



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.08.2024 Bulletin 2024/34

(51) International Patent Classification (IPC):
F25B 41/20 ^(2021.01)

(21) Application number: **24157571.1**

(52) Cooperative Patent Classification (CPC):
F25B 41/20; F25B 13/00; F25B 41/42;
F25B 2313/0233; F25B 2400/075

(22) Date of filing: **14.02.2024**

(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 ME MK MT NL
NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(72) Inventors:
• **MIURA, Ken**
Shizuoka 4168521 (JP)
• **SAKAMOTO, Junichi**
Shizuoka 4168521 (JP)
• **SHIMIZU, Katsuhiko**
Shizuoka 4168521 (JP)

(30) Priority: **16.02.2023 JP 2023022083**

(74) Representative: **Gramm, Lins & Partner**
Patent- und Rechtsanwälte PartGmbH
Frankfurter Straße 3c
38122 Braunschweig (DE)

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

(54) **AIR CONDITIONING APPARATUS**

(57) An air conditioning apparatus configured to execute an air conditioning operation including cooling and heating by circulating R32 as refrigerant through a refrigerant pipe connecting an outdoor unit (11) and an indoor unit (12) to each other, the outdoor unit including a compressor (18), an outdoor heat exchanger (20), and an expansion mechanism (21), the indoor unit including an indoor heat exchanger (31), the air conditioning apparatus including a plurality of the compressors (18A,18B), and a plurality of check valves (24A,24B) respectively provided in discharge pipes respectively connected to the plurality of the compressors. Each of the plurality of check valves is configured to have a valve diameter per air conditioning capacity of the compressor, which is set in a range of $\Phi 0.21$ mm/kW to $\Phi 0.42$ mm/kW.

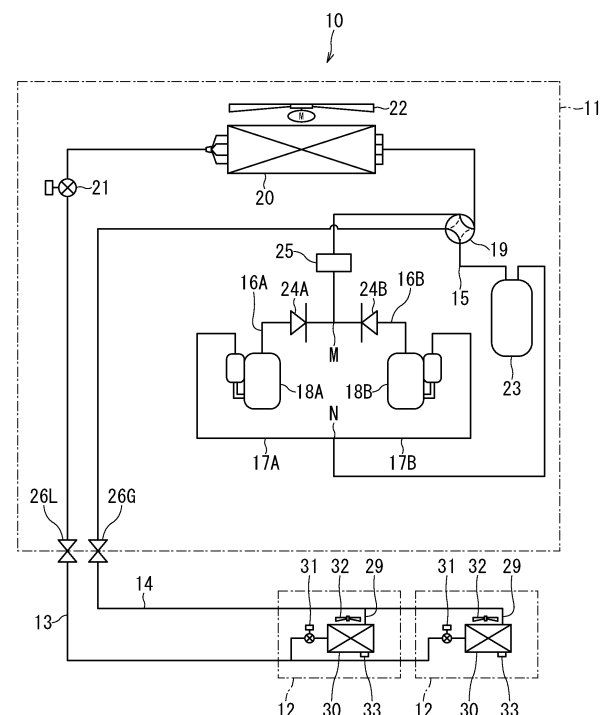


FIG. 1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] An embodiment of the present invention relates to an air conditioning apparatus including a plurality of compressors and check valves respectively provided in discharge pipes respectively connected to those compressors.

Description of the Related Art

[0002] As an air conditioning apparatus configured to execute an air conditioning operation including cooling and heating operations by circulating refrigerant through a refrigerant pipe connecting an outdoor unit including a compressor, an outdoor heat exchanger, and an outdoor expansion valve and an indoor unit including an indoor heat exchanger to each other, there are some types in which a plurality of the compressors is installed. In a discharge pipe connected to each of those compressors, a check valve is disposed in order to prevent backflow of discharge gas refrigerant from the compressor.

[0003] When the refrigerant is changed from R410A to R32 in the air conditioning apparatus, in the check valve provided in the discharge pipe connected to the compressor, a difference in density of the refrigerant causes reduction in a flow rate. Thus, there is a possibility that an own weight of a valve body of the check valve and a resistance caused by flow of the refrigerant are balanced with each other to cause chattering of repeatedly opening and closing the valve in a short period of time. In particular, when a plurality of compressors is present, in the check valves provided to correspond to the respective compressors, a discharge pressure of another compressor mutually acts as a counter pressure, and thus there is a high possibility of occurrence of the chattering.

SUMMARY OF THE INVENTION

[0004] An embodiment of the present invention has been made in consideration of the above-mentioned circumstance, and has an object to provide an air conditioning apparatus with which chattering of check valves respectively provided in discharge pipes respectively connected to a plurality of compressors can be suppressed.

[0005] An air conditioning apparatus according to an embodiment of the present invention is an air conditioning apparatus configured to execute an air conditioning operation including cooling and heating by circulating R32 as refrigerant through a refrigerant pipe connecting an outdoor unit and an indoor unit to each other, the outdoor unit including a compressor, an outdoor heat exchanger, and an expansion mechanism, the indoor unit including an indoor heat exchanger, the air conditioning

apparatus comprising: a plurality of the compressors; and a plurality of check valves respectively provided in discharge pipes respectively connected to the plurality of the compressors, in which each of the plurality of check valves is configured to have a valve diameter per air conditioning capacity of the compressor, which is set in a range of $\Phi 0.21$ mm/kW to $\Phi 0.42$ mm/kW.

[0006] An air conditioning apparatus according to another embodiment of the present invention is an air conditioning apparatus configured to execute an air conditioning operation including cooling and heating by circulating R32 as refrigerant through a refrigerant pipe connecting an outdoor unit and an indoor unit to each other, the outdoor unit including a compressor, an outdoor heat exchanger, and an expansion mechanism, the indoor unit including an indoor heat exchanger, the air conditioning apparatus comprising: a plurality of the compressors; and a plurality of check valves respectively provided in discharge pipes respectively connected to the plurality of the compressors, in which each of the plurality of check valves is configured to have a flow coefficient Cv per air conditioning capacity of the compressor, which is set in a range of 0.105/kW to 0.21 /kW.

