



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

(43) Date of publication:
24.08.2022 Bulletin 2022/34

(51) International Patent Classification (IPC):
F25B 41/20 ^(2021.01) **F24F 1/32** ^(2011.01)
F25B 41/00 ^(2021.01)

(21) Application number: **20889034.3**

(52) Cooperative Patent Classification (CPC):
F24F 1/32; F25B 41/00; F25B 41/20; F25B 41/40

(22) Date of filing: **26.06.2020**

(86) International application number:
PCT/JP2020/025138

(87) International publication number:
WO 2021/100234 (27.05.2021 Gazette 2021/21)

(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

(72) Inventors:
• **TAKEGAMI Masaaki**
Osaka-shi, Osaka 530-8323 (JP)
• **UENO Akitoshi**
Osaka-shi, Osaka 530-8323 (JP)
• **TAGUCHI Shuichi**
Osaka-shi, Osaka 530-8323 (JP)
• **OHZONO Takumi**
Osaka-shi, Osaka 530-8323 (JP)

(30) Priority: **18.11.2019 JP 2019207898**

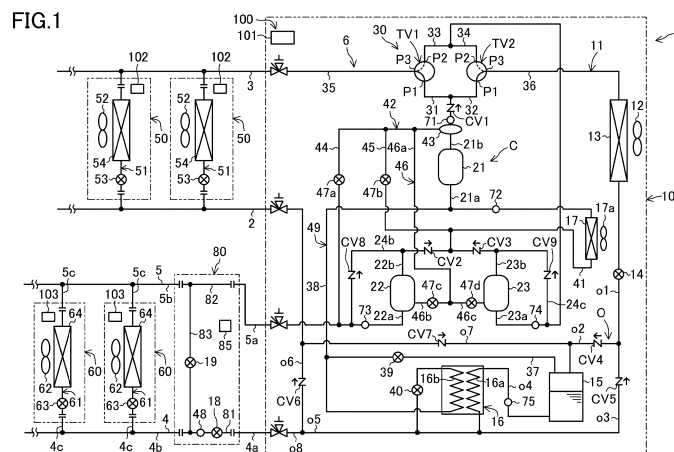
(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(71) Applicant: **Daikin Industries, Ltd.**
Osaka-shi, Osaka 530-8323 (JP)

(54) **INTERMEDIATE UNIT FOR REFRIGERATION DEVICE, AND REFRIGERATION DEVICE**

(57) An intermediate unit (80) includes a liquid-side pipe (81), a first valve (18), and a refrigerant pressure sensor (48). The liquid-side pipe (81) is connected to a liquid connection pipe (4) connecting a heat source unit (10) and a utilization unit (60) together. A controller (85) of the intermediate unit (80) adjusts the opening degree

of the first valve (18) based on a value measured by the refrigerant pressure sensor (48). The pressure of a refrigerant to be sent through the liquid connection pipe (4) from the intermediate unit (80) to the utilization unit (60) is adjusted by the first valve (18).



Description

TECHNICAL FIELD

[0001] The present disclosure relates to an intermediate unit for a refrigeration apparatus and a refrigeration apparatus.

BACKGROUND ART

[0002] Patent Document 1 discloses a heat source unit forming part of a refrigeration apparatus. This heat source unit is connected through a connection pipe to a show case or any other suitable object, which is a utilization unit, and circulates a refrigerant between the heat source unit and the utilization unit to perform a refrigeration cycle.

CITATION LIST

PATENT DOCUMENT

[0003] Patent Document 1: Japanese Unexamined Patent Publication No. 2017-138034

SUMMARY

TECHNICAL PROBLEM

[0004] The allowable refrigerant pressure (hereinafter referred to as the "allowable pressure") in the utilization unit connected to the heat source unit may vary among models. Meanwhile, the pressure of the refrigerant to be supplied from the heat source unit to the utilization unit is controlled by a decompression mechanism in the heat source unit. Thus, a need arises to change the manner of control performed by the decompression mechanism in the heat source unit in accordance with the allowable pressure in the utilization unit. This may complicate the manner of control performed by the heat source unit.

[0005] It is an object of the present disclosure to allow various models of utilization units to be connected to a heat source unit without complicating the manner of control performed by the heat source unit.

SOLUTION TO THE PROBLEM

[0006] A first aspect of the present disclosure is directed to an intermediate unit (80) for a refrigeration apparatus (1). The intermediate unit (80) is provided between a heat source unit (10) and a utilization unit (60). The heat source unit (10) and the utilization unit (60) are connected together through a liquid connection pipe (4) and a gas connection pipe (5) to form the refrigeration apparatus (1). The intermediate unit (80) includes: a liquid-side pipe (81) connected to the liquid connection pipe (4); a first valve (18) provided for the liquid-side pipe (81), the first valve (18) having a variable opening degree; a

refrigerant pressure sensor (48) disposed in a portion of the liquid-side pipe (81) closer to the utilization unit (60) than the first valve (18) is, the refrigerant pressure sensor (48) being configured to measure a pressure of a refrigerant flowing through the liquid-side pipe (81); and a controller (85) configured to adjust the opening degree of the first valve (18) based on a value measured by the refrigerant pressure sensor (48).

[0007] According to the first aspect, the refrigerant sent out from the heat source unit (10) and flowing through the liquid connection pipe (4) is supplied to the utilization unit (60) after passing through the liquid-side pipe (81) of the intermediate unit (80). The controller (85) changing the opening degree of the first valve (18) based on the value measured by the refrigerant pressure sensor (48) triggers a change in the pressure of the refrigerant to be sent from the intermediate unit (80) to the utilization unit (60).

[0008] In the first aspect, the intermediate unit (80) adjusts the pressure of the refrigerant flowing into the utilization unit (60). For this reason, even if the heat source unit (10) does not perform control with consideration given to the allowable pressure of the utilization unit (60), the utilization unit (60) having an allowable pressure that is lower than that of the heat source unit (10) can be connected to the heat source unit (10). Thus, according to this aspect, various models of utilization units can be connected to the heat source unit (10) without complicating the manner of control performed by the heat source unit (10).

[0009] A second aspect of the present disclosure is an embodiment of the first aspect. In the second aspect, the intermediate unit further includes: a gas-side pipe (82) connected to the gas connection pipe (5); a joint pipe (83) connecting the portion of the liquid-side pipe (81) closer to the utilization unit (60) than the first valve (18) is and the gas-side pipe (82) together; and a second valve (19) provided for the joint pipe (83).

[0010] According to the second aspect, the joint pipe (83) connecting the liquid-side pipe (81) and the gas-side pipe (82) together is provided with the second valve (19). While the second valve (19) is open, a portion of the liquid connection pipe (4) between the intermediate unit (80) and the utilization unit (60) communicates with the gas connection pipe (5) via the joint pipe (83). Thus, in a state where the first valve (18) of the intermediate unit (80) is closed., the refrigerant pressure in the portion of the liquid-side pipe (81) closer to the utilization unit (60) than the first valve (18) can be substantially prevented from increasing excessively.

[0011] A third aspect of the present disclosure is an embodiment of the second aspect. In the third aspect, the controller (85) adjusts the opening degree of the first valve (18) so that the value measured by the refrigerant pressure sensor (48) is less than or equal to a reference pressure, and opens the second valve (19) if the value measured by the refrigerant pressure sensor (48) is greater than the reference pressure with the first valve

(18) closed.

[0012] According to the third aspect, the controller (85) controls the first and second valves (18) and (19). The controller (85) controlling the first valve (18) allows the pressure of the refrigerant that is about to be supplied from the intermediate unit (80) to the utilization unit (60) to be substantially kept at or below the reference pressure. The controller (85) controlling the second valve (19) substantially prevents the internal pressure of the portion of the liquid connection pipe (4) between the intermediate unit (80) and the utilization unit (60) from increasing excessively even with the first valve (18) closed.

[0013] A fourth aspect of the present disclosure is an embodiment of any one of the first to third aspects. In the fourth aspect, the intermediate unit (80) is installed indoors, and is connected to the heat source unit (10) installed outdoors.

[0014] According to the fourth aspect, the intermediate unit (80) is placed indoors. Thus, in the summer when the outdoor air temperature is high, the air temperature around the portion of the liquid connection pipe (4) between the intermediate unit (80) and the utilization unit (60) is lower than that outdoors. Thus, in a state where the first valve (18) of the intermediate unit (80) is closed the refrigerant pressure in the portion of the liquid-side pipe (81) closer to the utilization unit (60) than the first valve (18) can be substantially prevented from increasing.

[0015] A refrigeration apparatus according to a fifth aspect of the present disclosure includes: the intermediate unit (80) of any one of the first to fourth aspects; a heat source unit (10); a utilization unit (60); and a liquid connection pipe (4) and a gas connection pipe (5) connecting the intermediate unit (80), the heat source unit (10), and the utilization unit (60) together to form a refrigerant circuit (6).

[0016] According to the fifth aspect, the intermediate unit (80) is disposed between the heat source unit (10) and the utilization unit (60) in the refrigerant circuit (6). The liquid-side pipe (81) of the intermediate unit (80) is connected to the liquid connection pipe (4). Changing the opening degree of the first valve (18) of the intermediate unit (80) triggers a change in the pressure of the refrigerant to be sent through the liquid connection pipe (4) from the intermediate unit (80) to the utilization unit (60).

[0017] A refrigeration apparatus according to a sixth aspect of the present disclosure includes: the intermediate unit (80) of the second or third aspect; a heat source unit (10); a plurality of utilization units (60); a liquid connection pipe (4) including a liquid-side trunk pipe (4a, 4b) and a plurality of liquid-side branch pipes (4c), the liquid-side trunk pipe (4a, 4b) being connected to the heat source unit (10), the liquid-side branch pipes (4c) each connecting an associated one of the utilization units (60) to the liquid-side trunk pipe (4a, 4b); and a gas connection pipe (5) including a gas-side trunk pipe (5a, 5b) and a plurality of gas-side branch pipes (5c), the gas-side trunk

pipe (5a, 5b) being connected to the heat source unit (10), the gas-side branch pipes (5c) each connecting an associated one of the utilization units (60) to the gas-side trunk pipe (5a, 5b). The liquid-side pipe (81) of the intermediate unit (80) is connected to the liquid-side trunk pipe (4a, 4b) of the liquid connection pipe (4). The gas-side pipe (82) of the intermediate unit (80) is connected to the gas-side trunk pipe (5a, 5b) of the gas connection pipe (5).

[0018] According to the sixth aspect, the plurality of utilization units (60) are connected through the liquid connection pipe (4) and the gas connection pipe (5) to the heat source unit (10). The intermediate unit (80) is connected to the liquid-side trunk pipe (4a, 4b) of the liquid connection pipe (4) and the gas-side trunk pipe (5a, 5b) of the gas connection pipe (5). The refrigerant that has flowed from the heat source unit (10) into the liquid-side trunk pipe (4a, 4b) of the liquid connection pipe (4) passes through the first valve (18) of the intermediate unit (80), and is then distributed among the plurality of utilization units (60).

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a piping system diagram illustrating a configuration of a refrigeration apparatus according to an embodiment.

FIG. 2 is a block diagram illustrating the relationship among controllers, a sensor, and components of a refrigerant circuit.

FIG. 3 corresponds to FIG. 1 and illustrates a flow of a refrigerant through the refrigerant circuit during a cooling operation.

FIG. 4 corresponds to FIG. 1 and illustrates a flow of the refrigerant through the refrigerant circuit during a heating operation.

FIG. 5 corresponds to FIG. 1 and illustrates the state of the refrigerant circuit observed while refrigeration-facility units are in a cooling-suspended state.

FIG. 6 is a flowchart showing how a hydraulic pressure controller of an embodiment operates to control a first valve.

FIG. 7 is a graph showing the relationship between the opening degree of a second valve controlled by the hydraulic pressure controller of the embodiment and a value P_k measured by a refrigerant pressure sensor.

FIG. 8 is a graph showing the relationship between the opening degree of a second valve controlled by a hydraulic pressure controller of a variation of the embodiment and a value P_k measured by a refrigerant pressure sensor.

FIG. 9 is a block diagram illustrating the relationship between components of an intermediate unit and a hydraulic pressure controller.

DESCRIPTION OF EMBODIMENTS

[0020] Embodiments will be described below with reference to the drawings. The embodiments below are merely exemplary ones in nature, and are not intended to limit the scope, applications, or use of the invention.

[0021] A refrigeration apparatus (1) of an embodiment can cool an object to be cooled, and can condition indoor air. The object to be cooled herein includes air in facilities such as a refrigerator, a freezer, and a show case. Hereinafter, such facilities are each referred to as a refrigeration-facility.

-General Configuration of Refrigeration Apparatus-

[0022] As illustrated in FIG. 1, the refrigeration apparatus (1) includes a heat source unit (10) installed outdoors, a plurality of air-conditioning units (50) configured to condition indoor air, a plurality of refrigeration-facility units (60) configured to cool air in a refrigeration-facility, an intermediate unit (80), and a main controller (100). In the refrigeration apparatus (1) of the present embodiment, the number of the heat source unit (10) is one, the number of the refrigeration-facility units (60) is two or more, and the number of the air-conditioning units (50) is two or more. Note that the number of the refrigeration-facility units (60) or the air-conditioning units (50) of the refrigeration apparatus (1) may be one.

[0023] In the refrigeration apparatus (1), the heat source unit (10), the refrigeration-facility units (60), the air-conditioning units (50), the intermediate unit (80), and connection pipes (2, 3, 4, 5) connecting these units (10, 50, 60, 80) together form a refrigerant circuit (6).

[0024] In the refrigerant circuit (6), a refrigerant circulates to perform a refrigeration cycle. The refrigerant in the refrigerant circuit (6) of the present embodiment is carbon dioxide. The refrigerant circuit (6) is configured to perform the refrigeration cycle so that the refrigerant has a pressure equal to or greater than the critical pressure.

