T_c from the high pressure HP .

In step S114, the controller 50 calculates a degree of subcooling SC at the outlet of the outdoor heat exchanger 12 from the outdoor heat exchanger outlet temperature T_{co} and the condensation temperature T_c . In step S115, when the condensation temperature T_c is equal

to or higher than a predetermined temperature T_{c1} set in advance, the controller 50 causes the processing to proceed to step S116. When the condensation temperature T_c is lower than the predetermined temperature T_{c1} , the processing returns to S111.

In step S116, when the degree of subcooling SC is equal to or greater than a predetermined value $SC1$ set in advance, the controller 50 causes the processing to proceed to step S117. When the degree of subcooling SC is less than the predetermined value $SC1$, the processing returns to S111. In step S117 (at a time of refrigerant accumulation), the controller 50 determines that the refrigerant liquid is accumulating in the outdoor heat exchanger 12, and sets the target degree of superheating SH_m in the electric valve control S100 to be low.

(3-4-2) Action

An action of the electric valve control S110 will be described with reference to FIG. 6. In FIG. 6, the action of the electric valve control S110 is represented by time-series changes in the condensation temperature T_c , the degree of subcooling SC at the outlet of the outdoor heat exchanger 12, the target degree of superheating SH_m of the indoor heat exchanger 22a, the opening degree of the electric valve 21a, and the operating capacity Cap of the compressor 11.

Here, it is assumed that the refrigerant liquid accumulates in the outdoor heat exchanger 12, the high pressure HP (condensation temperature T_c) rises, the high-pressure protection control S300 is activated, and the operating capacity Cap of the compressor 11 decreases in the air conditioner 100.

In step S115, the condensation temperature T_c is detected to be equal to or higher than the predetermined temperature T_{c1} . In step S116, the degree of subcooling SC is detected to be equal to or greater than the predetermined value $SC1$. Then, in step S116, it is determined that the refrigerant liquid is accumulating in the outdoor heat exchanger 12, and the target degree of superheating SH_m is set lower than a current level.

At this time, in the air conditioner 100, since the target degree of superheating SH_m is set lower than the current level, the opening degree of the electric valve 21a increases (6a in FIG. 6). Since the opening degree of the electric valve 21a increases, the refrigerant liquid accumulating in the outdoor heat exchanger 12 escapes from the outdoor heat exchanger 12.

When the refrigerant liquid accumulating in the outdoor heat exchanger 12 escapes from the outdoor heat exchanger 12, the condensation temperature T_c decreases (6b in FIG. 6). When the condensation temperature T_c decreases, the high-pressure protection control S300 is released. When the high-pressure protection control S300 is released, the operating capacity Cap of the compressor 11 is increased (6c in FIG. 6).

(3-4-3) Effects

In this way, the air conditioner 100 allows the refrigerant liquid accumulating in the outdoor heat exchanger 12 to escape from the outdoor heat exchanger 12. At the same time, in the air conditioner 100, the high-pressure protection control S300 is avoided, and a decrease
5 in the cooling capacity can be avoided.

(3-5) Electric valve control at the time of high pressure rise

An electric valve control S120 at the time of high pressure rise will be described with reference to FIGS. 7 and 8. The electric valve control S120 is a control that prevents the high pressure cutoff switch 82 from stopping the air conditioner 100 when the high pressure HP
10 rapidly rises in the cooling operation under high ambient air.

(3-5-1) Processing

Processing of the electric valve control S120 will be described with reference to FIG. 7. The processing will be described assuming that the indoor units 20b, 20c, and 20d are turned off to help make the description easier to understand.

15 In step S121, the controller 50 detects the high pressure HP by the high pressure sensor 62. In step S122, when the high pressure HP is equal to or higher than a predetermined value HP2 set in advance, the controller 50 causes the processing to proceed to step S123. When the high pressure HP is less than the predetermined value HP2, the processing returns to S121.

In step S123, when the operating capacity Cap of the compressor 11 is equal to or less
20 than a predetermined value Cap2 set in advance, the controller 50 causes the processing to proceed to step S124. When the operating capacity Cap is greater than the predetermined value Cap2, the processing proceeds to step S125.

In step S124 (at the time of high pressure rise), the controller 50 determines that the refrigerant is rapidly accumulating in the outdoor heat exchanger 12, and increases the opening
25 degree of the electric valve 21a by a predetermined amount. In step S125, the controller 50 decreases the operating capacity Cap of the compressor 11 by a predetermined amount.