[0007] According to the embodiments of the present invention, the chattering of the check valves provided in the discharge pipes respectively connected to the plurality of compressors can be suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is a system diagram illustrating a configuration of an air conditioning apparatus according to a first embodiment.

Fig. 2 is a sectional view illustrating a check valve of Fig. 1.

Fig. 3 is a view illustrating a state in which a plurality of discharge pipes in each of which the check valve is disposed are joined and connected to each other, in which Fig. 3A is a perspective view in a case in which a joining angle θ is 90 degrees and Fig. 3B is a perspective view in a case in which the joining angle θ is 180 degrees; and

Fig. 4 is a system diagram illustrating a configuration of an air conditioning apparatus according to a second embodiment.

DETAILED DESCRIPTION

[0009] Embodiments of the present invention are hereinafter described with reference to the drawings.

[A] First Embodiment (Fig. 1 to Fig. 3)

[0010] Fig. 1 is a system diagram illustrating a configuration of an air conditioning apparatus according to a first embodiment. In an air conditioning apparatus 10 illustrated in Fig. 1, an outdoor unit 11 and a plurality of indoor units 12 are connected to each other by a liquid refrigerant connection pipe 13 and a gas refrigerant connection pipe 14 so that refrigerant is circulated there-through. The air conditioning apparatus 10 thus executes an air conditioning operation including cooling and heating operations.

[0011] The outdoor unit 11 includes a plurality of compressors (for example, two compressors 18A and 18B), a four-way valve 19, an outdoor heat exchanger 20, an outdoor expansion valve 21 serving as an outdoor expansion mechanism, an outdoor fan 22, an accumulator 23, a plurality of check valves (for example, two check valves 24A and 24B), an oil separator 25, a liquid-side packed valve 26L, and a gas-side packed valve 26G.

[0012] Further, this outdoor unit 11 includes an outdoor refrigerant pipe 15 including a plurality of discharge pipes (for example, discharge pipes 16A and 16B) and a plurality of suction pipes (for example, suction pipes 17A and 17B). The plurality of discharge pipes and the plurality of suction pipes are respectively connected to the plurality of compressors 18A and 18B. The check valve 24A is disposed in the discharge pipe 16A, and the check valve 24B is disposed in the discharge pipe 16B. Further, the oil separator 25, the four-way valve 19, the outdoor heat exchanger 20, and the outdoor expansion valve 21 are disposed in order in the outdoor refrigerant pipe 15 on the downstream side from a joining point M of the discharge pipes 16A and 16B. Further, the accumulator 23 is disposed on the upstream side of a branching point N of the outdoor refrigerant pipe 15 from which the suction pipes 17A and 17B branch.

[0013] The compressors 18A and 18B are configured such that their discharge capacities of gas refrigerant are changeable by controlling their operation frequencies by, for example, an inverter. Further, the check valve 24A causes discharge gas refrigerant from the compressor 18A to flow only in the direction of the oil separator 25 and the four-way valve 19, and the check valve 24B causes discharge gas refrigerant from the compressor 18B to flow only in the direction of the oil separator 25 and the four-way valve 19, to thereby prevent backflow. Moreover, the oil separator 25 separates refrigerating machine oil from the discharge gas refrigerant discharged from each of the compressors 18A and 18B, and returns the refrigerating machine oil to each of the compressors 18A and 18B.

[0014] The four-way valve 19 is a valve for switching the flow of the refrigerant. At the time of a cooling operation, the four-way valve 19 causes the outdoor heat exchanger 20 to function as a condenser and causes an indoor heat exchanger 30 (described later) to function as an evaporator. At the time of the cooling operation, as

indicated by the solid lines of Fig. 1, the four-way valve 19 causes a discharge side of each of the compressors 18A and 18B and a gas side of the outdoor heat exchanger 20 to connect to each other, and causes a suction side of each of the compressors 18A and 18B (that is, the accumulator 23) and the gas-side packed valve 26G (that is, the gas refrigerant connection pipe 14) to connect to each other. Further, at the time of a heating operation, the four-way valve 19 causes the indoor heat exchanger 30 to function as the condenser and causes the outdoor heat exchanger 20 to function as the evaporator. At the time of this heating operation, as indicated by the broken lines of Fig. 1, the four-way valve 19 causes the discharge side of each of the compressors 18A and 18B and the gas-side packed valve 26G (that is, the gas refrigerant connection pipe 14) to connect to each other, and causes the suction side of each of the compressors 18A and 18B (that is, the accumulator 23) and the gas side of the outdoor heat exchanger 20 to connect to each other.

[0015] The outdoor heat exchanger 20 includes a heat transfer pipe and a large number of fins, and, as described above, functions as the condenser at the time of the cooling operation and functions as the evaporator at the time of the heating operation. This outdoor heat exchanger 20 has a gas side connected to the four-way valve 19, and a liquid side connected to the liquid-side packed valve 26L (that is, the liquid refrigerant connection pipe 13).

[0016] The outdoor expansion valve 21 is configured to adjust an amount of refrigerant flowing into the outdoor heat exchanger 20 in order to adjust a pressure and a flow rate of refrigerant flowing inside of the outdoor refrigerant pipe 15. The outdoor expansion valve 21 is connected to the liquid side of the outdoor heat exchanger 20. It is preferred that this outdoor expansion valve 21 be an electronic expansion valve whose valve opening degree is easily adjustable.

[0017] The outdoor fan 22 sucks external air into the outdoor unit 11, and, after the external air is subjected to heat exchange with the refrigerant in the outdoor heat exchanger 20, discharges the external air to the outside of the outdoor unit 11. This outdoor fan 22 is a fan capable of changing an air volume of the external air to be supplied to the outdoor heat exchanger 20.

[0018] The accumulator 23 is a container disposed in the outdoor refrigerant pipe 15 between the four-way valve 19 and each of the compressors 18A and 18B so as to store excessive refrigerant generated in the outdoor refrigerant pipe 15. This accumulator 23 separates liquid refrigerant and gas refrigerant from each other to cause each of the compressors 18A and 18B to suck only the gas refrigerant.

[0019] The liquid-side packed valve 26L is a valve provided at a connection port with the liquid refrigerant connection pipe 13 which is a pipe outside of the outdoor unit 11, and is connected to the outdoor expansion valve 21. Further, the gas-side packed valve 26G is a valve provided at a connection port with the gas refrigerant

connection pipe 14 which is a pipe outside of the outdoor unit 11, and is connected to the four-way valve 19.