[0025] In the refrigerant circuit (6), the plurality of air-conditioning units (50) are connected through a first liquid connection pipe (2) and a first gas connection pipe (3) to the heat source unit (10). In the refrigerant circuit (6), the plurality of air-conditioning units (50) are connected together in parallel.

[0026] In the refrigerant circuit (6), the plurality of refrigeration-facility units (60) are connected through a second liquid connection pipe (4) and a second gas connection pipe (5) to the heat source unit (10). In the refrigerant circuit (6), the plurality of refrigeration-facility units (60) are connected together in parallel.

[0027] In the refrigerant circuit (6), the intermediate unit (80) is connected to the second liquid connection pipe (4) and the second gas connection pipe (5) that connect the heat source unit (10) and the refrigeration-facility units (60) together. In other words, the intermediate unit (80) is disposed between the heat source unit (10) and

the refrigeration-facility units (60) in the refrigerant circuit (6).

[0028] The second liquid connection pipe (4) includes one first liquid-side trunk pipe (4a), one second liquid-side trunk pipe (4b), and liquid-side branch pipes (4c) equal in number to the refrigeration-facility units (60). The first liquid-side trunk pipe (4a) is provided for a portion of the intermediate unit (80) near the heat source unit (10). The second liquid-side trunk pipe (4b) is provided for a portion of the intermediate unit (80) near the refrigeration-facility units (60).

[0029] Specifically, the first liquid-side trunk pipe (4a) connects the heat source unit (10) and the intermediate unit (80) together. One end of the second liquid-side trunk pipe (4b) is connected to the intermediate unit (80). The other end of the second liquid-side trunk pipe (4b) is connected to one end of each liquid-side branch pipe (4c). The other end of each liquid-side branch pipe (4c) is connected to an associated one of the refrigeration-facility units (60).

[0030] The second gas connection pipe (5) includes one first gas-side trunk pipe (5a), one second gas-side trunk pipe (5b), and gas-side branch pipes (5c) equal in number to the refrigeration-facility units (60). The first gas-side trunk pipe (5a) is provided for the portion of the intermediate unit (80) near the heat source unit (10). The second gas-side trunk pipe (5b) is provided for the portion of the intermediate unit (80) near the refrigeration-facility units (60).

[0031] Specifically, the first gas-side trunk pipe (5a) connects the heat source unit (10) and the intermediate unit (80) together. One end of the second gas-side trunk pipe (5b) is connected to the intermediate unit (80). The other end of the second gas-side trunk pipe (5b) is connected to one end of each gas-side branch pipe (5c). The other end of each gas-side branch pipe (5c) is connected to an associated one of the refrigeration-facility units (60).

-Heat Source Unit-

[0032] The heat source unit (10) includes an outdoor fan (12) and an outdoor circuit (11). The outdoor circuit (11) includes a compression element (C), a flow path switching mechanism (30), an outdoor heat exchanger (13), an outdoor expansion valve (14), a gas-liquid separator (15), a subcooling heat exchanger (16), and an intercooler (17). The heat source unit (10) further includes an outdoor controller (101).

<Compression Element>

[0033] The compression element (C) compresses the refrigerant. The compression element (C) includes a first compressor (21), a second compressor (22), and a third compressor (23). The first, second, and third compressors (21), (22), and (23) are each a rotary compressor in which a motor drives a compression mechanism. The first, second, and third compressors (21), (22), and (23)

are each configured as a variable capacity compressor capable of changing the rotational speed of the compression mechanism.

[0034] The compression element (C) performs two-stage compression. The first compressor (21) that is a high-stage compressor constitutes a first compression section. The second and third compressors (22) and (23) that are low-stage compressors constitute a second compression section.

[0035] A first suction pipe (21a) and a first discharge pipe (21b) are connected to the first compressor (21). A second suction pipe (22a) and a second discharge pipe (22b) are connected to the second compressor (22). A third suction pipe (23a) and a third discharge pipe (23b) are connected to the third compressor (23). In the compression element (C), the second and third discharge pipes (22b) and (23b) are connected to the first suction pipe (21a).

[0036] The second suction pipe (22a) is connected through a pipe to the first gas-side trunk pipe (5a) of the second gas connection pipe (5). The second compressor (22) communicates with the refrigeration-facility units (60) through the second gas connection pipe (5). The second compressor (22) is a refrigeration-facility compressor associated with the refrigeration-facility units (60). The third suction pipe (23a) communicates with the air-conditioning units (50). The third compressor (23) is an indoor-side compressor associated with the air-conditioning units (50).

[0037] The compression element (C) includes a second bypass pipe (24b) and a third bypass pipe (24c). The second bypass pipe (24b) is a pipe through which the refrigerant is passed while bypassing the second compressor (22). The second bypass pipe (24b) has two ends respectively connected to the second suction pipe (22a) and the second discharge pipe (22b). The third bypass pipe (24c) is a pipe through which the refrigerant is passed while bypassing the third compressor (23). The third bypass pipe (24c) has two ends respectively connected to the third suction pipe (23a) and the third discharge pipe (23b).

<Flow Path Switching Mechanism>

[0038] The flow path switching mechanism (30) selects one of paths through which the refrigerant flows in the refrigerant circuit (6). The flow path switching mechanism (30) includes a first pipe (31), a second pipe (32), a third pipe (33), a fourth pipe (34), a first three-way valve (TV1), and a second three-way valve (TV2). The inflow end of the first pipe (31) and the inflow end of the second pipe (32) are connected to the first discharge pipe (21b). The first pipe (31) and the second pipe (32) are pipes on which the discharge pressure of the compression element (C) acts. The outflow end of the third pipe (33) and the outflow end of the fourth pipe (34) are connected to the third suction pipe (23a) of the third compressor (23). The third pipe (33) and the fourth pipe (34) are pipes on which the

suction pressure of the compression element (C) acts.

[0039] The first three-way valve (TV1) has a first port (P1), a second port (P2), and a third port (P3). The first port (P1) of the first three-way valve (TV1) is connected to the outflow end of the first pipe (31) that is a high-pressure flow path. The second port (P2) of the first three-way valve (TV1) is connected to the inflow end of the third pipe (33) that is a low-pressure flow path. The third port (P3) of the first three-way valve (TV1) is connected to one end of an indoor gas-side flow path (35). The other end of the indoor gas-side flow path (35) is connected to the first gas connection pipe (3).

[0040] The second three-way valve (TV2) has a first port (P1), a second port (P2), and a third port (P3). The first port (P1) of the second three-way valve (TV2) is connected to the outflow end of the second pipe (32) that is a high-pressure flow path. The second port (P2) of the second three-way valve (TV2) is connected to the inflow end of the fourth pipe (34) that is a low-pressure flow path. The third port (P3) of the second three-way valve (TV2) is connected to an outdoor gas-side flow path (36).

[0041] The first three-way valve (TV1) and the second three-way valve (TV2) are each an electric three-way valve. The three-way valves (TV1, TV2) are each switched between the first state (the state indicated by a solid line in FIG. 1) and the second state (the state indicated by a dashed line in FIG. 1). In the three-way valves (TV1, TV2) in the first state, the first port (P1) and the third port (P3) communicate with each other, and the second port (P2) is closed. In the three-way valves (TV1, TV2) in the second state, the second port (P2) and the third port (P3) communicate with each other, and the first port (P1) is closed.

<Outdoor Heat Exchanger>

[0042] The outdoor heat exchanger (13) constitutes a heat-source-side heat exchanger. The outdoor heat exchanger (13) is a fin-and-tube air heat exchanger. The outdoor fan (12) is disposed near the outdoor heat exchanger (13). The outdoor fan (12) transfers outdoor air. The outdoor heat exchanger exchanges heat between a refrigerant flowing therethrough and outdoor air transferred from the outdoor fan (12).

[0043] The gas end of the outdoor heat exchanger (13) is connected to the outdoor gas-side flow path (36). The liquid end of the outdoor heat exchanger (13) is connected to an outdoor flow path (O).

<Outdoor Flow Path>

[0044] The outdoor flow path (O) includes a first outdoor pipe (o1), a second outdoor pipe (o2), a third outdoor pipe (o3), a fourth outdoor pipe (o4), a fifth outdoor pipe (o5), a sixth outdoor pipe (o6), a seventh outdoor pipe (o7), and an eighth outdoor pipe (o8).

[0045] One end of the first outdoor pipe (o1) is connected to the liquid end of the outdoor heat exchanger

(13). The other end of the first outdoor pipe (o1) is connected to one end of the second outdoor pipe (o2) and one end of the third outdoor pipe (o3). The other end of the second outdoor pipe (o2) is connected to the top of the gas-liquid separator (15).

[0046] One end of the fourth outdoor pipe (o4) is connected to the bottom of the gas-liquid separator (15). The other end of the fourth outdoor pipe (o4) is connected to one end of the fifth outdoor pipe (o5) and the other end of the third outdoor pipe (o3). The other end of the fifth outdoor pipe (o5) is connected to one end of the sixth outdoor pipe (o6) and one end of the eighth outdoor pipe (o8).

[0047] The other end of the eighth outdoor pipe (o8) is connected to the first liquid-side trunk pipe (4a) of the second liquid connection pipe (4). The eighth outdoor pipe (o8) is a liquid pipe through which a liquid refrigerant downstream of the gas-liquid separator (15) flows. The other end of the sixth outdoor pipe (o6) is connected to the first liquid connection pipe (2). One end of the seventh outdoor pipe (o7) is connected to an intermediate portion of the sixth outdoor pipe (o6). The other end of the seventh outdoor pipe (o7) is connected to an intermediate portion of the second outdoor pipe (o2).

<Outdoor Expansion Valve>

[0048] The first outdoor pipe (o1) of the outdoor circuit (11) is provided with an outdoor expansion valve (14). The outdoor expansion valve (14) is an electronic expansion valve that has its opening degree adjusted by a pulse motor driven in response to a pulse signal from the main controller (100).

<Gas-Liquid Separator>

[0049] The gas-liquid separator (15) constitutes a container that stores the refrigerant. The gas-liquid separator (15) is provided downstream of the outdoor expansion valve (14). In the gas-liquid separator (15), the refrigerant is separated into a gas refrigerant and a liquid refrigerant. The top of the gas-liquid separator (15) is connected to the other end of the second outdoor pipe (o2) and one end of a venting pipe (37), which will be described below.

<Intermediate Injection Circuit>

[0050] The outdoor circuit (11) includes an intermediate injection circuit (49). The intermediate injection circuit (49) is a circuit through which the refrigerant decompressed by the outdoor expansion valve (14) is supplied to an intermediate pressure section of the compression element (C) between the first compression section (21) and the second compression section (22, 23). The intermediate injection circuit (49) includes the venting pipe (37) and an injection pipe (38).

[0051] One end of the injection pipe (38) is connected to an intermediate portion of the fifth outdoor pipe (o5).

The other end of the injection pipe (38) is connected to the first suction pipe (21a) of the first compressor (21). The injection pipe (38) is provided with a decompression valve (40). The decompression valve (40) is an expansion valve having a variable opening degree.

[0052] The venting pipe (37) is configured to allow the gas refrigerant in the gas-liquid separator (15) to flow out of the gas-liquid separator (15) into a flow path between the first compression section (21) and the second compression section (22, 23). Specifically, one end of the venting pipe (37) is connected to the top of the gas-liquid separator (15). The other end of the venting pipe (37) is connected to an intermediate portion of the injection pipe (38). The venting pipe (37) is connected to a venting valve (39). The venting valve (39) is an electronic expansion valve having a variable opening degree.

<Subcooling Heat Exchanger>

[0053] The outdoor circuit (11) includes the subcooling heat exchanger (16). The subcooling heat exchanger (16) is a cooling heat exchanger configured to cool the refrigerant (mainly the liquid refrigerant) separated in the gas-liquid separator (15). The subcooling heat exchanger (16) is connected between the gas-liquid separator (15) and a first valve (18). The subcooling heat exchanger (16) has a first flow path (16a) serving as a high-pressure flow path and a second flow path (16b) serving as a low-pressure flow path. In the subcooling heat exchanger (16), heat exchange occurs between the high-pressure refrigerant flowing through the first flow path (16a) and the decompressed refrigerant flowing through the second flow path (16b).

[0054] The refrigerant flowing through the first flow path (16a) is cooled in the subcooling heat exchanger (16). The first flow path (16a) is connected to an intermediate portion of the fourth outdoor pipe (o4) serving as a liquid pipe through which the liquid refrigerant in the outdoor circuit (11) flows.

[0055] The second flow path (16b) is a flow path through which the refrigerant serving to cool the refrigerant flowing through the first flow path (16a) flows. The second flow path (16b) is included in the intermediate injection circuit (49). Specifically, the second flow path (16b) is connected to a portion of the injection pipe (38) downstream of the decompression valve (40). The refrigerant that has been decompressed at the decompression valve (40) flows through the second flow path (16b).

<Intercooler>

[0056] The intercooler (17) is connected to an intermediate flow path (41). One end of the intermediate flow path (41) is connected to the second discharge pipe (22b) of the second compressor (22) and the third discharge pipe (23b) of the third compressor (23). The other end of the intermediate flow path (41) is connected to the first suction pipe (21a) of the first compressor (21). In other

words, the other end of the intermediate flow path (41) is connected to the intermediate pressure section of the compression element (C).

[0057] The intercooler (17) is a fin-and-tube air heat exchanger. A cooling fan (17a) is disposed near the intercooler (17). The intercooler (17) exchanges heat between the refrigerant flowing therethrough and the outdoor air transferred from the cooling fan (17a).

<Oil Separation Circuit>

[0058] The outdoor circuit (11) includes an oil separation circuit (42). The oil separation circuit (42) includes an oil separator (43), a first oil return pipe (44), a second oil return pipe (45), and a third oil return pipe (46).

[0059] The oil separator (43) is connected to the first discharge pipe (21b) of the first compressor (21). The oil separator (43) separates oil from the refrigerant discharged from the compression element (C).

[0060] The inflow end of the first oil return pipe (44) communicates with the oil separator (43). The outflow end of the first oil return pipe (44) is connected to the second suction pipe (22a) of the second compressor (22). The inflow end of the second oil return pipe (45) communicates with the oil separator (43). The outflow end of the second oil return pipe (45) is connected to the inflow end of the intermediate flow path (41).