(3-5-2) Action

An action of the electric valve control S120 will be described with reference to FIG. 8. In FIG. 8, the action of the electric valve control S120 is represented by time-series changes
30 in the high pressure HP, the operating capacity Cap of the compressor 11, and the opening degree of the electric valve 21a. Here, it is assumed that the refrigerant liquid is rapidly accumulating in the outdoor heat exchanger 12 immediately after an operation start under high ambient air in the air conditioner 100.

In step S122, the high pressure HP is detected to be equal to or higher than the

predetermined value HP2. In step S123, the operating capacity Cap of the compressor 11 is detected to be equal to or less than the predetermined value Cap2. In step S124, it is determined that the refrigerant is rapidly accumulating in the outdoor heat exchanger 12, and the opening degree of the electric valve 21a is increased by a predetermined amount.

5 At this time, in the air conditioner 100, since the opening degree of the electric valve 21a is increased by the predetermined amount, the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 escapes from the outdoor heat exchanger 12. When the refrigerant liquid accumulating in the outdoor heat exchanger 12 escapes from the outdoor heat exchanger 12, the high pressure HP decreases (8a in FIG. 8).

10 (3-5-3) Effects

In this way, the air conditioner 100 allows the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 to escape from the outdoor heat exchanger 12. At the same time, in the air conditioner 100, the activation of the high pressure cutoff switch 82 can be avoided, and the stop of the air conditioner 100 can be avoided.

15 (3-6) Electric valve control at the time of operating capacity decrease

The electric valve control S130 at the time of operating capacity decrease will be described with reference to FIGS. 9 and 10. The electric valve control S130 is a control that avoids a stop of the air conditioner 100 when the operating capacity TON of the indoor unit 20 rapidly decreases and the high pressure HP rapidly rises.

20 (3-6-1) Processing

Processing of the electric valve control S130 will be described with reference to FIG. 9. To help make the description easier to understand, the processing will be described assuming that the indoor units 20a, 20b, 20c, and 20d are turned on, and then the indoor units 20b, 20c, and 20d are turned off.

25 In step S131, the controller 50 detects the operating capacity TON as an operating capacity TON1 (the indoor units 20a, 20b, 20c, and 20d are turned on). In step S132, the controller 50 causes the processing to proceed to step S133 after a predetermined period t3 elapses. In step S133, the controller 50 detects the operating capacity TON as an operating capacity TON2 (the indoor unit 20 is turned on).

30 In step S134, when the operating capacity TON2 is less than the operating capacity TON1, the controller 50 causes the processing to proceed to step S135. When the operating capacity TON2 is equal to or greater than the operating capacity TON1, the processing returns to S131.

In step S135, the controller 50 sets a ratio of the operating capacity TON2 to the

operating capacity TON1, that is, when an operating capacity change rate R as a change rate of the operating capacity TON of the indoor unit 20 in the predetermined period t3 is equal to or lower than a predetermined rate R3, the processing proceeds to step S136. When the operating capacity change rate R is higher than the predetermined rate R3, the processing
5 returns to S131.

In step S136, the controller 50 detects the high pressure HP by the high pressure sensor 62. In step S137, when the high pressure HP is equal to or higher than a predetermined value HP3 set in advance, the controller 50 determines that the refrigerant is rapidly accumulating in the outdoor heat exchanger 12, and causes the processing to proceed to step S138. When the
10 high pressure HP is lower than the predetermined value HP3, the processing returns to S131.

In step S138, the controller 50 detects the low pressure LP by the low pressure sensor 61. In step S139, the controller 50 calculates a differential pressure dP between the high pressure HP and the low pressure LP.

In step S140, the controller 50 calculates the condensation temperature Tc from the
15 high pressure HP. In step S141, the controller 50 detects the outdoor heat exchanger outlet temperature Tco by the outdoor heat exchanger outlet temperature sensor 71. In step S142, the controller 50 calculates the degree of subcooling SC at the outlet of the outdoor heat exchanger 12 from the outdoor heat exchanger outlet temperature Tco and the condensation temperature Tc.

In step S143, the controller 50 increases the opening degree of the electric valve 21a
20 by a predetermined amount ΔEv in accordance with the differential pressure dP and the degree of subcooling SC. Specifically, when the differential pressure dP and the degree of subcooling SC are large, the predetermined amount ΔEv to be increased is large. When the differential pressure dP and the degree of subcooling SC are small, the predetermined amount
25 ΔEv to be increased is small.