[0020] Each of the plurality of indoor units 12 includes an indoor refrigerant pipe 29 connected to the liquid refrigerant connection pipe 13 and the gas refrigerant connection pipe 14. In this indoor refrigerant pipe 29, the indoor heat exchanger 30 and an indoor expansion valve 31 serving as an indoor expansion mechanism are sequentially disposed. Moreover, each of the indoor units 12 has an indoor fan 32 provided near the indoor heat exchanger 30, and also includes a room temperature sensor 33 or the like.

[0021] The indoor heat exchanger 30 is a heat exchanger including a heat transfer tube and a large number of fins. The indoor heat exchanger 30 functions as the evaporator at the time of the cooling operation to cool indoor air, and functions as the condenser at the time of the heating operation to heat the indoor air. Further, the indoor expansion valve 31 is configured to adjust an amount of refrigerant flowing into the indoor heat exchanger 30 in order to adjust, a flow rate or the like of refrigerant flowing inside of the indoor refrigerant pipe 29, and is connected to a liquid side of the indoor heat exchanger 30. It is preferred that this indoor expansion valve 31 be an electronic expansion valve whose valve opening degree is easily adjustable.

[0022] The indoor fan 32 sucks the indoor air into the indoor unit 12, and, after this sucked air is subjected to heat exchange with the refrigerant in the indoor heat exchanger 30, supplies the sucked air into a room. Further, the room temperature sensor 33 is provided on an air inflow side of the indoor heat exchanger 30, and measures the temperature of the indoor air flowing into the indoor unit 12.

[0023] In the above-mentioned outdoor unit 11 and indoor unit 12, the compressors 18A and 18B, the four-way valve 19, the outdoor heat exchanger 20, and the outdoor expansion valve 21 of the outdoor unit 11, the indoor expansion valve 31 and the indoor heat exchanger 30 of the indoor unit 12, and the accumulator 23 of the outdoor unit 11 form a refrigeration cycle by circulating the refrigerant therethrough. The refrigerant flowing through this refrigeration cycle is preferred to be a mixed refrigerant containing R32 serving as a refrigerant type of less than 30%.

[0024] Next, the cooling operation and the heating operation which are the air conditioning operation of the air conditioning apparatus 10 are described.

(A) Cooling Operation

[0025] At the time of the cooling operation, the four-way valve 19 is brought into a state indicated by the solid lines of Fig. 1, that is, the discharge side of each of the compressors 18A and 18B is connected to the gas side of the outdoor heat exchanger 20, and the suction side of each of the compressors 18A and 18B is connected to a gas side of the indoor heat exchanger 30 via the gas-

side packed valve 26G and the gas refrigerant connection pipe 14.

[0026] In this state, when the compressors 18A and 18B, the outdoor fan 22, and the indoor fan 32 are activated, low-pressure gas refrigerant is sucked into each of the compressors 18A and 18B to be compressed and becomes high-pressure gas refrigerant. After that, the high-pressure gas refrigerant is sent to the outdoor heat exchanger 20 via the four-way valve 19, and is condensed through heat exchange with the external air supplied by the outdoor fan 22 so as to become high-pressure liquid refrigerant. This high-pressure liquid refrigerant is sent to the indoor unit 12 via the liquid refrigerant connection pipe 13.

[0027] The high-pressure liquid refrigerant sent to the indoor unit 12 is decompressed by the indoor expansion valve 31 to have a pressure close to the suction pressure of the compressors 18A and 18B, and becomes low-pressure gas-liquid two-phase state refrigerant to be sent to the indoor heat exchanger 30. In this indoor heat exchanger 30, the refrigerant is subjected to heat exchange with the indoor air to cool the indoor air and is evaporated to become low-pressure gas refrigerant.

[0028] This low-pressure gas refrigerant is sent to the outdoor unit 11 via the gas refrigerant connection pipe 14, and flows into the accumulator 23 via the four-way valve 19. This low-pressure gas refrigerant that has flowed into the accumulator 23 is sucked into each of the compressors 18A and 18B again.

(B) Heating Operation

[0029] At the time of the heating operation, the four-way valve 19 is brought into a state indicated by the broken lines of Fig. 1, that is, the discharge side of each of the compressors 18A and 18B is connected to the gas side of the indoor heat exchanger 30 via the gas-side packed valve 26G and the gas refrigerant connection pipe 14, and the suction side of each of the compressors 18A and 18B is connected to the gas side of the outdoor heat exchanger 20.

[0030] In this state, when the compressors 18A and 18B, the outdoor fan 22, and the indoor fan 32 are activated, low-pressure gas refrigerant is sucked into each of the compressors 18A and 18B to be compressed, and becomes high-pressure gas refrigerant to be sent to the indoor unit 12 via the four-way valve 19 and the gas refrigerant connection pipe 14.

[0031] The high-pressure gas refrigerant sent to the indoor unit 12 is subjected to, in the indoor heat exchanger 30, heat exchange with the indoor air to heat the indoor air and is condensed to become high-pressure liquid refrigerant. After that, when this refrigerant passes through the indoor expansion valve 31, a flow rate thereof is adjusted in accordance with a valve opening degree of this indoor expansion valve 31.

[0032] The refrigerant that has passed through the indoor expansion valve 31 is sent to the outdoor unit 11

via the liquid refrigerant connection pipe 13, and is decompressed via the outdoor expansion valve 21. After that, the refrigerant flows into the outdoor heat exchanger 20. This low-pressure gas-liquid two-phase state refrigerant that has flowed into the outdoor heat exchanger 20 is subjected to heat exchange with external air supplied by the outdoor fan 22 to be evaporated to become low-pressure gas refrigerant, and flows into the accumulator 23 via the four-way valve 19. This low-pressure gas refrigerant that has flowed into the accumulator 23 is sucked into each of the compressors 18A and 18B again.

[0033] Now, the check valves 24A and 24B, the discharge pipes 16A and 16B, and the compressors 18A and 18B in the above-mentioned air conditioning apparatus 10 are further described in detail.