[0061] The third oil return pipe (46) includes a main return pipe (46a), a refrigeration-facility-side branch pipe (46b), and an indoor-side branch pipe (46c). The inflow end of the main return pipe (46a) communicates with the oil separator (43). The outflow end of the main return pipe (46a) is connected to the inflow end of the refrigeration-facility-side branch pipe (46b) and the inflow end of the indoor-side branch pipe (46c). The outflow end of the refrigeration-facility-side branch pipe (46b) communicates with an oil reservoir inside a casing of the second compressor (22). The outflow end of the indoor-side branch pipe (46c) communicates with an oil reservoir inside a casing of the third compressor (23).

[0062] The first oil return pipe (44) is connected to a first oil level control valve (47a). The second oil return pipe (45) is connected to a second oil level control valve (47b). The refrigeration-facility-side branch pipe (46b) is connected to a third oil level control valve (47c). The indoor-side branch pipe (46c) is connected to a fourth oil level control valve (47d).

[0063] A portion of oil separated in the oil separator (43) returns to the second compressor (22) via the first oil return pipe (44). Another portion of the oil separated in the oil separator (43) returns to the third compressor (23) via the second oil return pipe (45). The remaining portion of the oil separated in the oil separator (43) returns to the oil reservoir in the casing of each of the second compressor (22) and the third compressor (23) via the third oil return pipe (46).

<Check Valve>

[0064] The outdoor circuit (11) has a first check valve (CV1), a second check valve (CV2), a third check valve (CV3), a fourth check valve (CV4), a fifth check valve (CV5), a sixth check valve (CV6), a seventh check valve (CV7), an eighth check valve (CV8), and a ninth check valve (CV9). Each of these check valves (CV1 to CV9) allows the refrigerant to flow in the direction of the associated arrow shown in FIG. 1 and prohibits the refrigerant to flow in the opposite direction.

[0065] The first check valve (CV1) is connected to the first discharge pipe (21b). The second check valve (CV2) is connected to the second discharge pipe (22b). The third check valve (CV3) is connected to the third discharge pipe (23b). The fourth check valve (CV4) is connected to the second outdoor pipe (o2). The fifth check valve (CV5) is connected to the third outdoor pipe (o3). The sixth check valve (CV6) is connected to the sixth outdoor pipe (o6). The seventh check valve (CV7) is connected to the seventh outdoor pipe (o7). The eighth check valve (CV8) is connected to the second bypass pipe (24b). The ninth check valve (CV9) is connected to the third bypass pipe (24c).

<Sensor>

[0066] The heat source unit (10) includes various sensors. The sensors include a high-pressure sensor (71), an intermediate-pressure sensor (72), a first low-pressure sensor (73), a second low-pressure sensor (74), and a liquid refrigerant pressure sensor (75).

[0067] The high-pressure sensor (71) detects the pressure of the refrigerant (the pressure (HP) of a high-pressure refrigerant) discharged from the first compressor (21). The intermediate-pressure sensor (72) detects the pressure of the refrigerant in the intermediate flow path (41), i.e., the pressure of the refrigerant between the first compressor (21) and a pair of the second and third compressors (22) and (23) (the pressure (MP) of an intermediate-pressure refrigerant). The first low-pressure sensor (73) detects the pressure of the refrigerant (the pressure (LP1) of a first low-pressure refrigerant) to be sucked by the second compressor (22). The second low-pressure sensor (74) detects the pressure of the refrigerant (the pressure (LP2) of a second low-pressure refrigerant) to be sucked by the third compressor (23). The liquid refrigerant pressure sensor (75) detects the pressure of the liquid refrigerant (the pressure (RP) of the liquid refrigerant) in the gas-liquid separator (15).

-Air-Conditioning Unit-

[0068] The air-conditioning units (50) are utilization units installed indoors. The air-conditioning units (50) each condition air in an indoor space. The air-conditioning units (50) each include an indoor fan (52) and an indoor circuit (51). The liquid end of the indoor circuit (51)

is connected to the first liquid connection pipe (2). The gas end of the indoor circuit (51) is connected to the first gas connection pipe (3).

[0069] The indoor circuit (51) includes an indoor expansion valve (53) and an indoor heat exchanger (54) in order from the liquid end to the gas end. The indoor expansion valve (53) is a first utilization expansion valve. The indoor expansion valve (53) is an electronic expansion valve having a variable opening degree.

[0070] The indoor heat exchanger (54) is a fin-and-tube air heat exchanger. The indoor fan (52) is disposed near the indoor heat exchanger (54). The indoor fan (52) transfers indoor air. The indoor heat exchanger (54) exchanges heat between a refrigerant flowing therethrough and indoor air transferred from the indoor fan (52).

[0071] The air-conditioning units (50) each include an indoor controller (102). Although not shown, the air-conditioning units (50) each include a plurality of temperature sensors. The temperature sensors of each air-conditioning unit (50) include a sensor configured to measure the temperature of indoor air and a sensor configured to measure the temperature of the refrigerant flowing through the indoor circuit (51).

-Main Controller-

[0072] As illustrated in FIG. 2, the main controller (100) includes an outdoor controller (101) for the heat source unit (10) and the indoor controllers (102) for the respective air-conditioning units (50). The outdoor controller (101) and each of the indoor controllers (102) forming the main controller (100) are connected together through a communication line to be capable of communicating with each other.

[0073] The outdoor controller (101) and the indoor controllers (102) each include a microcomputer mounted on a control board, and a memory device (specifically, a semiconductor memory) storing software for operating the microcomputer. The main controller (100) controls various components of the refrigeration apparatus (1) based on detection signals of the various sensors.

[0074] The outdoor controller (101) controls the compression element (C) so that a value measured by the high-pressure sensor (71) (the pressure (HP) of the high-pressure refrigerant) is greater than or equal to the critical pressure of the refrigerant (in the present embodiment, carbon dioxide). The outdoor controller (101) controls the outdoor expansion valve (14) so that the refrigerant pressure in the gas-liquid separator (15) (specifically, a value measured by the liquid refrigerant pressure sensor (75)) is less than the critical pressure of the refrigerant.

[0075] The outdoor controller (101) controls the cooling capability of the subcooling heat exchanger (16). Specifically, the outdoor controller (101) controls the decompression valve (40) so that the refrigerant flowing out of the subcooling heat exchanger (16) is subcooled.

[0076] The indoor controllers (102) each control the operation of the associated air-conditioning unit (50) so

that the temperature of air sucked into the associated air-conditioning unit (50) becomes equal to a set temperature. Specifically, the indoor controllers (102) each control the associated indoor expansion valve (53) and the associated indoor fan (52).

-Refrigeration-Facility Unit-

[0077] The refrigeration-facility units (60) are each, for example, a refrigerated show case installed in a store, such as a convenience store. Each refrigeration-facility unit (60) is a utilization unit that is installed indoors to cool air in the show case (inside air). The refrigeration-facility unit (60) includes a refrigeration-facility fan (62) and a refrigeration-facility circuit (61). The liquid end of the refrigeration-facility circuit (61) is connected to the associated liquid-side branch pipe (4c) of the second liquid connection pipe (4). The gas end of the refrigeration-facility circuit (61) is connected to the associated gas-side branch pipe (5c) of the second gas connection pipe (5).

[0078] The refrigeration-facility circuit (61) includes a refrigeration-facility expansion valve (63) and a refrigeration-facility heat exchanger (64) in order from the liquid end to the gas end. The refrigeration-facility expansion valve (63) is configured as an electronic expansion valve having a variable opening degree.

[0079] The refrigeration-facility heat exchanger (64) is a fin-and-tube air heat exchanger. The refrigeration-facility fan (62) is disposed near the refrigeration-facility heat exchanger (64). The refrigeration-facility fan (62) transfers inside air. The refrigeration-facility heat exchanger (64) exchanges heat between the refrigerant flowing therethrough and inside air transferred from the refrigeration-facility fan (62).

[0080] The refrigeration-facility units (60) each include a refrigeration-facility controller (103). Although not shown, the refrigeration-facility units (60) each include a plurality of temperature sensors. The temperature sensors of each refrigeration-facility unit (60) include a sensor configured to measure the temperature of inside air and a sensor configured to measure the temperature of the refrigerant flowing through the refrigeration-facility circuit (61).

[0081] As illustrated in FIG. 2, the refrigeration-facility controllers (103) each include a microcomputer mounted on a control board, and a memory device (specifically, a semiconductor memory) storing software for operating the microcomputer. The refrigeration-facility controllers (103) do not communicate with the outdoor controller (101) and the indoor controllers (102).

[0082] Each refrigeration-facility controller (103) controls the associated refrigeration-facility expansion valve (63) and the associated refrigeration-facility fan (62) based on detection signals of the various sensors. The refrigeration-facility controller (103) adjusts the opening degree of the associated refrigeration-facility expansion valve (63) so that the degree of superheat of the refrigerant

erant at the outlet of the associated refrigeration-facility heat exchanger (64) functioning as an evaporator becomes equal to a predetermined target value. If the temperature of inside air falls within a set temperature range, the refrigeration-facility controller (103) allows a cooling operation of the associated refrigeration-facility unit (60) to be suspended. In this cooling-suspended state, while the refrigeration-facility fan (62) operates, the refrigeration-facility expansion valve (63) is closed.

-Intermediate Unit-

[0083] The intermediate unit (80) is separate from the heat source unit (10), the air-conditioning units (50), and the refrigeration-facility units (60). The intermediate unit (80) includes a liquid-side pipe (81), a gas-side pipe (82), and a joint pipe (83). Although not shown, the intermediate unit (80) includes a casing that houses the liquid-side pipe (81), the gas-side pipe (82), and the joint pipe (83). The intermediate unit (80) is installed indoors together with the refrigeration-facility units (60).

[0084] One end of the liquid-side pipe (81) is connected to the first liquid-side trunk pipe (4a) of the second liquid connection pipe (4), and the other end thereof is connected to the second liquid-side trunk pipe (4b) of the second liquid connection pipe (4). As can be seen, the liquid-side pipe (81) is connected to the liquid-side trunk pipes (4a, 4b) of the second liquid connection pipe (4) connecting the heat source unit (10) and the refrigeration-facility units (60) together.

[0085] The liquid-side pipe (81) is provided with the first valve (18) and a refrigerant pressure sensor (48) in order from the one end to the other end thereof. Thus, the refrigerant pressure sensor (48) is disposed in a portion of the liquid-side pipe (81) closer to the refrigeration-facility units (60) than the first valve (18) is.

[0086] The first valve (18) is a control valve having a variable opening degree. The first valve (18) of the present embodiment is an electronic expansion valve including a pulse motor that drives its valve body. The refrigerant pressure sensor (48) measures the pressure of the refrigerant flowing through the liquid-side pipe (81). A value measured by the refrigerant pressure sensor (48) is substantially equal to the pressure of the refrigerant flowing through the liquid-side pipe (81) into the second liquid-side trunk pipe (4b).

[0087] One end of the gas-side pipe (82) is connected to the first gas-side trunk pipe (5a) of the second gas connection pipe (5), and the other end thereof is connected to the second gas-side trunk pipe (5b) of the second gas connection pipe (5). As can be seen, the gas-side pipe (82) is connected to the gas-side trunk pipes (5a, 5b) of the second gas connection pipe (5) connecting the heat source unit (10) and the refrigeration-facility units (60) together.

[0088] One end of the joint pipe (83) is connected to the liquid-side pipe (81), and the other end thereof is connected to the gas-side pipe (82). The one end of the joint

pipe (83) is connected to a portion of the liquid-side pipe (81) closer to the second liquid-side trunk pipe (4b) than the first valve (18) is. The one end of the joint pipe (83) of the present embodiment is connected to a portion of the liquid-side pipe (81) closer to the second liquid-side trunk pipe (4b) than the refrigerant pressure sensor (48) is. Note that the one end of the joint pipe (83) may be connected to a portion of the liquid-side pipe (81) between the first valve (18) and the refrigerant pressure sensor (48).

[0089] The joint pipe (83) is provided with a second valve (19). The second valve (19) is a control valve having a variable opening degree. The second valve (19) of the present embodiment is an electronic expansion valve including a pulse motor that drives its valve body.

[0090] The intermediate unit (80) includes a hydraulic pressure controller (85). The hydraulic pressure controller (85) is connected to the first valve (18), the second valve (19), and the refrigerant pressure sensor (48) via communication lines. The hydraulic pressure controller (85) controls the first and second valves (18) and (19) based on the value measured by the refrigerant pressure sensor (48).

[0091] As illustrated in FIG. 2, the hydraulic pressure controller (85) includes a microcomputer mounted on a control board, and a memory device (specifically, a semiconductor memory) storing software for operating the microcomputer. The hydraulic pressure controller (85) does not communicate with the outdoor controller (101), the indoor controllers (102), and the refrigeration-facility controllers (103).

-Operation of Refrigeration Apparatus-

[0092] An operation of the refrigeration apparatus (1) will be described. The refrigeration apparatus (1) can perform a cooling operation and a heating operation. The cooling operation is an operation in which the air-conditioning units (50) cool the respective indoor spaces. The heating operation is an operation in which the air-conditioning units (50) heat the respective indoor spaces. In each of the cooling operation and the heating operation, the refrigeration-facility units (60) are each either in an active state or in the cooling-suspended state.

<Cooling Operation>

[0093] The cooling operation of the refrigeration apparatus (1) will be described with reference to FIG. 3. The cooling operation will be hereinafter described using an example in which the refrigeration-facility units (60) are in the active state.

[0094] In the cooling operation illustrated in FIG. 3, the refrigerant circuit (6) allows the refrigerant to circulate therethrough to perform a refrigeration cycle. The outdoor heat exchanger (13) functions as a radiator (a gas cooler), and the refrigeration-facility heat exchangers (64) and the indoor heat exchangers (54) function as

evaporators.