(3-6-2) Action

An action of the electric valve control S130 will be described with reference to FIG.
10. In FIG. 10, the action of the electric valve control S130 is represented by time-series changes in the operating capacity TON of the indoor unit 20, the high pressure HP, the
30 differential pressure dP, the degree of subcooling SC of the outdoor heat exchanger 12, and the opening degree of the electric valve 21a.

In step S131, the operating capacity TON is detected as the operating capacity TON1 (the indoor units 20a, 20b, 20c, and 20d are turned on). After t3 elapses, the operating capacity TON is detected as the operating capacity TON2 (the indoor unit 20a is turned on) in

step S133.

In step S134, the operating capacity TON2 is detected to be less than the operating capacity TON1. In step S135, the operating capacity change rate R is detected to be equal to or lower than the predetermined rate R3. At this time, in the air conditioner 100, it is
5 determined that the operating capacity TON of the indoor unit 20 has rapidly decreased.

In step S137, the high pressure HP is detected to be equal to or higher than the predetermined value HP3, and it is determined that the refrigerant is rapidly accumulating in the outdoor heat exchanger 12. In step S143, the opening degree of the electric valve 21a is increased on the basis of the differential pressure dP and the degree of subcooling SC.

10 At this time, in the air conditioner 100, since the opening degree of the electric valve 21a is increased, the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 escapes from the outdoor heat exchanger 12. When the refrigerant liquid accumulating in the outdoor heat exchanger 12 escapes from the outdoor heat exchanger 12, the high pressure HP decreases (10a in FIG. 10).

15 (3-6-3) Effects

In this way, the air conditioner 100 allows the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 to escape from the outdoor heat exchanger 12. At the same time, the activation of the high pressure cutoff switch 82 can be avoided, and the stop of the air conditioner 100 can be avoided.

20 (3-7) Compressor operating capacity control at a time of operating capacity increase

A compressor operating capacity control S210 at the time of operating capacity increase will be described with reference to FIGS. 11 and 12. The compressor operating capacity control S210 is a control that suppresses a rise in the evaporation temperature T_e when the operating capacity TON of the indoor unit 20 rapidly increases and the evaporation
25 temperature T_e rapidly rises.

(3-7-1) Processing

Processing of the compressor operating capacity control S210 will be described with reference to FIG. 11. To help make the description easier to understand, the processing will be described assuming that only the indoor unit 20a is turned on, and then the indoor units 20b,
30 20c, and 20d are turned on.

In step S211, the controller 50 detects the operating capacity TON of the indoor unit 20 as an operating capacity TON3 (the indoor unit 20a is turned on). In step S212, the controller 50 causes the processing to proceed to step S213 after a predetermined period t_4 elapses. In step S213, the controller 50 detects the operating capacity TON as an operating

capacity TON4 (the indoor units 20a, 20b, 20c, and 20d are turned on).

In step S214, when the operating capacity TON4 is greater than the operating capacity TON3, the controller 50 causes the processing to proceed to step S215. When the operating capacity TON4 is equal to or less than the operating capacity TON3, the processing returns to
5 S211.

In step S215, a ratio of the operating capacity TON4 to the operating capacity TON3, that is, when the operating capacity change rate R as the change rate of the operating capacity TON of the indoor unit 20 in the predetermined period t4 is equal to or higher than a predetermined rate R4, the controller 50 determines that the operating capacity TON of the
10 indoor unit 20 has rapidly increased, and causes the processing to proceed to step S216. When the operating capacity change rate R is lower than the predetermined rate R4, the processing returns to S211.

In step S216, the controller 50 detects indoor suction air temperatures Taa, Tab, Tac, and Tad by the indoor suction air temperature sensors 73a, 73b, 73c, and 73d. Here, an
15 average value of the indoor suction air temperatures Taa, Tab, Tac, and Tad of the operating indoor units 20a, 20b, 20c, and 20d is an indoor suction air temperature average Ta-ave.

In step S217, the controller 50 increases the operating capacity Cap of the compressor 11 by a predetermined amount ΔCap in accordance with the increased operating capacity TON and the indoor suction air temperature average Ta-ave.