[0034] Each of the check valves 24A and 24B is configured such that, as illustrated in Fig. 2, a valve seat 36 is fixed inside of a valve casing 35, and a valve body 37 can move toward and away from this valve seat 36. Each of the check valves 24A and 24B is closed by the valve body 37 abutting against the valve seat 36 by its own weight. Further, each of the check valves 24A and 24B is opened by the valve body 37 being separated away from the valve seat 36 when the discharge gas refrigerant from each of the compressors 18A and 18B flows through a valve port 38 of the valve seat 36. In those check valves 24A and 24B, a valve diameter d (that is, a diameter of the valve port 38) per air conditioning capacity of each of the compressors 18A and 18B is set in a range of $\Phi 0.21 \text{ mm/kW}$ to $\Phi 0.42 \text{ mm/kW}$. In this case, Φ represents a diameter.

[0035] For example, when the air conditioning capacity of the outdoor unit 11 in which two compressors 18A and 18B having a same capacity are installed is set to 67.2 kW, the air conditioning capacity per each of the compressors 18A and 18B is 33.6 kW. Accordingly, the valve diameter d of each of the check valves 24A and 24B is in a range of $\Phi 0.21 \text{ mm/kW} \times 33.6 \text{ kW} \approx \Phi 7.0 \text{ mm}$ or more and $\Phi 0.42 \text{ mm/kW} \times 33.6 \text{ kW} \approx \Phi 14 \text{ mm}$ or less. In this case, kW refers to an air conditioning (cooling) capacity at the time of a cooling rated condition described in a catalog or the like, and may be alternatively read as HP assuming that $2.8 \text{ kW} = 1 \text{ HP}$.

[0036] According to results of experiments performed in advance, in a case in which the valve diameter d of each of the check valves 24A and 24B is more than $\Phi 14 \text{ mm}$ (for example, $d = \Phi 16 \text{ mm}$), particularly when the operation frequencies of the compressors 18A and 18B are low, in the check valve 24A, the discharge pressure from another compressor 18B acts as a counter pressure, and, in the check valve 24B, the discharge pressure from another compressor 18A acts as a counter pressure. Thus, chattering of repeatedly opening and closing the check valves 24A and 24B in a short period of time occurs. Further, there were obtained such experiment results that, in a case in which the valve diameter d of each of the check valves 24A and 24B was small, such as $\Phi 12 \text{ mm}$ or $\Phi 14 \text{ mm}$, no chattering occurred due to the above-

mentioned counter pressures in the check valves 24A and 24B.

[0037] Further, when the valve diameter d of each of the check valves 24A and 24B is less than $\Phi 7.0 \text{ mm}$, a pressure loss of each of the check valves 24A and 24B increases to cause rise of the discharge pressure of each of the compressors 18A and 18B, and hence the performance of the air conditioning apparatus 10 is greatly reduced.

[0038] The operation frequencies of the compressors 18A and 18B illustrated in Fig. 1 are set to be different to have a difference from the viewpoint of suppressing the above-mentioned chattering in the check valves 24A and 24B. For example, when the operation frequency of the compressor 18A is higher and the operation frequency of the compressor 18B is lower, in the check valve 24A on the compressor 18A side (that is, in the check valve 24A disposed in the discharge pipe 16A connected to the compressor 18A), the discharge pressure acting as a counter pressure from the compressor 18B having a lower operation frequency is reduced, and hence occurrence of the chattering is suppressed. Further, in the check valve 24B on the compressor 18B side (that is, in the check valve 24B disposed in the discharge pipe 16B connected to the compressor 18B), the discharge pressure from the compressor 18A having a higher operation frequency acts as a counter pressure, but the check valve 24B opens by the discharge pressure caused by the compressor 18B after an elapse of a predetermined time period. No chattering occurs also in this case.

[0039] As illustrated in Fig. 1, the discharge pipes 16A and 16B are joined each other at the joining point M, but the joining angle θ is set to 90 degrees or less as illustrated in Fig. 3A from the viewpoint of suppressing the chattering of the check valves 24A and 24B. As illustrated in Fig. 3B, when the joining angle θ of the discharge pipes 16A and 16B is set to 180 degrees, gas refrigerants discharged from the respective compressors 18A and 18B have a head-on collision. Accordingly, the check valve 24A is easily influenced by the discharge pressure acting as a counter pressure from the compressor 18B, and the check valve 24B is easily influenced by the discharge pressure acting as a counter pressure from the compressor 18A. As a result, in the check valves 24A and 24B, the chattering is caused by the counter pressures.

[0040] In contrast, as illustrated in Fig. 3A, when the joining angle θ of the discharge pipes 16A and 16B is set to 90 degrees, the head-on collision of the gas refrigerants discharged from the respective compressors 18A and 18B is avoided. Thus, the check valve 24A is less influenced by the discharge pressure acting as a counter pressure from the compressor 18B, and the check valve 24B is less influenced by the discharge pressure acting as a counter pressure from the compressor 18A. As a result, in the check valves 24A and 24B, it is possible to suppress the chattering to be caused by the counter pressures.

[0041] With the above-mentioned configuration, ac-

According to this first embodiment, the following effects (1) to (5) are provided.

(1) In the check valve 24A, the valve diameter d per air conditioning capacity of the compressor 18A is set to $\Phi 0.42$ mm/kW or less, and hence the influence of the discharge pressure from another compressor 18B acting as the counter pressure can be reduced. Further, in the check valve 24B, the valve diameter d per air conditioning capacity of the compressor 18B is set to $\Phi 0.42$ mm/kW or less, and hence the influence of the discharge pressure from another compressor 18A acting as the counter pressure can be reduced. From those points, in the check valves 24A and 24B, the occurrence of the chattering due to the above-mentioned counter pressures can be suppressed.

(2) The valve diameter d per air conditioning capacity of each of the compressors 18A and 18B in each of the check valves 24A and 24B is set to $\Phi 0.21$ mm/kW or more, and hence the pressure loss of each of the check valves 24A and 24B is reduced, and no rise of the discharge pressure of each of the compressors 18A and 18B is caused. As a result, the performance of the air conditioning apparatus 10 can be satisfactorily ensured.