[0095] In the cooling operation illustrated in FIG. 3, the first three-way valve (TV1) is set in the second state, and the second three-way valve (TV2) is set in the first state. The outdoor expansion valve (14), the refrigeration-facility expansion valves (63), the indoor expansion valves (53), the decompression valve (40), and the first valve (18) have their opening degrees adjusted as appropriate. The outdoor fan (12), the cooling fan (17a), the refrigeration-facility fans (62), and the indoor fans (52) operate. The first, second, and third compressors (21), (22), and (23) operate.

[0096] The refrigerant that has been compressed in each of the second and third compressors (22) and (23) dissipates heat to outdoor air in the intercooler (17), and is then sucked into the first compressor (21). The refrigerant that has been compressed in the first compressor (21) dissipates heat to outdoor air in the outdoor heat exchanger (13), and is then decompressed while passing through the outdoor expansion valve (14). The decompressed refrigerant has a pressure that is lower than a second pressure (critical pressure). This refrigerant passes through the gas-liquid separator (15), and is then cooled in the subcooling heat exchanger (16). A portion of the refrigerant that has been cooled in the subcooling heat exchanger (16) flows into the eighth outdoor pipe (o8), and the remaining portion thereof flows into the sixth outdoor pipe (o6).

[0097] The refrigerant that has flowed into the sixth outdoor pipe (o6) flows through the first liquid connection pipe (2), and is distributed among the plurality of air-conditioning units (50). In each air-conditioning unit (50), the refrigerant that has flowed into the indoor circuit (51) is decompressed while passing through the indoor expansion valve (53), and then absorbs heat from the indoor air to evaporate in the indoor heat exchanger (54). The air-conditioning unit (50) blows the air cooled in the indoor heat exchanger (54) into the indoor space. The flows of the refrigerant that has flowed out of the indoor heat exchangers (54) of the air-conditioning units (50) enter the first gas connection pipe (3) to merge together. Thereafter, this refrigerant flows into the outdoor circuit (11), and is then sucked into the third compressor (23) so as to be again compressed.

[0098] The refrigerant that has flowed into the eighth outdoor pipe (o8) flows through the first liquid-side trunk pipe (4a) of the second liquid connection pipe (4) into the liquid-side pipe (81) of the intermediate unit (80). The refrigerant that has flowed into the liquid-side pipe (81) is decompressed while passing through the first valve (18), then passes through the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) of the second liquid connection pipe (4), and is distributed among the plurality of refrigeration-facility units (60).

[0099] In each refrigeration-facility unit (60), the refrigerant that has flowed into the refrigeration-facility circuit (61) is decompressed while passing through the refrigeration-facility expansion valve (63), and then absorbs

heat from the inside air to evaporate in the refrigeration-facility heat exchanger (64). The refrigeration-facility unit (60) blows the air cooled in the refrigeration-facility heat exchanger (64) into a space inside the refrigeration-facility.

[0100] The flows of the refrigerant that has flowed out of the refrigeration-facility heat exchangers (64) of the refrigeration-facility units (60) enter the second gas connection pipe (5) to merge together. Thereafter, this refrigerant flows into the gas-side pipe (82) of the intermediate unit (80), passes through the gas-side pipe (82), and then flows through the first gas-side trunk pipe (5a) into the outdoor circuit (11). Thereafter, the refrigerant is sucked into the second compressor (22) so as to be again compressed.

<Heating Operation>

[0101] The heating operation of the refrigeration apparatus (1) will be described with reference to FIG. 4. The heating operation will be hereinafter described using an example in which the refrigeration-facility units (60) are in the active state.

[0102] In the heating operation illustrated in FIG. 4, the refrigerant circuit (6) allows the refrigerant to circulate therethrough to perform a refrigeration cycle. The indoor heat exchangers (54) function as radiators (gas coolers), and the refrigeration-facility heat exchangers (64) and the outdoor heat exchanger (13) function as evaporators. Note that, in the heating operation, the refrigeration apparatus (1) of the present embodiment is operable either in a mode in which the outdoor heat exchanger (13) functions as a radiator or in a mode in which the outdoor heat exchanger (13) is suspended.

[0103] In the heating operation illustrated in FIG. 4, the first three-way valve (TV1) is set in the first state, and the second three-way valve (TV2) is set in the second state. The outdoor expansion valve (14), the refrigeration-facility expansion valves (63), the indoor expansion valves (53), the decompression valve (40), and the first valve (18) have their opening degrees adjusted as appropriate. The outdoor fan (12), the refrigeration-facility fans (62), and the indoor fans (52) operate, and the cooling fan (17a) is suspended. The first, second, and third compressors (21), (22), and (23) operate.

[0104] The refrigerant that has been compressed in each of the second and third compressors (22) and (23) passes through the intercooler (17), and is then sucked into the first compressor (21). The refrigerant that has been compressed in the first compressor (21) flows through the first gas connection pipe (3), and is distributed among the plurality of air-conditioning units (50). In each air-conditioning unit (50), the refrigerant that has flowed into the indoor circuit (51) dissipates heat to the indoor air in the indoor heat exchanger (54), and then flows into the first liquid connection pipe (2) after passing through the indoor expansion valve (53). The air-conditioning unit (50) blows the air heated in the indoor heat

exchanger (54) into the indoor space.

[0105] The flows of the refrigerant that has flowed out of the air-conditioning units (50) into the first liquid connection pipe (2) merge together. Thereafter, this refrigerant flows through the seventh outdoor pipe (o7) of the outdoor circuit (11) into the gas-liquid separator (15), and is then cooled in the subcooling heat exchanger (16). A portion of the refrigerant that has been cooled in the subcooling heat exchanger (16) flows into the fifth outdoor pipe (o5), and the remaining portion thereof flows into the third outdoor pipe (o3).

[0106] The refrigerant that has flowed into the fifth outdoor pipe (o5) then flows through the eighth outdoor pipe (o8) and the first liquid-side trunk pipe (4a) of the second liquid connection pipe (4) in this order into the liquid-side pipe (81) of the intermediate unit (80). The refrigerant that has flowed into the liquid-side pipe (81) is decompressed while passing through the first valve (18), then passes through the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) of the second liquid connection pipe (4), and is distributed among the plurality of refrigeration-facility units (60).

[0107] In each refrigeration-facility unit (60), the refrigerant that has flowed into the refrigeration-facility circuit (61) is decompressed while passing through the refrigeration-facility expansion valve (63), and then absorbs heat from the inside air to evaporate in the refrigeration-facility heat exchanger (64). The refrigeration-facility unit (60) blows the air cooled in the refrigeration-facility heat exchanger (64) into a space inside the refrigeration-facility.

[0108] The flows of the refrigerant that has flowed out of the refrigeration-facility heat exchangers (64) of the refrigeration-facility units (60) enter the second gas connection pipe (5) to merge together. Thereafter, this refrigerant flows into the gas-side pipe (82) of the intermediate unit (80), passes through the gas-side pipe (82), and then flows through the first gas-side trunk pipe (5a) into the outdoor circuit (11). Thereafter, the refrigerant is sucked into the second compressor (22) so as to be again compressed.

[0109] The refrigerant that has flowed into the third outdoor pipe (o3) is decompressed while passing through the outdoor expansion valve (14), then flows into the outdoor heat exchanger (13), and absorbs heat from the outdoor air to evaporate in the outdoor heat exchanger (13). The refrigerant that has flowed out of the outdoor heat exchanger (13) is sucked into the third compressor (23) so as to be again compressed.

<Cooling-Suspended State of Refrigeration-Facility Unit>

[0110] While there is no need to cool the inside air, the associated refrigeration-facility unit (60) is in the cooling-suspended state. Specifically, if the inside air sucked into each refrigeration-facility unit (60) has a temperature that falls below the lower limit of a predetermined target range,

the refrigeration-facility controller (103) of the refrigeration-facility unit (60) closes the refrigeration-facility expansion valve (63) to change the state of the refrigeration-facility unit (60) from the active state to the cooling-suspended state. In this cooling-suspended state, the refrigeration-facility fan (62) keeps operating. The refrigeration-facility expansion valve (63) closed prevents the refrigerant from being supplied from the second liquid connection pipe (4) to the refrigeration-facility unit (60), thereby stopping the cooling of air in the refrigeration-facility heat exchanger (64).

[0111] If the inside air sucked into each refrigeration-facility unit (60) has a temperature that exceeds the upper limit of the predetermined target range, the refrigeration-facility controller (103) opens the refrigeration-facility expansion valve (63) to change the state of the refrigeration-facility unit (60) from the cooling-suspended state to the active state. If the state of the refrigeration-facility unit (60) is changed from the cooling-suspended state to the active state, the cooling of air in the refrigeration-facility heat exchanger (64) is restarted.

[0112] If all of the refrigeration-facility units (60) are in the cooling-suspended state during operation of the second compressor (22), the refrigerant pressure in the second gas connection pipe (5) decreases. As a result, a value measured by the first low-pressure sensor (73) decreases. If the value measured by the first low-pressure sensor (73) thus falls below a predetermined first reference value, the outdoor controller (101) stops the second compressor (22).

[0113] If the state of at least one of the refrigeration-facility units (60) is changed from the cooling-suspended state to the active state during the stop of the second compressor (22), the refrigerant pressure in the second gas connection pipe (5) increases. As a result, the value measured by the first low-pressure sensor (73) increases. If the value measured by the first low-pressure sensor (73) thus exceeds a predetermined second reference value, the outdoor controller (101) actuates the second compressor (22).

-Control Operation of Hydraulic Pressure Controller-

[0114] A control operation performed by the hydraulic pressure controller (85) of the intermediate unit (80) will be described.

[0115] The hydraulic pressure controller (85) controls the first and second valves (18) and (19) so that the refrigerant pressure in the refrigeration-facility circuit (61) of each refrigeration-facility unit (60) is kept at or below the refrigerant pressure that can be allowed by the refrigeration-facility circuit (61). The refrigerant pressure that can be allowed by the refrigeration-facility circuit (61) is the allowable pressure P_u of the refrigeration-facility unit (60). The allowable pressure P_u of the refrigeration-facility unit (60) of the present embodiment is 6 MPa ($P_u = 6 \text{ MPa}$). Note that the pressure value used to describe the control operation of the hydraulic pressure controller

(85) is merely an example.

[0116] Here, if each refrigeration-facility unit (60) is in the active state, the value measured by the refrigerant pressure sensor (48) is slightly higher than the pressure of the refrigerant at the inlet of the refrigeration-facility circuit (61). The reason for this is that the refrigerant has its pressure gradually reduced, while flowing through the second liquid-side trunk pipe (4b) and the liquid-side branch pipe (4c). Meanwhile, the hydraulic pressure controller (85) of the present embodiment controls the opening degrees of the first and second valves (18) and (19) so that the value P_k measured by the refrigerant pressure sensor (48) is lower than the allowable pressure P_u of the refrigeration-facility units (60), as will be described below. Thus, the hydraulic pressure controller (85) controlling the first and second valves (18) and (19) allows the pressure of the refrigerant flowing into the refrigeration-facility circuit (61) of each refrigeration-facility unit (60) to be kept below the allowable pressure P_u of the refrigeration-facility unit (60).

<Control of First Valve>

[0117] An operation performed by the hydraulic pressure controller (85) to control the opening degree of the first valve (18) will be described with reference to the flowchart shown in FIG. 6. The hydraulic pressure controller (85) repeatedly performs the control operation shown in the flowchart of FIG. 6 at predetermined time intervals (e.g., 30 seconds).

[0118] In the process performed in step ST1, the hydraulic pressure controller (85) reads the value P_k measured by the refrigerant pressure sensor (48), and compares the measured value P_k with a first reference pressure $PL1$. The first reference pressure $PL1$ is lower than the allowable pressure P_u of the refrigeration-facility units (60) ($PL1 < P_u$). The first reference pressure $PL1$ of the present embodiment is 4.5 MPa.

[0119] In the process performed in step ST1, if the value P_k measured by the refrigerant pressure sensor (48) is less than or equal to the first reference pressure $PL1$ ($P_k \leq PL1$), the hydraulic pressure controller (85) performs a process in step ST2. On the other hand, if the value P_k measured by the refrigerant pressure sensor (48) exceeds the first reference pressure $PL1$ ($P_k > PL1$), the hydraulic pressure controller (85) performs a process in step ST3.

[0120] In the process performed in step ST2, the hydraulic pressure controller (85) makes the first valve (18) fully open. In other words, in the process performed in step ST2, the hydraulic pressure controller (85) sets the opening degree of the first valve (18) at a maximum value.

[0121] In the process performed in step ST3, the hydraulic pressure controller (85) compares the value P_k measured by the refrigerant pressure sensor (48) with a second reference pressure $PL2$. The second reference pressure $PL2$ is lower than the allowable pressure P_u of the refrigeration-facility units (60), and is higher than the

first reference pressure $PL1$ ($PL1 < PL2 < P_u$). The second reference pressure $PL2$ of the present embodiment is 5.2 MPa.

[0122] In the process performed in step ST3, if the value P_k measured by the refrigerant pressure sensor (48) is greater than or equal to the second reference pressure $PL2$ ($PL2 \leq P_k$), the hydraulic pressure controller (85) performs a process in step ST4. On the other hand, if the value P_k measured by the refrigerant pressure sensor (48) falls below the second reference pressure $PL2$ ($P_k < PL2$), the hydraulic pressure controller (85) performs a process in step ST5.

[0123] In the process performed in step ST4, the hydraulic pressure controller (85) makes the first valve (18) fully closed. In other words, in the process performed in step ST4, the hydraulic pressure controller (85) sets the opening degree of the first valve (18) to be substantially zero.

[0124] In the process performed in step ST5, the hydraulic pressure controller (85) adjusts the opening degree of the first valve (18) in accordance with the value P_k measured by the refrigerant pressure sensor (48). Specifically, the hydraulic pressure controller (85) performs proportional-integral-derivation (PID) control to adjust the opening degree of the first valve (18) so that the value P_k measured by the refrigerant pressure sensor (48) becomes equal to a third reference pressure $PL3$. The third reference pressure $PL3$ is greater than the first reference pressure $PL1$, and is less than the second reference pressure $PL2$ ($PL1 < PL3 < PL2$). The third reference pressure $PL3$ of the present embodiment is 4.8 MPa. Note that the hydraulic pressure controller (85) may adjust the opening degree of the first valve (18) using a control system except the PID control.