20 Here, the increased operating capacity TON is the operating capacity TON4 detected in step S213.

Specifically, when the operating capacity TON and the indoor suction air temperature average Ta-ave are large, the predetermined amount ΔCap to be increased is large. When the operating capacity TON and the indoor suction air temperature average Ta-ave are small, the
25 predetermined amount ΔCap to be increased is small.

In other words, when the controller 50 determines that the operating capacity TON of the indoor unit 20 has rapidly increased, the controller 50 comes out of the compressor operating capacity control S200 during the normal operation (including control of the operating capacity Cap of the compressor 11 on the basis of the evaporation temperature Te), a feed-
30 forward control is performed to increase the operating capacity Cap of the compressor 11 in accordance with the operating capacity TON and the indoor suction air temperature average Ta-ave.

(3-7-2) Action

An action of the compressor operating capacity control S210 will be described with

reference to FIG. 12. Note that, in FIG. 12, the action of the compressor operating capacity control S210 is represented by time-series changes in the operating capacity TON of the indoor unit 20, the indoor suction air temperature T_a , the operating capacity Cap of the compressor 11, and the evaporation temperature T_e .

5 In step 211, the operating capacity TON is detected as the operating capacity TON3 (the indoor unit 20a is turned on). After t_4 elapses, in step S213, the operating capacity TON is detected as the operating capacity TON4 (the indoor units 20a, 20b, 20c, and 20d are turned on). At this time, in the air conditioner 100, it is determined that the operating capacity TON of the indoor unit 20 has rapidly increased.

10 In step 216, the indoor suction air temperature T_a is detected. In step S217, the operating capacity Cap of the compressor 11 is increased by the predetermined amount ΔCap on the basis of the operating capacity TON and the indoor suction air temperature T_a .

At this time, in the air conditioner 100, since the operating capacity Cap of the compressor 11 is increased by the predetermined amount ΔCap , the low pressure LP decreases, and a rise in the evaporation temperature T_e is suppressed (12a in FIG. 12). By suppressing the rise in the evaporation temperature T_e , a decrease in a heat exchange efficiency of the indoor heat exchanger 22 is avoided.

(3-7-3) Effect

20 In this way, in the air conditioner 100, the decrease in the heat exchange efficiency of the indoor heat exchanger 22 can be avoided.

<Characteristics>

(1)

25 In the air conditioner 100, when the operating capacity TON of the indoor unit 20 is small, excessive refrigerant is generated. The generated excessive refrigerant accumulates in the outdoor heat exchanger 12. For example, when the operating capacity Cap of the compressor 11 rapidly decreases under high ambient air (e.g., when the number of operating indoor units 20 decreases), the refrigerant liquid rapidly accumulates in the outdoor heat exchanger 12.

30 When the refrigerant liquid rapidly accumulates in the outdoor heat exchanger 12, the high pressure HP of the air conditioner 100 rapidly rises. At this time, in the air conditioner 100, the activation of the high-pressure protection control S300 may not catch up, and the high pressure cutoff switch 82 may be activated. When the high pressure cutoff switch 82 is activated, the air conditioner 100 stops.

The air conditioner 100 includes a plurality of the indoor units 20 that each has the

electric valve 21 and the indoor heat exchanger 22, and is individually operated to be turned on or off, the outdoor unit 10 that has the compressor 11 and the outdoor heat exchanger 12, and is connected to the plurality of indoor units 20, and the controller 50 that controls the opening degree of the electric valve 21, in which the controller 50 increases the opening degree of the electric valve 21 of the indoor unit 20 that is operating, at the time of operating capacity decrease when an entire operating capacity TON of the plurality of indoor units 20 decreases by the predetermined rate R3 in the predetermined period t3.

This configuration allows the opening degree of the electric valve 21 to increase when the operating capacity TON of the indoor unit 20 decreases by the predetermined rate R3 in the predetermined period t3 in the air conditioner 100. At this time, the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 flows from the outdoor heat exchanger 12 toward the indoor heat exchanger 22.

In this way, the air conditioner 100 allows the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 to escape from the outdoor heat exchanger 12.

(2)

The air conditioner 100 includes the plurality of indoor units 20 that each has the electric valve 21 and the indoor heat exchanger 22, and is individually operated to be turned on or off, the outdoor unit 10 that has the compressor 11 and the outdoor heat exchanger 12, and is connected to the plurality of indoor units 20, and the controller 50 that controls the opening degree of the electric valve 21, in which the controller 50 increases the opening degree of the electric valve 21 of the indoor unit 20 that is operating, at the time of operating capacity decrease when the entire operating capacity TON of the plurality of indoor units 20 decreases by the predetermined rate in the predetermined period and when the high pressure HP is equal to or higher than the predetermined value HP3 as a first predetermined value.