(3) The plurality of compressors 18A and 18B are set to have different operation frequencies to provide a difference in operation frequency. Accordingly, for example, the discharge pressure as a counter pressure acting on the check valve 24A from the compressor 18B having a lower operation frequency is reduced, and hence the occurrence of the chattering in the check valve 24A can be further suppressed. Further, even when the check valve 24B is closed by the discharge pressure from the compressor 18A having a higher operation frequency acting as a counter pressure, the check valve 24B is opened by the discharge pressure from the compressor 18B having a lower operation frequency after an elapse of a predetermined time period, and no chattering of repeatedly opening and closing the valve in a short period of time occurs.

(4) The joining angle θ of the discharge pipes 16A and 16B respectively connected to the plurality of compressors 18A and 18B is set to 90 degrees or less. Accordingly, in each of the plurality of check valves 24A and 24B, the influence of the discharge pressure acting as a counter pressure from another compressor (from the compressor 18B in the check valve 24A and from the compressor 18A in the check valve 24B) can be reduced, and hence the occurrence of the chattering due to the counter pressure can be more suppressed.

(5) The refrigerant flowing through the air conditioning apparatus 10 is a mixed refrigerant containing R32 serving as a refrigerant type of less than 30%. Accordingly, R32 as the refrigerant has a GWP (global warming potential) of 675, and the GWP is low. Accordingly, the air conditioning apparatus 10 can adopt low-GWP refrigerant by using the mixed refrigerant having the content of R32 of less than 30%.

[B] Second Embodiment (Fig. 4)

[0042] Fig. 4 is a system diagram illustrating a configuration of an air conditioning apparatus according to a second embodiment. In this second embodiment, parts similar to those of the first embodiment are denoted by the same reference symbols as the first embodiment, and description thereof is simplified or omitted.

[0043] An outdoor unit 41 of an air conditioning apparatus 40 according to this second embodiment is different from the first embodiment in that a check valve 42A is disposed in the discharge pipe 16A and a check valve 42B is disposed in the discharge pipe 16B. The check valve 42A causes the discharge gas refrigerant from the compressor 18A to flow only in the direction of the oil separator 25 and the four-way valve 19, and the check valve 42B causes the discharge gas refrigerant from the compressor 18B to flow only in the direction of the oil separator 25 and the four-way valve 19, to thereby prevent backflow. Moreover, in each of the check valves 42A and 42B, a flow coefficient C_v per air conditioning capacity of each of the compressors 18A and 18B is set in a range of 0.105/kW to 0.21/kW.

[0044] For example, when the air conditioning capacity of the outdoor unit 41 in which two compressors 18A and 18B having a same capacity are installed is set to 67.2 kW, the air conditioning capacity per each of the compressors 18A and 18B is 33.6 kW. Accordingly, the flow coefficient C_v of each of the check valves 42A and 42B is in a range of $0.105/\text{kW} \times 33.6 \text{ kW} \approx 3.5$ or more and $0.21/\text{kW} \times 33.6 \text{ kW} \approx 7.0$ or less. In this case, kW refers to an air conditioning (cooling) capacity at the time of a cooling rated condition described in a catalog or the like, and may be alternatively read as HP assuming that 2.8 kW=1 HP.

[0045] According to results of experiments performed in advance, in a case in which flow coefficient C_v of each of the check valves 42A and 42B exceeds 7.0 (for example, $C_v=9.0$), particularly when the operation frequencies of the compressors 18A and 18B are low, in the check valve 42A, the discharge pressure from another compressor 18B acts as a counter pressure, and in the check valve 24B, the discharge pressure from another compressor 18A acts as a counter pressure. Thus, chattering of repeatedly opening and closing the check valves 42A and 42B in a short period of time occurs. Further, there were obtained such experiment results that, when the flow coefficient C_v of each of the check valves 42A and 42B was small, such as 6.0 or 7.0, no chattering occurred

due to the above-mentioned counter pressures in the check valves 42A and 42B.

[0046] Further, when the flow coefficient C_v of each of the check valves 42A and 42B is less than 3.5, the pressure loss of each of the check valves 42A and 42B increases to cause rise of the discharge pressure of each of the compressors 18A and 18B, and hence the performance of the air conditioning apparatus 40 is greatly reduced.

[0047] With the above-mentioned configuration, according to this second embodiment, effects similar to the effects (3) to (5) of the first embodiment are provided, and further the following effects (6) and (7) are provided.

[0048] (6) In the check valve 42A, the flow coefficient C_v per air conditioning capacity of the compressor 18A is set to 0.21/kW or less, and hence the influence of the discharge pressure from another compressor 18B acting as the counter pressure can be reduced. Further, in the check valve 42B, the flow coefficient C_v per air conditioning capacity of the compressor 18B is set to 0.21/kW or less, and hence the influence of the discharge pressure from another compressor 18A acting as the counter pressure can be reduced. From those points, in the check valves 42A and 42B, the occurrence of the chattering due to the above-mentioned counter pressures can be suppressed.

[0049] (7) In the check valves 42A and 42B, the flow coefficient C_v per air conditioning capacity of each of the compressors 18A and 18B is set to 0.105/kW or more, and hence the pressure loss of each of the check valves 42A and 42B is reduced, and no rise of the discharge pressure of each of the compressors 18A and 18B is caused. As a result, the performance of the air conditioning apparatus 40 can be satisfactorily ensured.

[0050] While certain embodiments of the present invention have been described, those embodiments have been merely presented as examples, and are not intended to limit the scope of the inventions. Those embodiments can be embodied in various other modes, and various omissions, substitutions, changes, and combinations may be made without departing from the spirit of the inventions. Further, those substitutions, changes, and combinations fall within the scope and spirit of the inventions, and also fall within the inventions described in claims as well as within a range equivalent to those claims.

Claims

1. An air conditioning apparatus configured to execute an air conditioning operation including cooling and heating by circulating R32 as refrigerant through a refrigerant pipe connecting an outdoor unit and an indoor unit to each other, the outdoor unit including a compressor, an outdoor heat exchanger, and an expansion mechanism, the indoor unit including an indoor heat exchanger, the air conditioning apparatus comprising:

tus comprising:

a plurality of the compressors; and
a plurality of check valves respectively provided in discharge pipes respectively connected to the plurality of the compressors,
wherein each of the plurality of check valves is configured to have a valve diameter per air conditioning capacity of the compressor, that is set in a range of $\Phi 0.21$ mm/kW to $\Phi 0.42$ mm/kW.