[0125] As described above, the hydraulic pressure controller (85) adjusts the opening degree of the first valve (18) so that the value P_k measured by the refrigerant pressure sensor (48) becomes less than or equal to the second reference pressure $PL2$. As a result, the pressure of the refrigerant to be supplied through the second liquid connection pipe (4) from the intermediate unit (80) to the refrigeration-facility units (60) in the active state is kept below the allowable pressure P_u of the refrigeration-facility units (60).

<Control of Second Valve>

[0126] An operation performed by the hydraulic pressure controller (85) to control the opening degree of the second valve (19) will be described with reference to FIG. 7.

[0127] The hydraulic pressure controller (85) reads the value P_k measured by the refrigerant pressure sensor (48) at predetermined time intervals (e.g., one second). The hydraulic pressure controller (85) sets the opening degree of the second valve (19) in accordance with the value P_k measured by the refrigerant pressure sensor (48).

[0128] If the value P_k measured by the refrigerant pressure sensor (48) is less than a fourth reference pressure PL_4 ($P_k < PL_4$), the hydraulic pressure controller (85) makes the second valve (19) fully closed. In other words, in this case, the hydraulic pressure controller (85) sets the opening degree of the second valve (19) to be substantially zero. The fourth reference pressure PL_4 is greater than the second reference pressure PL_2 , and is less than the allowable pressure P_u ($PL_2 < PL_4 < P_u$). The fourth reference pressure PL_4 of the present embodiment is 5.4 MPa.

[0129] If the value P_k measured by the refrigerant pressure sensor (48) is greater than or equal to a fifth reference pressure PL_5 ($PL_5 \leq P_k$), the hydraulic pressure controller (85) makes the second valve (19) fully open. In other words, in this case, the hydraulic pressure controller (85) sets the opening degree of the second valve (19) at a maximum value. The fifth reference pressure PL_5 is greater than the fourth reference pressure PL_4 , and is less than the allowable pressure P_u ($PL_4 < PL_5 < P_u$). The fifth reference pressure PL_5 of the present embodiment is 5.8 MPa.

[0130] If the value P_k measured by the refrigerant pressure sensor (48) is greater than or equal to the fourth reference pressure PL_4 and less than or equal to the fifth reference pressure PL_5 ($PL_4 \leq P_k \leq PL_5$), the hydraulic pressure controller (85) sets the opening degree of the second valve (19) to be a value proportional to the value P_k measured by the refrigerant pressure sensor (48).

[0131] Specifically, the hydraulic pressure controller (85) sets the opening degree of the second valve (19) to be a value proportional to the difference between the value P_k measured by the refrigerant pressure sensor (48) and the fourth reference pressure PL_4 ($P_k - PL_4$). If the value P_k measured by the refrigerant pressure sensor (48) is equal to the fourth reference pressure PL_4 ($P_k = PL_4$), the hydraulic pressure controller (85) sets the opening degree of the second valve (19) to be substantially zero. On the other hand, if the value P_k measured by the refrigerant pressure sensor (48) is equal to the fifth reference pressure PL_5 ($P_k = PL_5$), the hydraulic pressure controller (85) sets the opening degree of the second valve (19) at a maximum value.

[0132] As described above, if the value P_k measured by the refrigerant pressure sensor (48) is greater than or equal to the second reference pressure PL_2 ($PL_2 \leq P_k$), the hydraulic pressure controller (85) makes the first valve (18) fully closed. The fourth reference pressure PL_4 is higher than the second reference pressure PL_2 ($PL_2 < PL_4$). Thus, if the value P_k measured by the refrigerant pressure sensor (48) is greater than the second reference pressure PL_2 even with the first valve (18) closed, the hydraulic pressure controller (85) opens the second valve (19).

-Refrigerant Pressure Acting on Refrigeration-Facility Expansion Valve of Refrigeration-Facility Unit-

[0133] If the refrigeration-facility units (60) are in the active state, the hydraulic pressure controller (85) adjusts the opening degree of the first valve (18) so that the value P_k measured by the refrigerant pressure sensor (48) becomes less than or equal to the second reference pressure PL_2 . Thus, if the refrigeration-facility units (60) are in the active state, the refrigerant pressure acting on the refrigeration-facility expansion valves (63) is kept below the allowable pressure P_u of the refrigeration-facility units (60).

[0134] On the other hand, if the temperature of the inside air falls within a set temperature range, the associated refrigeration-facility controller (103) closes the associated refrigeration-facility expansion valve (63) to change the state of the associated refrigeration-facility unit (60) from the active state to the cooling-suspended state. If all of the refrigeration-facility units (60) are in the cooling-suspended state, the refrigerant pressure in the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) increases. As a result, the value P_k measured by the refrigerant pressure sensor (48) increases. If the value P_k measured by the refrigerant pressure sensor (48) then increases to a value greater than or equal to the second reference pressure PL_2 , the hydraulic pressure controller (85) closes the first valve (18).

[0135] As can be seen, if all of the refrigeration-facility units (60) are in the cooling-suspended state, the refrigeration-facility expansion valves (63) of all of the refrigeration-facility units (60) and the first valve (18) of the intermediate unit (80) are closed. In this state, a portion of the refrigerant circuit (6) between the refrigeration-facility expansion valves (63) and the first valve (18) (the portion indicated by the thick line in FIG. 5) encloses the refrigerant. If the temperatures around the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) are relatively high, the pressure of the refrigerant enclosed in the portion of the refrigerant circuit (6) between the refrigeration-facility expansion valves (63) and the first valve (18) (the portion indicated by the thick line in FIG. 5) increases. This may cause the refrigerant pressure acting on the refrigeration-facility expansion valves (63) to exceed the allowable pressure P_u of the refrigeration-facility units (60) unless some countermeasure is taken.

[0136] To address this problem, the hydraulic pressure controller (85) of the intermediate unit (80) of the present embodiment controls the opening degree of the second valve (19). Specifically, if the value P_k measured by the refrigerant pressure sensor (48) exceeds the fourth reference pressure PL_4 , the hydraulic pressure controller (85) opens the second valve (19). The open second valve (19) allows a portion of the refrigerant present in the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) to flow through the joint pipe (83) to the gas-side pipe (82) and the gas connection pipe (5). As a result,

the refrigerant pressure in the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) decreases.

[0137] As can be seen, in the refrigeration apparatus (1) including the intermediate unit (80) of the present embodiment, even if all of the refrigeration-facility units (60) are in the cooling-suspended state, the refrigerant pressure acting on the refrigeration-facility expansion valves (63) of the refrigeration-facility units (60) is kept below the allowable pressure P_u of the refrigeration-facility units (60).

[0138] Here, in principle, the second valve (19) opens when all of the refrigeration-facility units (60) are in the cooling-suspended state and the second compressor (22) is stopped. If the second valve (19) opens during operations of the first and third compressors (21) and (23), the refrigerant present in the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) is drawn by the first compressor (21). Specifically, the refrigerant present in the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) flows through the joint pipe (83), the gas-side pipe (82), and the gas connection pipe (5) in this order into the outdoor circuit (11), and joins the refrigerant discharged from the third compressor (23) after passing through the second bypass pipe (24b). The resultant refrigerant is subsequently sucked into the first compressor (21) after passing through the intercooler (17).

[0139] In some cases, the hydraulic controller (85) opens the second valve (19) while all of the compressors (21, 22, 23) are stopped. In such a case, the first compressor (21) may be started, and the refrigerant present in the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) may be drawn into the first compressor (21). This causes the refrigerant present in the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) to turn into the form of single-phase gas while passing through the intercooler (17), and to be then sucked into the first compressor (21).

- Feature (1) of Embodiment -

[0140] The intermediate unit (80) of the present embodiment is provided between the heat source unit (10) and the refrigeration-facility units (60), which are connected together through the liquid connection pipe (4) and the gas connection pipe (5) to form part of the refrigeration apparatus (1). The intermediate unit (80) includes the liquid-side pipe (81), the first valve (18), the refrigerant pressure sensor (48), and the hydraulic pressure controller (85). The liquid-side pipe (81) is connected to the liquid connection pipe (4). The first valve (18) is a valve provided for the liquid-side pipe (81) and having a variable opening degree. The refrigerant pressure sensor (48) is disposed in a portion of the liquid-side pipe (81) closer to the refrigeration-facility units (60) than the first valve (18) is, and measures the pressure of the refrigerant flowing through the liquid-side pipe (81). The hydraulic pressure controller (85) adjusts the opening degree

of the first valve (18) based on the value measured by the refrigerant pressure sensor (48).

[0141] In the refrigeration apparatus (1) of the present embodiment, the refrigerant sent out from the heat source unit (10) and flowing through the liquid connection pipe (4) is supplied to the refrigeration-facility units (60) after passing through the liquid-side pipe (81) of the intermediate unit (80). The hydraulic pressure controller (85) changing the opening degree of the first valve (18) for the liquid-side pipe (81) triggers a change in the pressure of the refrigerant that has passed through the first valve (18). The hydraulic pressure controller (85) changing the opening degree of the first valve (18) based on the value measured by the refrigerant pressure sensor (48) triggers a change in the pressure of the refrigerant to be sent from the intermediate unit (80) to the refrigeration-facility units (60).

[0142] In the refrigeration apparatus (1) of the present embodiment, the intermediate unit (80) adjusts the pressure of the refrigerant flowing into the refrigeration-facility units (60). For this reason, even if the heat source unit (10) does not perform control with consideration given to the allowable pressure of the refrigeration-facility units (60), the refrigeration-facility units (60) having an allowable pressure that is lower than that of the heat source unit (10) can be connected to the heat source unit (10). Thus, according to the present embodiment, various models of refrigeration-facility units can be connected to the heat source unit (10) without complicating the manner of control performed by the heat source unit (10).

- Feature (2) of Embodiment -

[0143] The intermediate unit (80) of the present embodiment includes the gas-side pipe (82), the joint pipe (83), and the second valve (19). The gas-side pipe (82) is connected to the gas connection pipe (5). The joint pipe (83) connects the portion of the liquid-side pipe (81) closer to the refrigeration-facility units (60) than the first valve (18) is and the gas-side pipe (82) together. The second valve (19) is provided for the joint pipe (83).

[0144] Here, while the refrigeration-facility expansion valves (63) of the refrigeration-facility units (60) and the first valve (18) of the intermediate unit (80) are all closed, the refrigerant is enclosed in a portion of the liquid connection pipe (4) between the intermediate unit (80) and the refrigeration-facility units (60). If this state occurs while the air temperature around the liquid connection pipe (4) is high, the internal pressure of the liquid connection pipe (4) increases. This may damage the refrigeration-facility units (60).

[0145] To address this problem, the intermediate unit (80) of the present embodiment includes the joint pipe (83) connecting the liquid-side pipe (81) and the gas-side pipe (82) together and provided with the second valve (19). While the second valve (19) is open, the portion of the liquid connection pipe (4) between the intermediate unit (80) and the refrigeration-facility units (60) commu-

nicates with the gas connection pipe (5) via the joint pipe (83). This can substantially prevent the internal pressure of the liquid connection pipe (4) from increasing excessively while the refrigeration-facility expansion valves (63) of the refrigeration-facility units (60) and the first valve (18) of the intermediate unit (80) are all closed. As a result, the refrigeration-facility units (60) can be substantially prevented from being damaged.

- Feature (3) of Embodiment -

[0146] In the intermediate unit (80) of the present embodiment, the hydraulic pressure controller (85) adjusts the opening degree of the first valve (18) so that the value measured by the refrigerant pressure sensor (48) becomes less than or equal to the second reference pressure PL2. If the value measured by the refrigerant pressure sensor (48) exceeds "the fourth reference pressure PL4 higher than the second reference pressure PL2" even with the first valve (18) closed, the hydraulic pressure controller (85) opens the second valve (19).

[0147] The hydraulic pressure controller (85) of the intermediate unit (80) of the present embodiment controls the first and second valves (18) and (19). The hydraulic pressure controller (85) controlling the first valve (18) allows the pressure of the refrigerant that is about to be supplied from the intermediate unit (80) to the refrigeration-facility units (60) to be substantially kept at or below the second reference pressure PL2. The hydraulic pressure controller (85) controlling the second valve (19) substantially prevents the internal pressure of the portion of the liquid connection pipe (4) between the intermediate unit (80) and the refrigeration-facility units (60) from increasing excessively even while the first valve (18) is closed.

- Feature (4) of Embodiment -

[0148] The intermediate unit (80) of the present embodiment is installed indoors, and is connected to the heat source unit (10) installed outdoors.

[0149] The intermediate unit (80) of the present embodiment is placed indoors. Thus, in the summer when the outdoor air temperature is high, the air temperature around the portion of the liquid connection pipe (4) between the intermediate unit (80) and the refrigeration-facility units (60) is lower than that outdoors. This can substantially prevent the internal pressure of the portion of the liquid connection pipe (4) between the intermediate unit (80) and the refrigeration-facility units (60) from increasing while the refrigeration-facility expansion valves (63) of the refrigeration-facility units (60) and the first valve (18) of the intermediate unit (80) are all closed.

[0150] The intermediate unit (80) may be arranged in the indoor space where the refrigeration-facility units (60) are also arranged. The refrigeration-facility units (60) are typically installed in an indoor space to be air-conditioned by an air-conditioning unit (50). For example, even if the

outdoor air temperature is relatively high in the summer, the air temperature in the indoor space including the intermediate unit (80) and the refrigeration-facility units (60) is lower than the outdoor air temperature. Thus, the intermediate unit (80) installed indoors could substantially prevent the internal pressure of the portion of the liquid connection pipe (4) between the intermediate unit (80) and the refrigeration-facility units (60) from increasing while the refrigeration-facility expansion valves (63) of the refrigeration-facility units (60) and the first valve (18) of the intermediate unit (80) are all closed.