This configuration allows the opening degree of the electric valve 21 to increase when the operating capacity TON of the indoor unit 20 decreases by the predetermined rate R3 in the predetermined period t3 in the air conditioner 100 and when the high pressure HP is equal to or greater than the predetermined value HP3. At this time, the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 flows from the outdoor heat exchanger 12 toward the indoor heat exchanger 22.

In this way, the air conditioner 100 allows the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 to escape from the outdoor heat exchanger 12.

(3)

In the air conditioner 100, the controller 50 increases the opening degree of the electric

valve 21 in accordance with the differential pressure dP between the high pressure HP and the low pressure LP at the time of operating capacity decrease.

This configuration allows the opening degree of the electric valve 21 to increase in accordance with the differential pressure dP between the high pressure HP and the low pressure

5 LP in the air conditioner 100

In this way, the air conditioner 100 allows the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 to escape from the outdoor heat exchanger 12.

(4)

In the air conditioner 100, the controller 50 increases the opening degree of the electric
10 valve 21 in accordance with the degree of subcooling SC at the outlet of the outdoor heat exchanger 12 at the time of operating capacity decrease.

This configuration allows the opening degree of the electric valve 21 to increase in accordance with the degree of subcooling SC at the outlet of the outdoor heat exchanger 12 in the air conditioner 100.

15 In this way, the air conditioner 100 allows the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 to escape from the outdoor heat exchanger 12.

(5)

In the air conditioner 100, the controller 50 controls the opening degree of the electric valve 21 such that the degree of superheating SH at the outlet of the indoor heat exchanger 22
20 becomes the target degree of superheating SHm during the normal operation different from the time of operating capacity decrease.

This configuration allows the air conditioner 100 to operate such that the degree of superheating SH of the indoor heat exchanger 22 becomes the target degree of superheating SHm during the normal operation.

25 In this way, in the air conditioner 100, the wet operation or the overheat operation of the compressor 11 can be prevented.

(6)

In the air conditioner 100, the controller 50 sets the opening degree of the electric valve 21 to a fully open state at the time of operating capacity decrease.

30 This configuration allows the opening degree of the electric valve 21 to be set to the fully open state when the opening degree of the electric valve 21 is increased in the air conditioner 100.

In this way, the air conditioner 100 allows the refrigerant liquid rapidly accumulating in the outdoor heat exchanger 12 to escape from the outdoor heat exchanger 12.

(7)

In the air conditioner 100, the controller 50 decreases the operating capacity Cap of the compressor 11 when the high pressure HP of the air conditioner 100 is equal to or higher than the predetermined value HPn as a second predetermined value.

5 This configuration in the air conditioner 100 decreases the high pressure HP before the high pressure cutoff switch 82 is activated.

This can prevent the air conditioner 100 from being stopped by the activation of the high pressure cutoff switch 82.

(8)

10 In the air conditioner 100, the controller 50 stops the compressor 11 when the high pressure HP is equal to or higher than the predetermined value HPm as a third predetermined value.

In this way, in the air conditioner 100, a pipe or a container can be prevented from being damaged.

15 (9)

The air conditioner 100 is an apparatus exclusive for cooling, and does not have a container that adjusts a refrigerant amount.

<Modifications>

(1)

20 In step S135 of the electric valve control S130, when the controller 50 determines that the operating capacity change rate R is equal to or lower than the predetermined rate R3, the opening degree of the electric valve 21a may be increased, assuming that the refrigerant liquid rapidly accumulates in the condenser 12 and the high pressure HP rapidly rises.

(2)

25 In steps s135 and S136 of the electric valve control S130, when the controller 50 determines that the operating capacity change rate R is equal to or lower than the predetermined rate R3, the opening degree of the electric valve 21a may be increased, assuming that the refrigerant liquid rapidly accumulates in the condenser 12 and the high pressure HP rapidly rises.

30 (3)

In step S143 of the electric valve control S130, the controller 50 increases the opening degree of the electric valve 21a on the basis of the differential pressure dP and the degree of subcooling SC. However, the opening degree of the electric valve 21a may be increased, for example, in accordance with the operating capacity change rate R.