2. An air conditioning apparatus configured to execute an air conditioning operation including cooling and heating by circulating R32 as refrigerant through a refrigerant pipe connecting an outdoor unit and an indoor unit to each other, the outdoor unit including a compressor, an outdoor heat exchanger, and an expansion mechanism, the indoor unit including an indoor heat exchanger, the air conditioning apparatus comprising:

a plurality of the compressors; and
a plurality of check valves respectively provided in discharge pipes respectively connected to the plurality of the compressors,
wherein each of the plurality of check valves is configured to have a flow coefficient C_v per air conditioning capacity of the compressor, that is set in a range of 0.105/kW to 0.21 /kW.

3. The air conditioning apparatus according to claim 1 or 2, wherein the plurality of the compressors is set to have different operation frequencies to provide a difference in operation frequency.

4. The air conditioning apparatus according to claim 1 or 2, wherein the discharge pipes, that are respectively connected to the plurality of the compressors, have a joining angle set to be 90 degrees or less.

5. The air conditioning apparatus according to claim 1 or 2, wherein the refrigerant is a mixed refrigerant containing R32 serving as a refrigerant type of less than 30%.

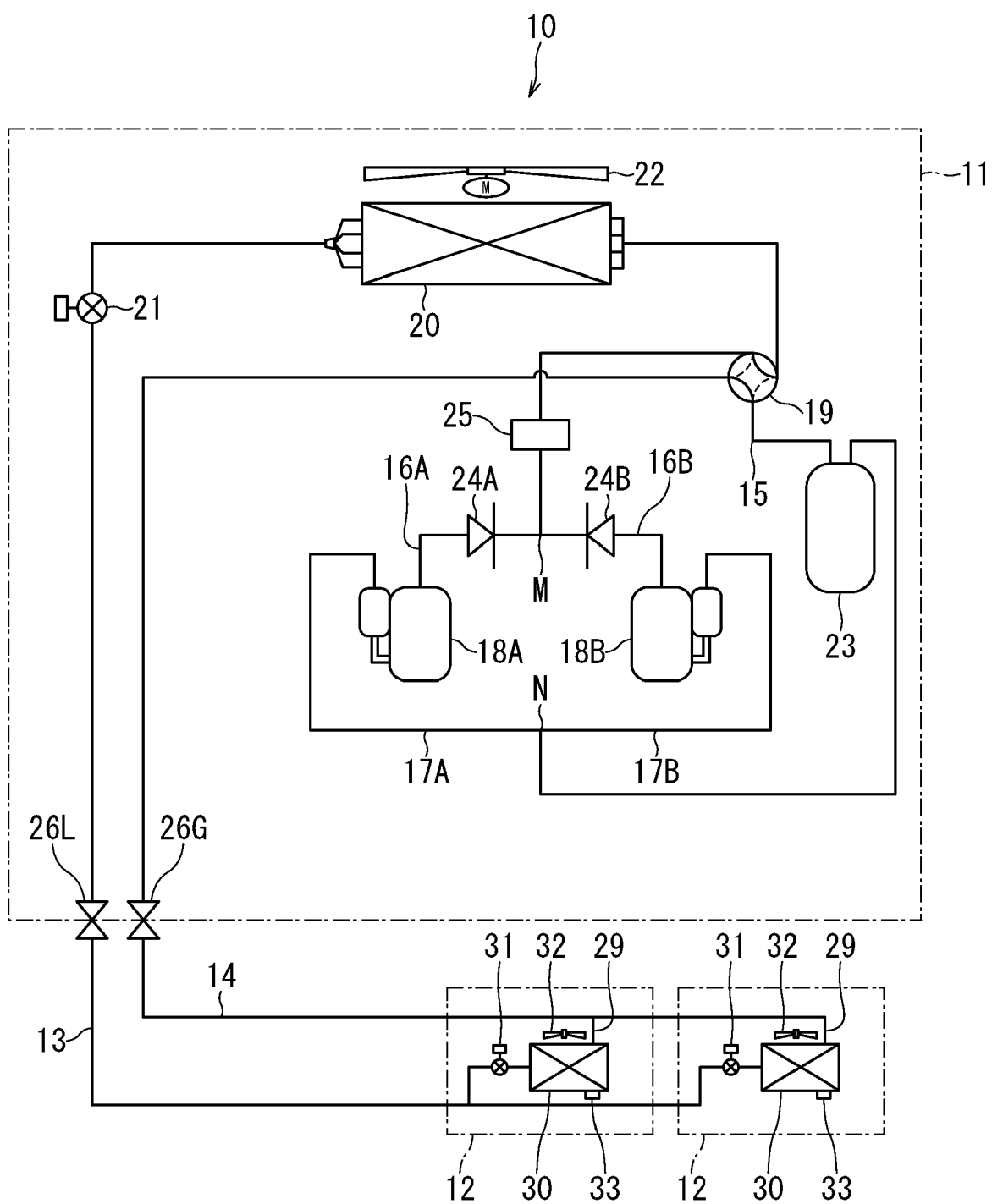


FIG. 1

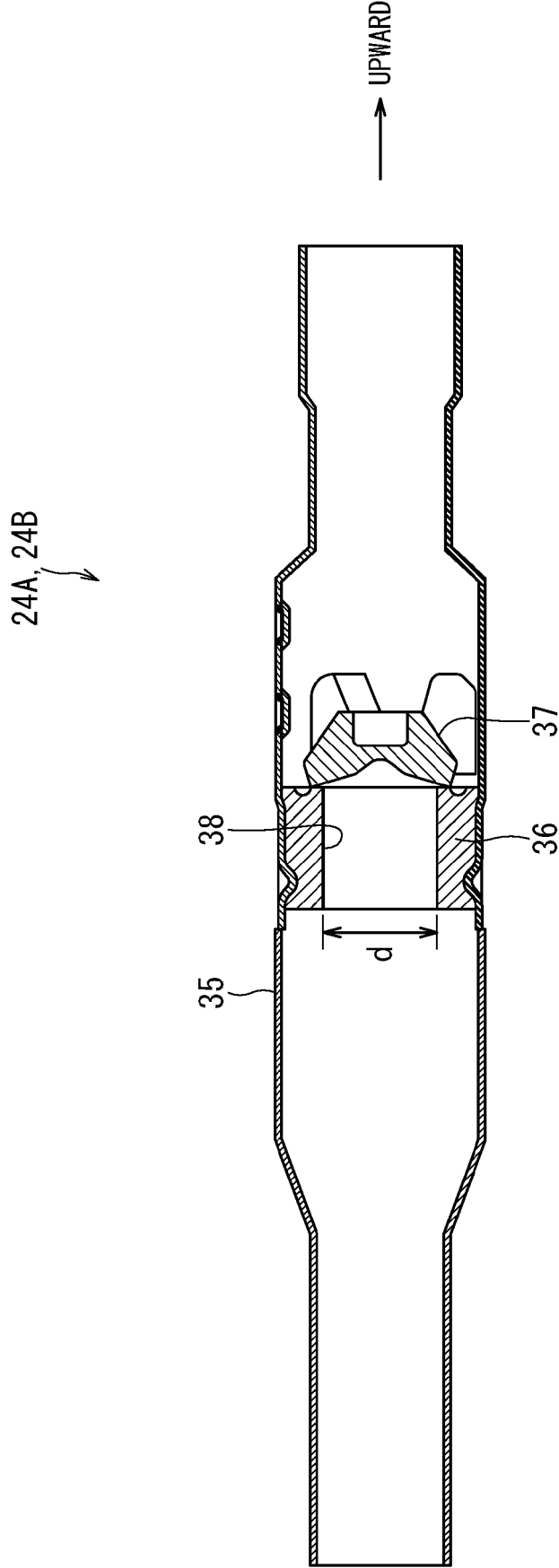


FIG. 2

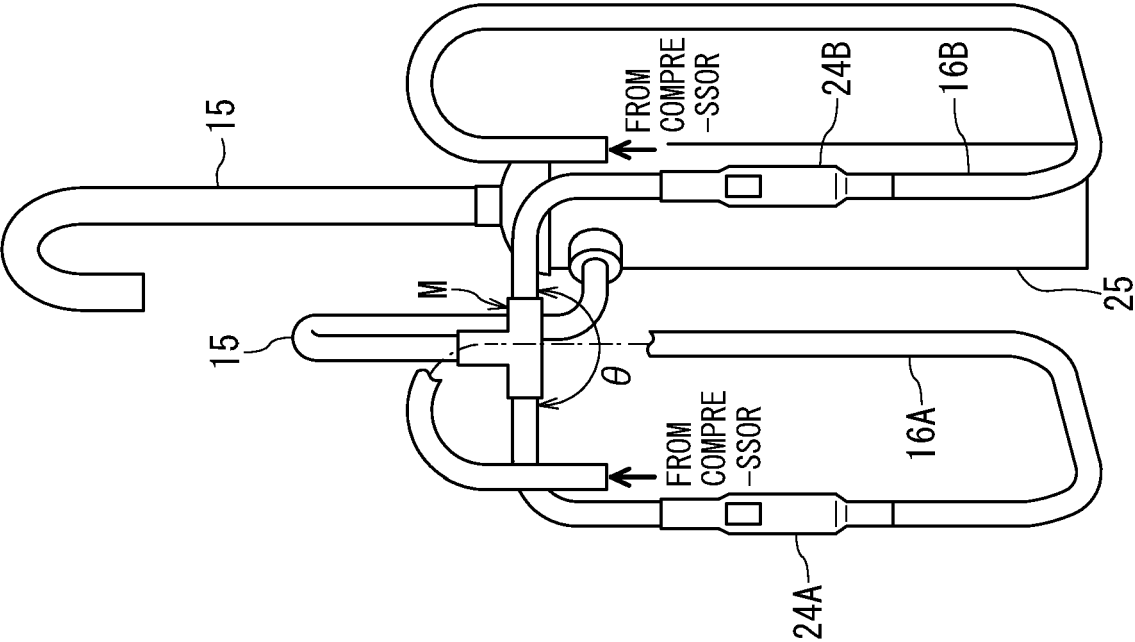


FIG. 3B

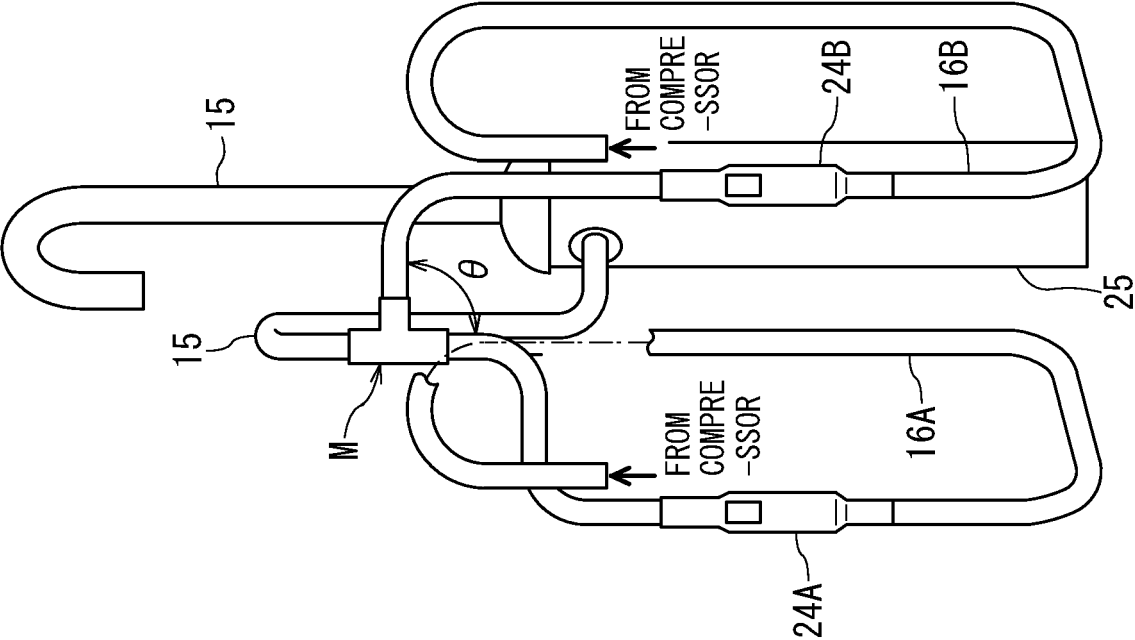


FIG. 3A

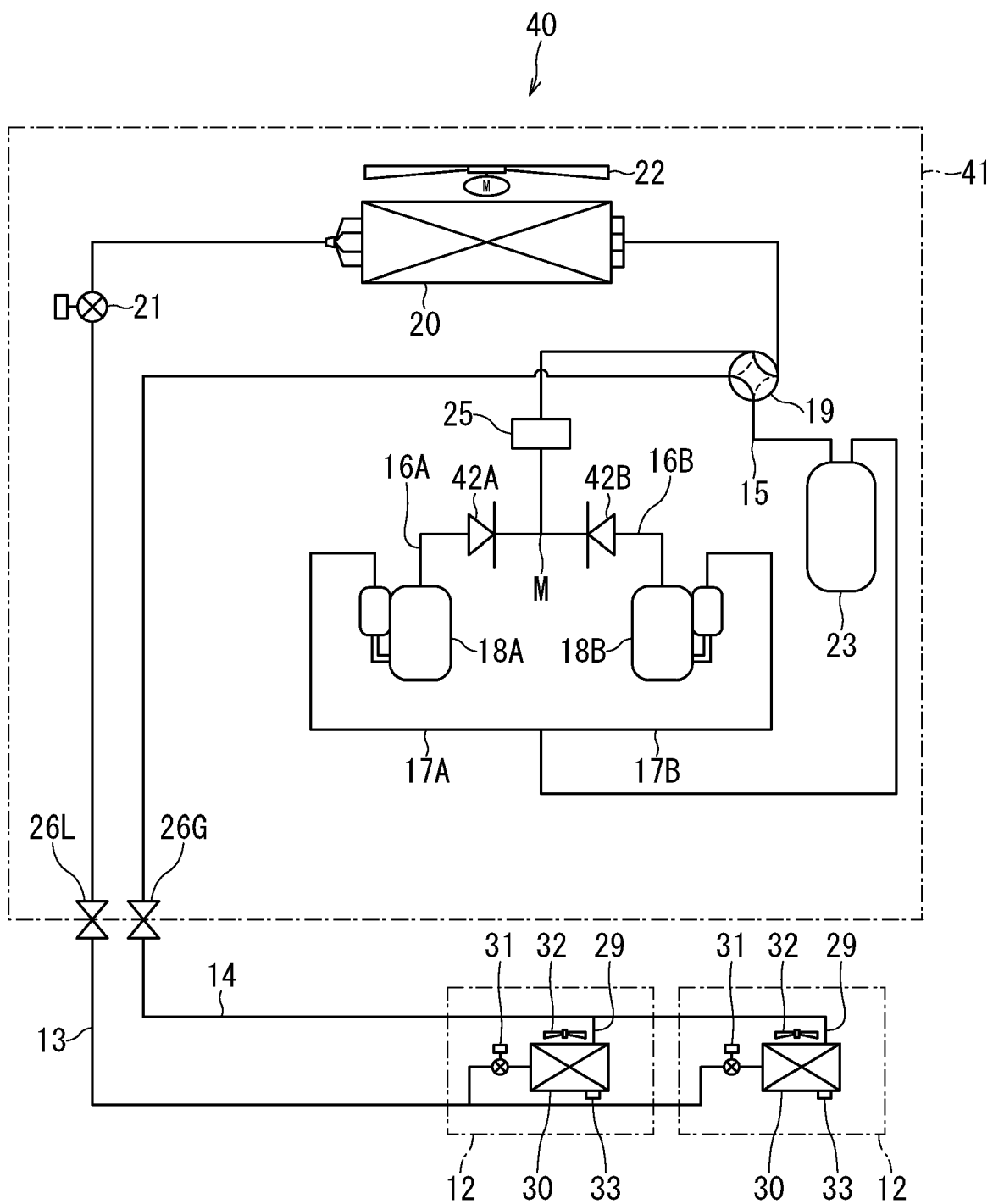


FIG. 4



EUROPEAN SEARCH REPORT

Application Number

EP 24 15 7571

5

10

15

20

25

30

35

40

45

50

55

1

EPO FORM 1503 03:82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 3 374 704 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 19 September 2018 (2018-09-19)	1-3,5	INV. F25B41/20
Y	* paragraph [0036] - paragraph [0125]; figures 1-10 *	4	
X	EP 4 033 178 A1 (DAIKIN IND LTD [JP]) 27 July 2022 (2022-07-27) * paragraphs [0033], [0034]; figure 3 *	1-3,5	
Y	US 2019/063805 A1 (MUTHUSUBRAMANIAN KAMALAKKANNAN [US]) 28 February 2019 (2019-02-28) * paragraph [0050]; figure 2 *	4	
A	Sheila Kennedy: "Proper Check Valve Sizing Can Avoid Costly Problems", , 8 October 2020 (2020-10-08), XP002811712, Retrieved from the Internet: URL:https://fluidpowerjournal.com/proper-check-valve-sizing-can-avoid-costly-problems/ [retrieved on 2024-06-07]	1-5	TECHNICAL FIELDS SEARCHED (IPC) F25B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 June 2024	Examiner Szilagyi, Barnabas
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 24 15 7571

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

10-06-2024

10	Patent document cited in search report		Publication date	Patent family member(s)		Publication date
15	EP 3374704	A1	19-09-2018	CN	108474595 A	31-08-2018
				EP	3374704 A1	19-09-2018
				JP	2017146061 A	24-08-2017
				KR	20170098138 A	29-08-2017

20	EP 4033178	A1	27-07-2022	CN	114341569 A	12-04-2022
				EP	4033178 A1	27-07-2022
				WO	2021065156 A1	08-04-2021

25	US 2019063805	A1	28-02-2019	CN	111033155 A	17-04-2020
				EP	3673217 A1	01-07-2020
				US	2019063805 A1	28-02-2019
				WO	2019040905 A1	28-02-2019

30						
35						
40						
45						
50						
55						

ORM P0459

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82