- Feature (5) of Embodiment -

[0151] The refrigeration apparatus (1) of the present embodiment includes the intermediate unit (80), the heat source unit (10), the refrigeration-facility units (60), the liquid connection pipe (4), and the gas connection pipe (5). The liquid connection pipe (4) and the gas connection pipe (5) connect the intermediate unit (80), the heat source unit (10), and the refrigeration-facility units (60) together to form the refrigerant circuit (6).

[0152] In the refrigeration apparatus (1) of the present embodiment, the intermediate unit (80) is disposed between the heat source unit (10) and the refrigeration-facility units (60) in the refrigerant circuit (6). The liquid-side pipe (81) of the intermediate unit (80) is connected to the liquid connection pipe (4). Changing the opening degree of the first valve (18) of the intermediate unit (80) triggers a change in the pressure of the refrigerant to be sent through the liquid connection pipe (4) from the intermediate unit (80) to the refrigeration-facility units (60).

- Feature (6) of Embodiment -

[0153] The refrigeration apparatus (1) of the present embodiment includes the intermediate unit (80), the heat source unit (10), the refrigeration-facility units (60), the liquid connection pipe (4), and the gas connection pipe (5). The liquid connection pipe (4) includes the liquid-side trunk pipes (4a, 4b) connected to the heat source unit (10), and the plurality of liquid-side branch pipes (4c) each connecting an associated one of the refrigeration-facility units (60) to the liquid-side trunk pipes (4a, 4b). The gas connection pipe (5) includes the gas-side trunk pipes (5a, 5b) connected to the heat source unit (10), and the plurality of gas-side branch pipes (5c) each connecting an associated one of the refrigeration-facility units (60) to the gas-side trunk pipes (5a, 5b). The liquid-side pipe (81) of the intermediate unit (80) is connected to the liquid-side trunk pipes (4a, 4b) of the liquid connection pipe (4). The gas-side pipe (82) of the intermediate unit (80) is connected to the gas-side trunk pipes (5a, 5b) of the gas connection pipe (5).

[0154] In the refrigeration apparatus (1) of the present embodiment, the plurality of refrigeration-facility units (60) are connected through the liquid connection pipe (4) and the gas connection pipe (5) to the heat source unit

(10). The intermediate unit (80) is connected to the liquid-side trunk pipes (4a, 4b) of the liquid connection pipe (4) and the gas-side trunk pipes (5a, 5b) of the gas connection pipe (5). The refrigerant that has flowed from the heat source unit (10) into the liquid-side trunk pipes (4a, 4b) of the liquid connection pipe (4) passes through the first valve (18) of the intermediate unit (80), and is then distributed among the plurality of refrigeration-facility units (60).

- First Variation of Embodiment -

[0155] The second valve (19) of the intermediate unit (80) of the foregoing embodiment may be an on-off valve that selectively switches between the fully-closed state and the fully-open state. A second valve (19) of this variation is an electromagnetic valve including a solenoid that drives its valve body.

[0156] As shown in FIG. 8, when the second valve (19) is in the fully-closed state, and the value P_k measured by the refrigerant pressure sensor (48) reaches the fifth reference pressure PL_5 ($P_k = PL_5$), a hydraulic pressure controller (85) of this variation changes the state of the second valve (19) from the fully-closed state to the fully-open state. When the second valve (19) is in the fully-open state, and the value P_k measured by the refrigerant pressure sensor (48) reaches the fourth reference pressure PL_4 ($P_k = PL_4$), the hydraulic pressure controller (85) of this variation changes the state of the second valve (19) from the fully-open state to the fully-closed state. The fourth and fifth reference pressures PL_4 and PL_5 are respectively equal to those set when the second valve (19) is a control valve having a variable opening degree.

- Second Variation of Embodiment -

[0157] The hydraulic pressure controller (85) of the foregoing embodiment may set the fourth reference pressure PL_4 at a value slightly less than the second reference pressure PL_2 ($PL_4 < PL_2$). Even in such a case, the fourth reference pressure PL_4 is set at a value greater than the first reference pressure PL_1 ($PL_1 < PL_4$). It is possible for a second valve (19) of an intermediate unit (80) of this variation to start opening before the first valve (18) falls into the fully-closed state.

- Third Variation of Embodiment -

[0158] The intermediate unit (80) of the foregoing embodiment may include a pressure input section (86). The pressure input section (86) is a member to be operated by an operator to input information on the allowable pressure P_u of the refrigeration-facility units (60) to the hydraulic pressure controller (85). Examples of the pressure input section (86) include a DIP switch and a numeric keypad for input of numerals.

[0159] As shown in FIG. 9, a pressure input section

(86) of an intermediate unit (80) of this variation is electrically connected to a hydraulic pressure controller (85) via a communication line or any other similar element. Information input to the pressure input section (86) is transmitted to the hydraulic pressure controller (85), and is recorded in a memory device of the hydraulic pressure controller (85). Information to be input to the pressure input section (86) may include the allowable pressure P_u of the refrigeration-facility units (60) or a symbol such as a number corresponding to the allowable pressure P_u .

[0160] The hydraulic pressure controller (85) of this variation sets the reference pressures PL_1 to PL_5 based on the information input to the pressure input section (86), and controls the opening degrees of the first and second valves (18) and (19) with reference to the set reference pressures PL_1 to PL_5 .

- Fourth Variation of Embodiment -

[0161] The intermediate unit (80) of the foregoing embodiment may omit the gas-side pipe (82), the joint pipe (83), and the second valve (19). For example, if the refrigeration apparatus (1) is installed in a cold climate area where the air temperature in the summer is not so high, the refrigerant pressure in the second liquid-side trunk pipe (4b) and the liquid-side branch pipes (4c) may be kept at or below the allowable pressure of the refrigeration-facility units (60) even with the refrigeration-facility expansion valves (63) of all of the refrigeration-facility units (60) and the first valve (18) of the intermediate unit (80) closed. Thus, the intermediate unit (80) forming part of the refrigeration apparatus (1) installed in the cold climate area may omit the gas-side pipe (82), the joint pipe (83), and the second valve (19). An intermediate unit (80) of this variation is connected only to a liquid connection pipe (4) but is not connected to a gas connection pipe (5).

- Fifth Variation of Embodiment -

[0162] The refrigeration apparatus (1) of the foregoing embodiment may omit the air-conditioning units (50) while including the heat source unit (10) and the refrigeration-facility units (60). A refrigeration apparatus (1) of this variation exclusively cools inside air. A heat source unit (10) forming part of the refrigeration apparatus (1) of this variation omits a third compressor (23).

- Sixth Variation of Embodiment -

[0163] The utilization units of the refrigeration apparatus (1) of the foregoing embodiment are not limited to the air-conditioning units (50) configured to condition air in a room. The utilization units of the refrigeration apparatus (1) of the foregoing embodiment may be configured to heat or cool water using a refrigerant. A utilization unit of this variation includes a heat exchanger configured to exchange heat between a refrigerant and water, as a utilization heat exchanger.

[0164] While the embodiment and variations thereof have been described above, it will be understood that various changes in form and details may be made without departing from the spirit and scope of the claims. The embodiment and the variations thereof may be combined and replaced with each other without deteriorating intended functions of the present disclosure.

INDUSTRIAL APPLICABILITY

[0165] As can be seen from the foregoing description, the present disclosure is useful for an intermediate unit for a refrigeration apparatus, and a refrigeration apparatus including the intermediate unit.

DESCRIPTION OF REFERENCE CHARACTERS

[0166]

- 1 Refrigeration Apparatus
- 4 Liquid Connection Pipe
- 4a First Liquid-Side Trunk Pipe
- 4b Second Liquid-Side Trunk Pipe
- 4c Liquid-Side Branch Pipe
- 5 Gas Connection Pipe
- 5a First Gas-Side Trunk Pipe
- 5b Second Gas-Side Trunk Pipe
- 5c Gas-Side Branch Pipe
- 10 Heat Source Unit
- 18 First Valve
- 19 Second Valve
- 48 Refrigerant Pressure Sensor
- 60 Refrigeration-Facility Unit (Utilization Unit)
- 80 Intermediate Unit
- 81 Liquid-Side Pipe
- 82 Gas-Side Pipe
- 83 Joint Pipe
- 85 Hydraulic Pressure Controller (Controller)

Claims

1. An intermediate unit (80) for a refrigeration apparatus (1), the intermediate unit (80) being provided between a heat source unit (10) and a utilization unit (60), the heat source unit (10) and the utilization unit (60) being connected together through a liquid connection pipe (4) and a gas connection pipe (5) to form the refrigeration apparatus (1), the intermediate unit (80) comprising:

a liquid-side pipe (81) connected to the liquid connection pipe (4);
 a first valve (18) provided for the liquid-side pipe (81), the first valve (18) having a variable opening degree;
 a refrigerant pressure sensor (48) disposed in a portion of the liquid-side pipe (81) closer to the

utilization unit (60) than the first valve (18) is, the refrigerant pressure sensor (48) being configured to measure a pressure of a refrigerant flowing through the liquid-side pipe (81); and
 a controller (85) configured to adjust the opening degree of the first valve (18) based on a value measured by the refrigerant pressure sensor (48).

2. The intermediate unit of claim 1 further comprising:

a gas-side pipe (82) connected to the gas connection pipe (5);
 a joint pipe (83) connecting the portion of the liquid-side pipe (81) closer to the utilization unit (60) than the first valve (18) is and the gas-side pipe (82) together; and
 a second valve (19) provided for the joint pipe (83).

3. The intermediate unit of claim 2, wherein the controller (85) adjusts the opening degree of the first valve (18) so that the value measured by the refrigerant pressure sensor (48) is less than or equal to a reference pressure, and opens the second valve (19) if the value measured by the refrigerant pressure sensor (48) is greater than the reference pressure with the first valve (18) closed.

4. The intermediate unit of any one of claims 1 to 3, wherein the intermediate unit (80) is installed indoors, and is connected to the heat source unit (10) installed outdoors.

5. A refrigeration apparatus, comprising:

the intermediate unit (80) of any one of claims 1 to 4;
 a heat source unit (10);
 a utilization unit (60); and
 a liquid connection pipe (4) and a gas connection pipe (5) connecting the intermediate unit (80), the heat source unit (10), and the utilization unit (60) together to form a refrigerant circuit (6).

6. A refrigeration apparatus, comprising:

the intermediate unit (80) of claim 2 or 3;
 a heat source unit (10);
 a plurality of utilization units (60);
 a liquid connection pipe (4) including a liquid-side trunk pipe (4a, 4b) and a plurality of liquid-side branch pipes (4c), the liquid-side trunk pipe (4a, 4b) being connected to the heat source unit (10), the liquid-side branch pipes (4c) each connecting an associated one of the utilization units (60) to the liquid-side trunk pipe (4a, 4b); and

a gas connection pipe (5) including a gas-side trunk pipe (5a, 5b) and a plurality of gas-side branch pipes (5c), the gas-side trunk pipe (5a, 5b) being connected to the heat source unit (10), the gas-side branch pipes (5c) each connecting an associated one of the utilization units (60) to the gas-side trunk pipe (5a, 5b), the liquid-side pipe (81) of the intermediate unit (80) being connected to the liquid-side trunk pipe (4a, 4b) of the liquid connection pipe (4), the gas-side pipe (82) of the intermediate unit (80) being connected to the gas-side trunk pipe (5a, 5b) of the gas connection pipe (5).