(4)

In step S143 of the electric valve control S130, the controller 50 increases the opening degree of the electric valve 21a on the basis of the differential pressure dP and the degree of subcooling SC. However, the opening degree of the electric valve 21a may be increased on the basis of only the differential pressure dP. Alternatively, the opening degree of the electric valve 21a may be increased on the basis of only the degree of subcooling SC.

In step S143 of the electric valve control S130, the controller 50 increases the opening degree of the electric valve 21a by the predetermined amount. However, the opening degree of the electric valve 21a may be in a fully open state.

The electric valve control S130 is applied during the cooling operation of the apparatus exclusive for cooling. However, the electric valve control S130 may be applied during a heating operation of an air conditioner capable of cooling and heating.

INDUSTRIAL APPLICABILITY

The present invention can be utilized for an air conditioner.

REFERENCE SIGNS LIST

10	Outdoor unit
11	Compressor
20	12 Outdoor heat exchanger (condenser)
13	Outdoor fan
20	Indoor unit
21	Electric valve (expansion valve)
22	Indoor heat exchanger (evaporator)
25	31 Suction pipe
32	Discharge pipe
33	Liquid pipe
50	Controller (control device)
61	Low pressure sensor
30	62 High pressure sensor
71	Outdoor heat exchanger outlet temperature sensor
72	Indoor heat exchanger outlet temperature sensor
73	Indoor suction air temperature sensor
74	Outdoor suction air temperature sensor

- 82 High pressure cutoff switch
100 Air conditioner

CITATION LIST

5 PATENT LITERATURE

<Patent Document 1> JP 2015-124958 A

CLAIMS

1. An air conditioner (100) comprising:
 - a plurality of indoor units (20) that each has an expansion valve (21) and an evaporator (22), and is individually operated to be turned on or off;
 - 5 an outdoor unit (10) that has a compressor (11) and a condenser (12), and is connected to the plurality of indoor units (20); and
 - a control device (50) that controls an opening degree of the expansion valve (21),
 - wherein the control device (50) increases the opening degree of the expansion valve (21) of the indoor unit (20) that is operating, at a time of operating capacity decrease when an
 - 10 entire operating capacity of the plurality of indoor units (20) decreases by a predetermined rate in a predetermined period.
2. An air conditioner (100) comprising:
 - a plurality of indoor units (20) that each has an expansion valve (21) and an evaporator (22), and is individually operated to be turned on or off;
 - 15 an outdoor unit (10) that has a compressor (11) and a condenser (12), and is connected to the plurality of indoor units (20); and
 - a control device (50) that controls an opening degree of the expansion valve (21),
 - wherein the control device (50) increases the opening degree of the expansion valve (21) of the indoor unit (20) that is operating at a time of operating capacity decrease when an
 - 20 entire operating capacity of the plurality of indoor units (20) decreases by a predetermined rate in a predetermined period, and when a high pressure is equal to or higher than a first predetermined value.
3. The air conditioner (100) according to claim 1 or 2, wherein the control device (50) increases the opening degree of the expansion valve (21) in accordance with a differential
- 25 pressure between a high pressure and a low pressure at the time of operating capacity decrease.
4. The air conditioner (100) according to any one of claims 1 to 3, wherein the control device (50) increases the opening degree of the expansion valve (21) in accordance with a degree of subcooling at an outlet of the condenser (12) at the time of operating capacity decrease.
5. The air conditioner (100) according to any one of claims 1 to 4, wherein the control device
- 30 (50) controls the opening degree of the expansion valve (21) such that a degree of superheating at an outlet of the evaporator (22) becomes a target degree of superheating during a normal operation different from the time of operating capacity decrease.
6. The air conditioner (100) according to any one of claims 1 to 5, wherein the control device (50) sets the opening degree of the expansion valve (21) to a fully open state at the time of

operating capacity decrease.

7. The air conditioner (100) according to any one of claims 1 to 6, wherein the control device (50) decreases the operating capacity of the compressor (11) when a high pressure is equal to or higher than a second predetermined value.
- 5 8. The air conditioner (100) according to any one of claims 1 to 7, wherein the control device (50) stops the compressor (11) when a high pressure is equal to or higher than a third predetermined value.
9. The air conditioner (100) according to any one of claims 1 to 8, wherein the air conditioner (100) is an apparatus exclusive for cooling, and does not have a container that adjusts a
10 refrigerant amount.