15

20

25

30

35

40

45

50

55

FIG.1

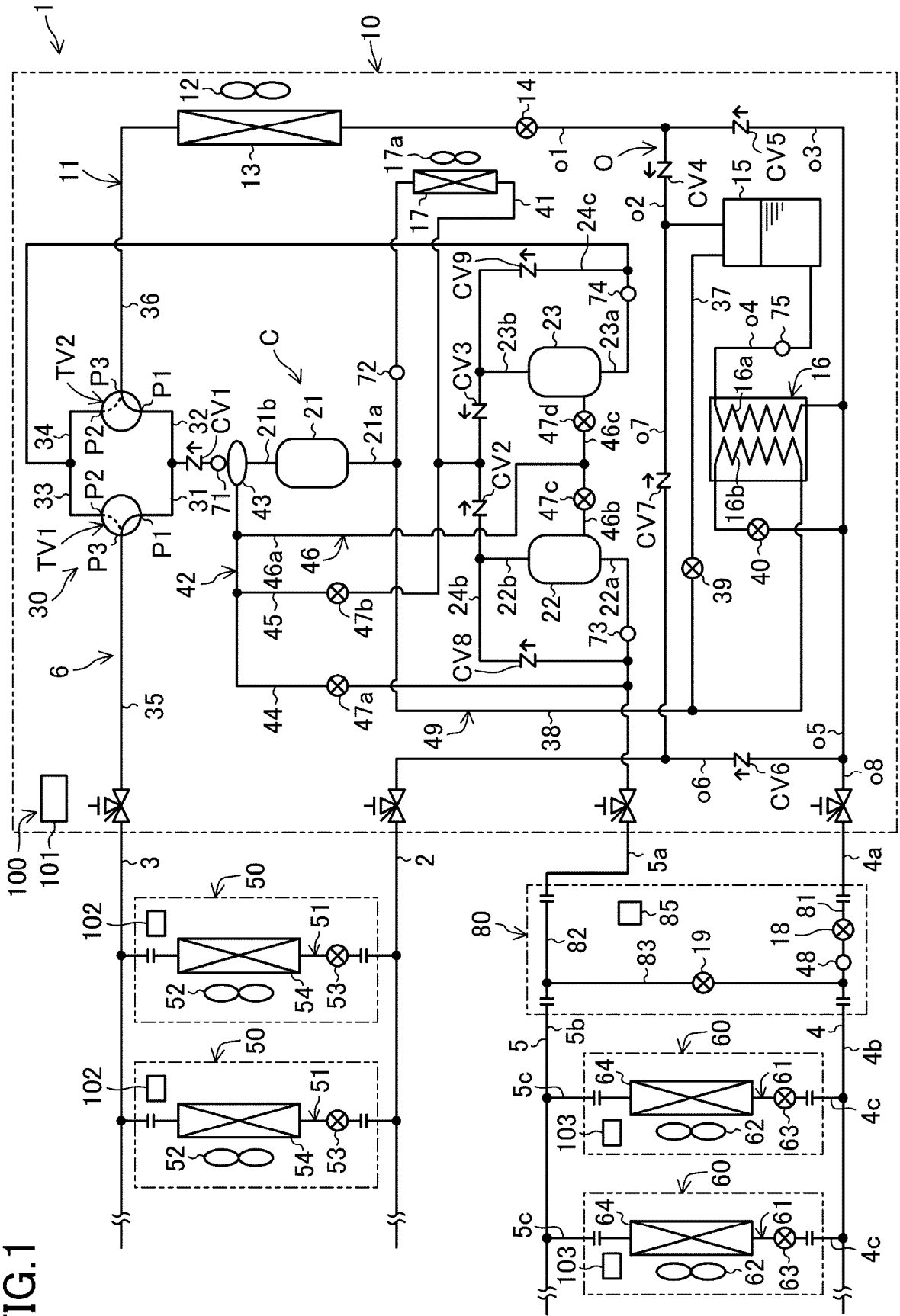
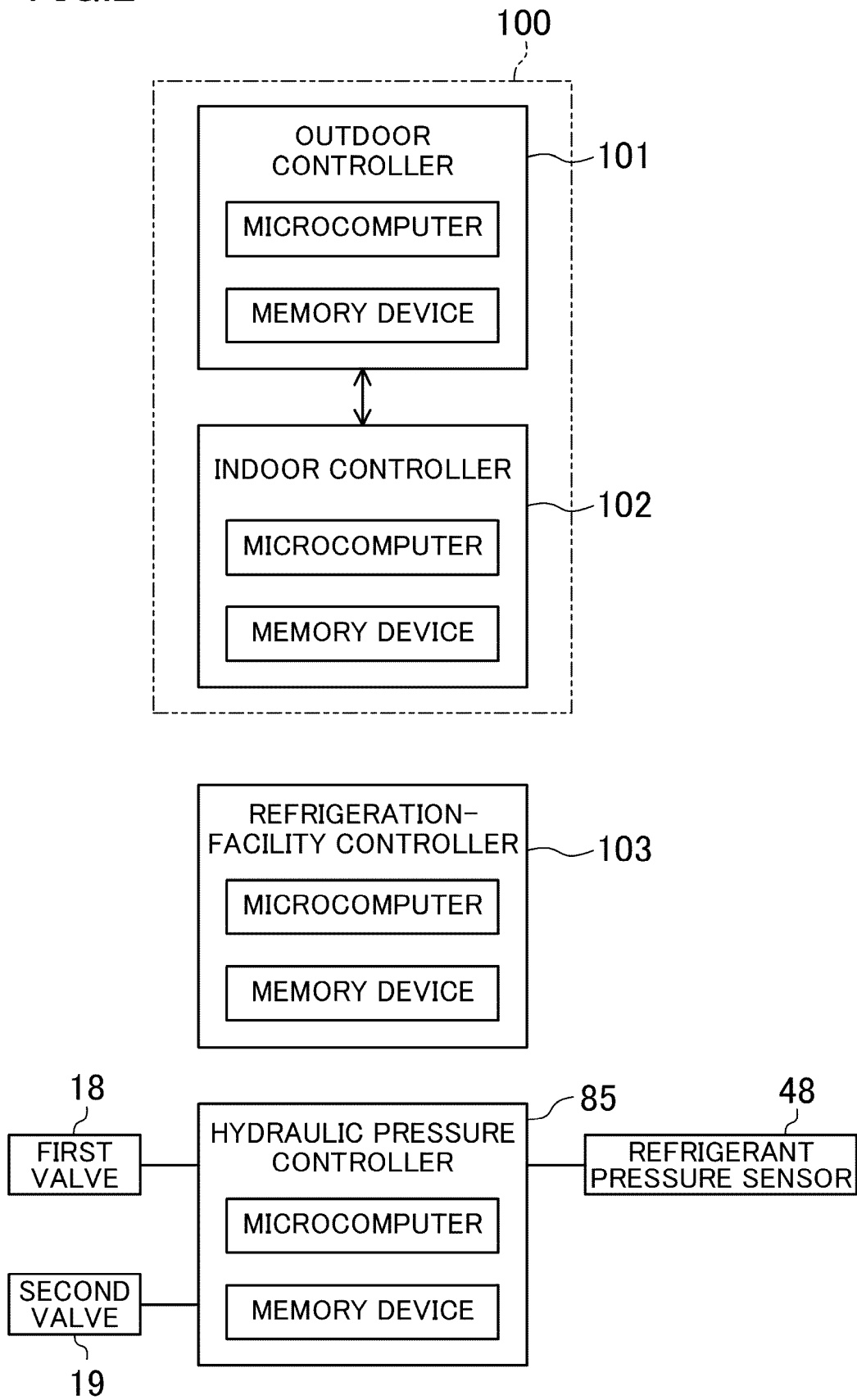


FIG.2



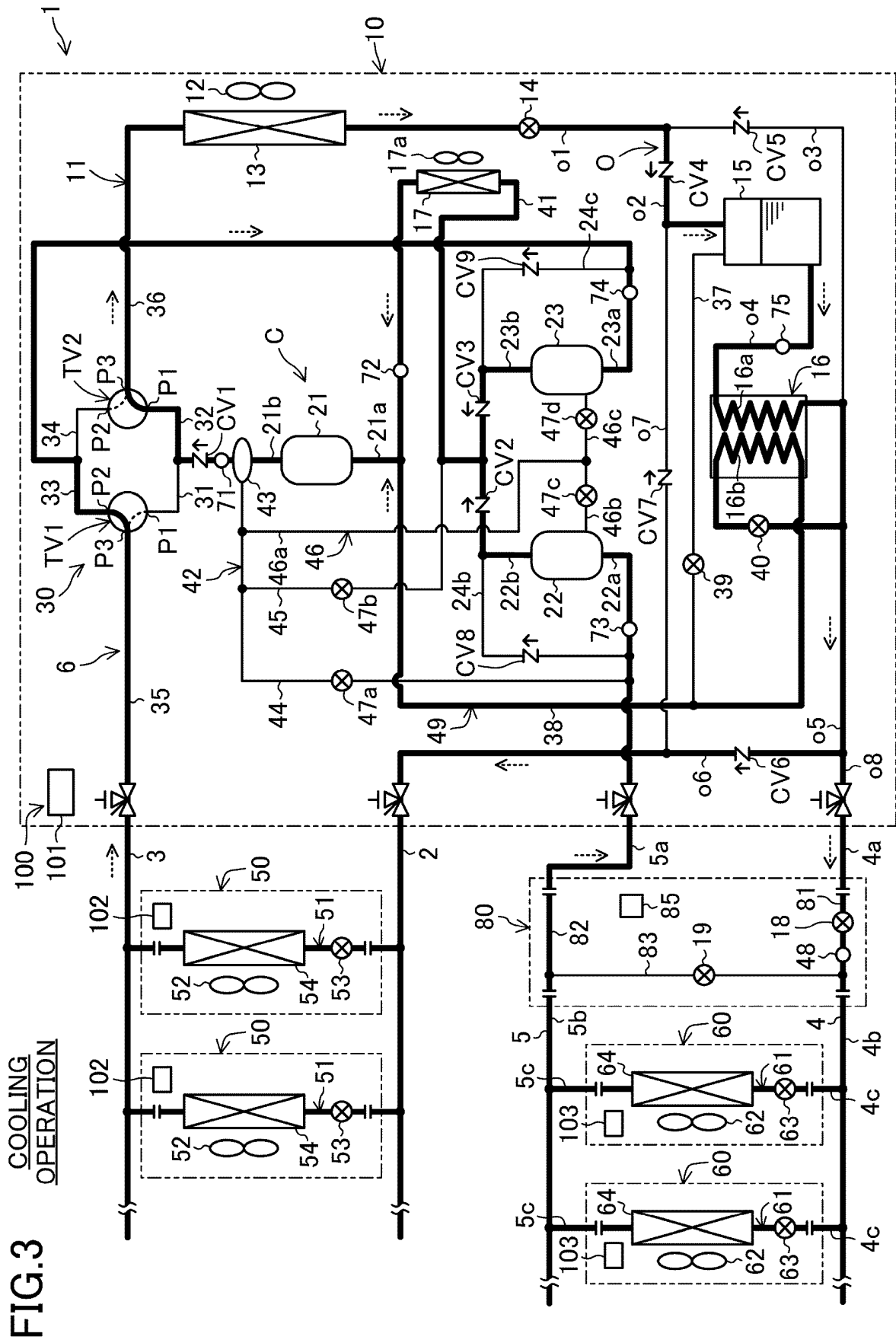


FIG. 4

HEATING
OPERATION

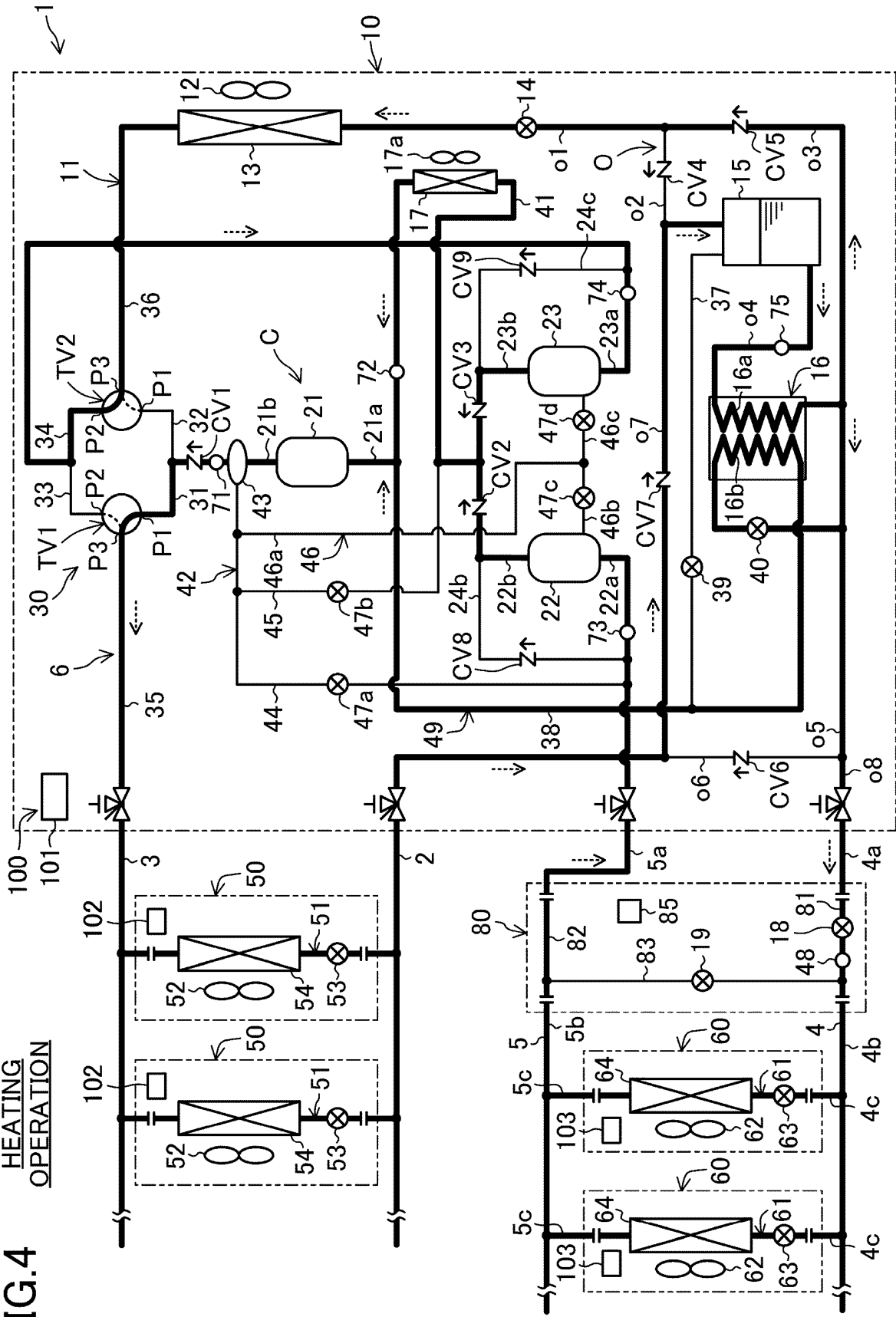


FIG.5

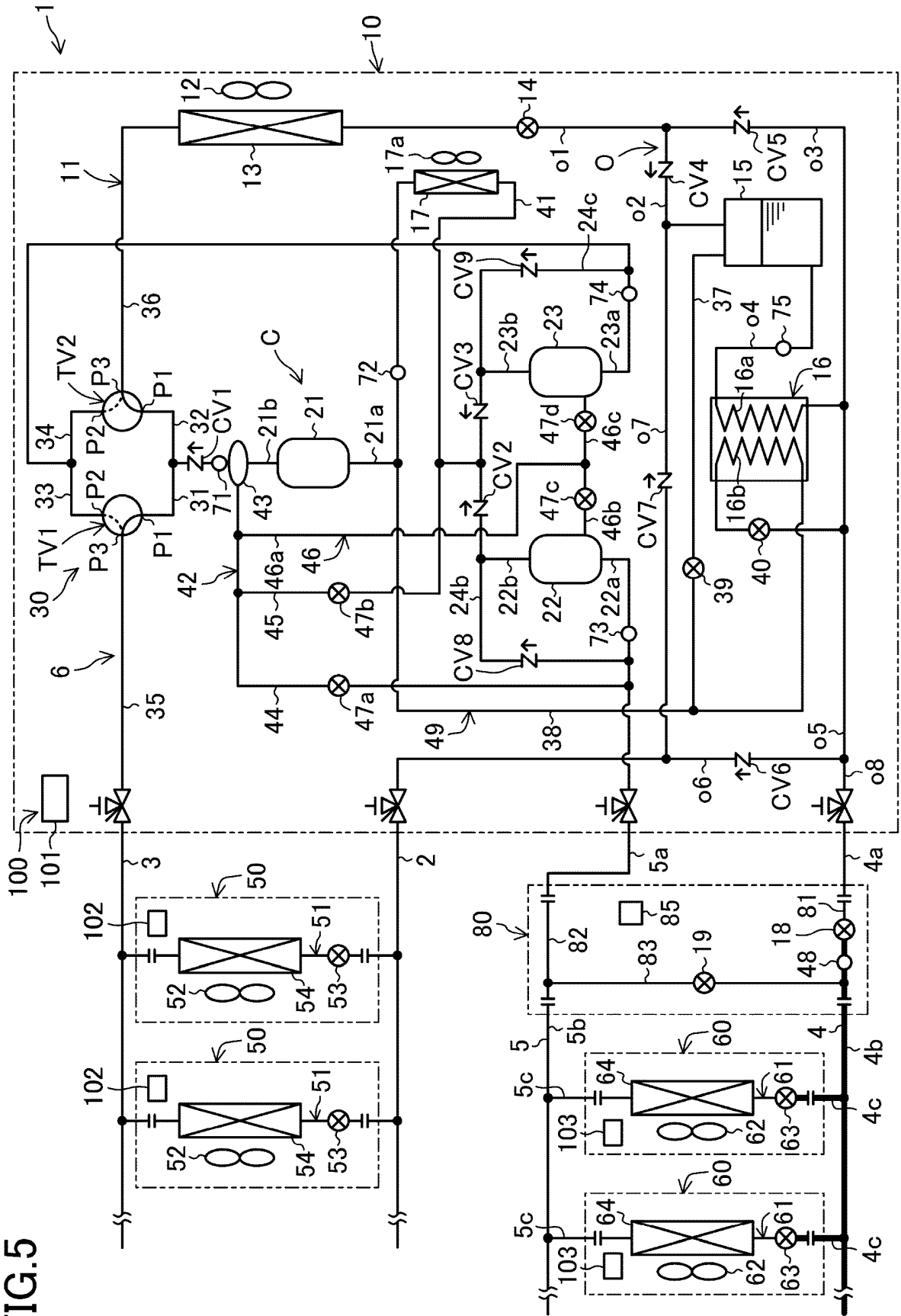


FIG.6

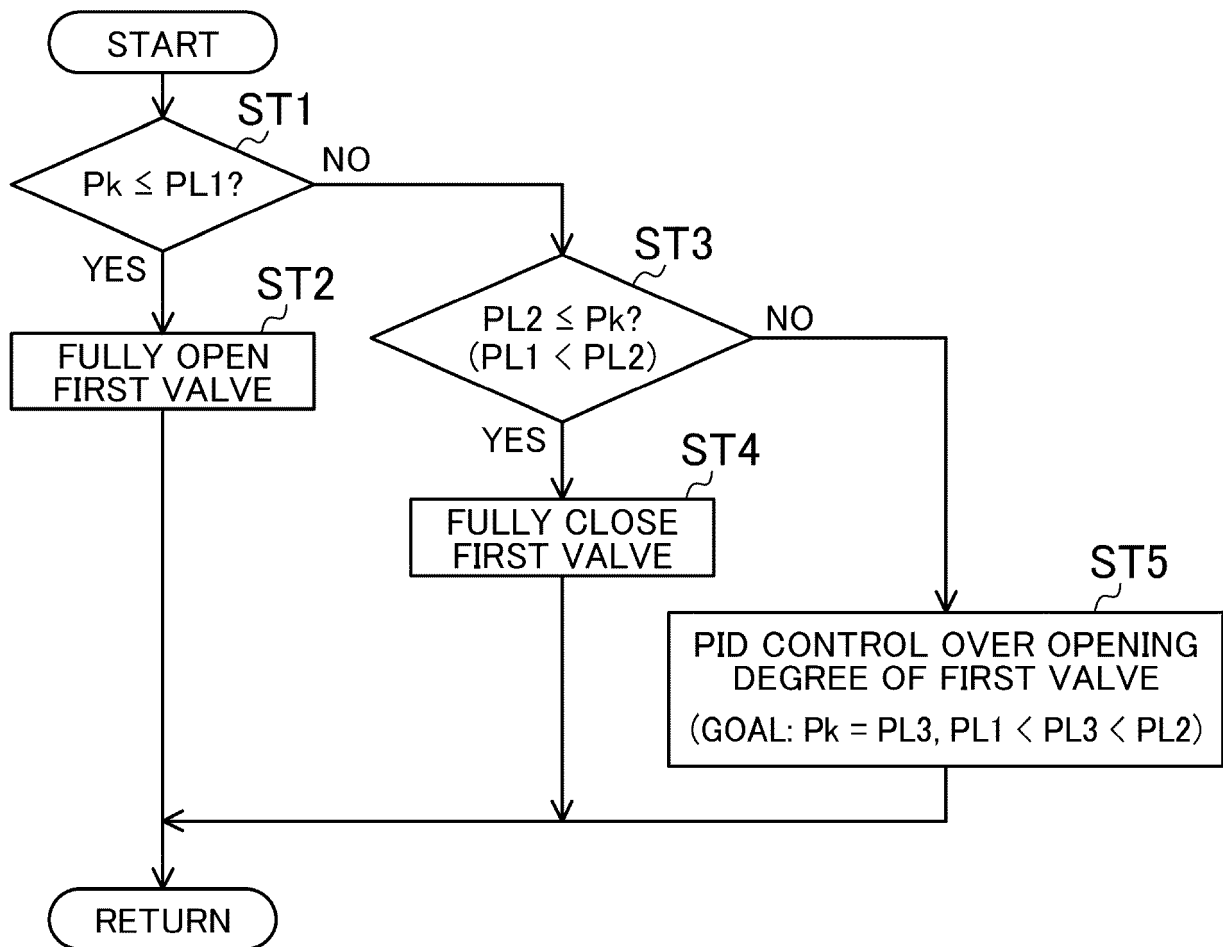


FIG.7

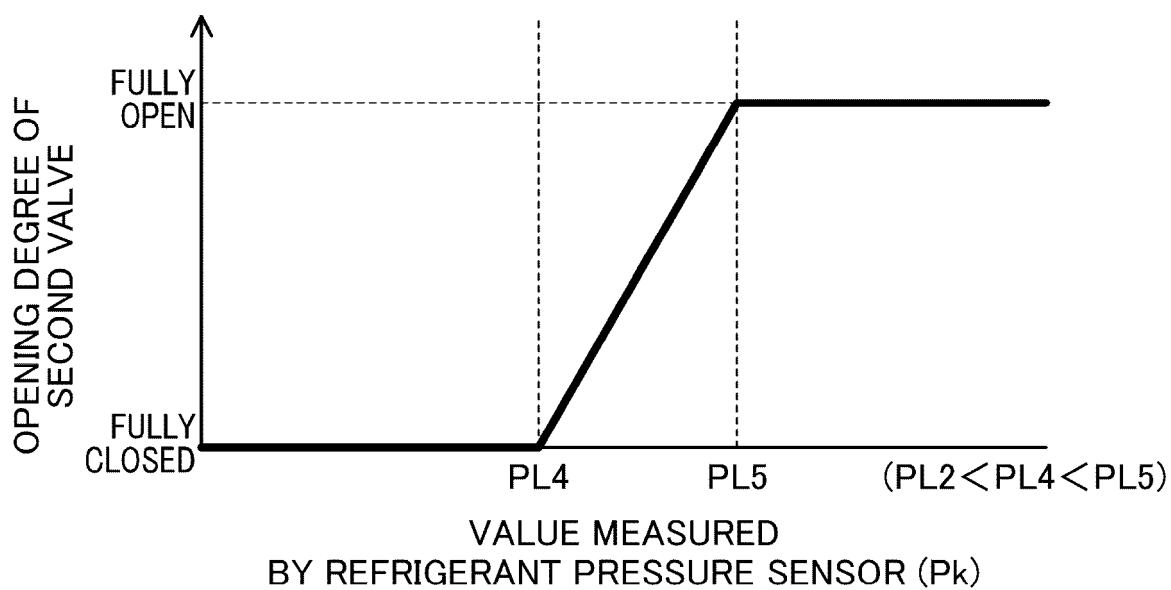


FIG.8

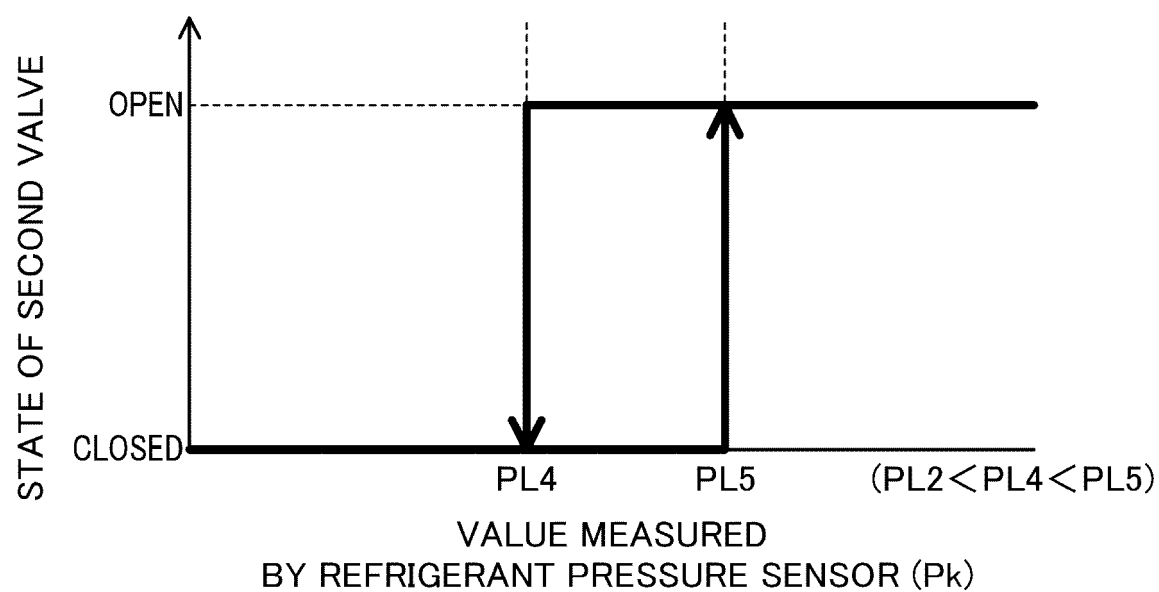
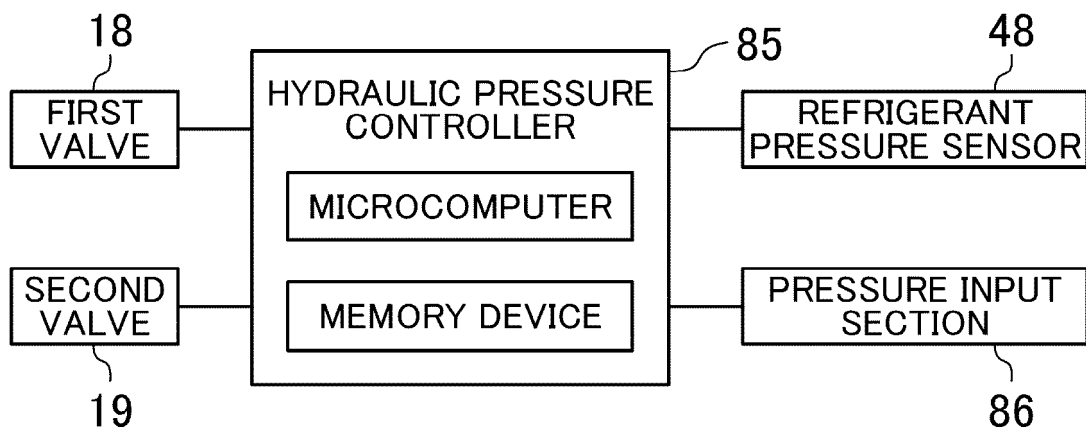


FIG.9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/025138

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F25B41/04 (2006.01) i, F24F1/32 (2011.01) i, F25B41/00 (2006.01) i
 FI: F25B41/04 Z, F24F1/32, F25B41/00 J

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. F25B41/04, F24F1/32, F25B41/00

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 1971-2020

Registered utility model specifications of Japan 1996-2020

Published registered utility model applications of Japan 1994-2020

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.
X	WO 2017/179166 A1 (MITSUBISHI ELECTRIC CORP.) 19	1-2, 4-5
Y	October 2017, paragraphs [0011]-[0137], fig. 1-6	3, 6
Y	WO 2016/194098 A1 (MITSUBISHI ELECTRIC CORP.) 08	1-6
	December 2016, paragraphs [0010]-[0075]	
Y	JP 2015-227734 A (DAIKIN INDUSTRIES, LTD.) 17	6
	December 2015, fig. 1, 3	
Y	WO 2018/062528 A1 (DAIKIN INDUSTRIES, LTD.) 05	1-6
	April 2018, paragraphs [0021]-[0149], fig. 1-3	



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
18.08.2020

Date of mailing of the international search report
25.08.2020

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/025138

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
WO 2017/179166 A1	19.10.2017	(Family: none)	
WO 2016/194098 A1	08.12.2016	EP 3306214 A1 paragraphs [0010]- [0075] CN 107709887 A	
JP 2015-227734 A	17.12.2015	(Family: none)	
WO 2018/062528 A1	05.04.2018	US 2019/0234660 A1 paragraphs [0034]- [0162], fig. 1-3 EP 3521731 A1 CN 109791009 A	

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- JP 2017138034 A [0003]