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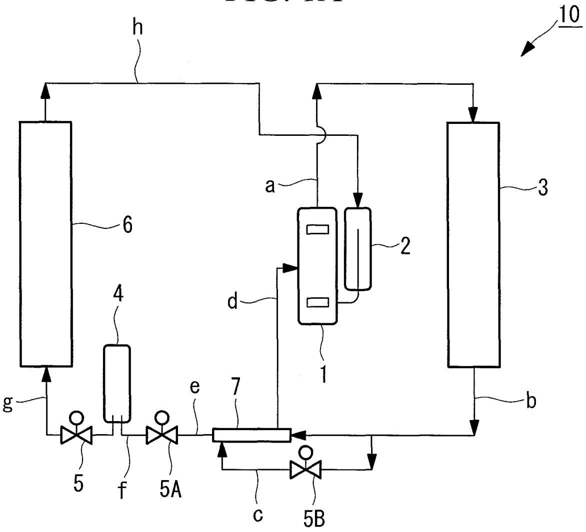
(54) **REFRIGERANT CIRCUIT**

(57) In a refrigerant circuit for a supercritical cycle that uses carbon dioxide as a refrigerant, a refrigerant circuit that can hold an amount of surplus refrigerant is provided. The refrigerant circuit 10 for a refrigerating cycle that uses carbon dioxide as a refrigerant includes an intercooler 7 that is provided downstream of a condenser 3 and an intermediate pressure receiver 4 that is provided via a restriction mechanism 5 downstream of the intercooler 7.

FIG. 1A



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Description

Technical Field

[0001] The present invention relates to a refrigerant circuit that is applied to an air conditioning apparatus, a refrigerator, a hot water supply system or the like, which uses a refrigerating cycle in which carbon dioxide (CO_2) serves as a refrigerant.

Background Art

[0002] Conventionally, in a refrigerant circuit (refer to FIG. 9A and FIG. 9B) that uses an HFC refrigerant, surplus refrigerant can be held as a saturated liquid refrigerant by providing a receiver at the condenser outlet. Note that in the refrigerant circuit that is shown in FIG. 9A, reference numeral 1 indicates a compressor, 2 indicates an accumulator, 3 indicates a condenser, 4 indicates a receiver, 5 indicates a restriction mechanism, and 6 indicates a evaporator. The state at the positions that are indicated by "a" to "d" in the figures corresponds to those in the Mollier diagram that is shown in FIG. 9B.

[0003] However, in a supercritical refrigerating cycle that uses carbon dioxide as a refrigerant, a conventional condenser unit is supercritical and there is no liquid refrigerant, and thus, it is impossible to hold any surplus refrigerant. In addition, in the case of carbon dioxide refrigerant, the theoretical coefficient of performance (COP) significantly falls when the evaporator outlet temperature is high.

In order to improve this, in a supercritical refrigerating cycle that uses carbon dioxide as a refrigerant, 1) a two-stage compression two-stage expansion cycle (gas-liquid separation method) and 2) a two-stage compression one-stage expansion cycle (intercooler method) and the like are used.

[0004] FIG. 10A is a refrigerant circuit for a two-stage compression two-stage expansion cycle (gas-liquid separation method), a restriction mechanism 5A is additionally provided between the condenser 3 and the receiver 4, and the space between the receiver 4 and the compressor 1 is connected by a refrigerant pipe. Note that the state at the positions that are indicated by "a" to "f" in the figure corresponds to those in the Mollier diagram in FIG. 10B.

[0005] FIG. 11A is a refrigerating circuit for a two-stage compression one-stage expansion cycle (intercooler method), and an intercooler 7 is placed between the condenser 3 and the restriction mechanism 4. This intercooler 7 is connected to the compressor 1 by a refrigerant pipe, and furthermore, it is connected to a refrigerant pipe that branches upstream of the intercooler 7 and is provided with a restriction mechanism 5B. Note that the state at the positions that are indicated by "a" to "g" in the figure corresponds to those in the Mollier diagram that is shown in FIG. 11B.

[0006] In addition, as a prior application related to a refrigerant apparatus that uses a two-stage compression one-stage expansion cycle (intercooler method) using carbon dioxide as a refrigerant, there is a patent application that improves performance by improving the refrigeration capacity in the evaporator of a refrigeration device (refer, for example, to Patent Citation 1).

In addition, there is a prior application related to an operation method and apparatus for a supercritical evaporation-compression cycle that can operate normally under supercritical conditions by controlling the refrigeration and heating capacity of an apparatus by using the thermodynamic characteristics of the supercritical state (refer, for example, to Patent Citation 2).

Patent Citation 1: Japanese Unpublished Patent Application, First Publication, No. 2006-242557
Patent Citation 2: Japanese Published Patent Application, Second Publication, No. H7-18602

Disclosure of Invention

[0007] However, in the conventional refrigerating cycle described above, the refrigerant after expansion is a gas-liquid two-phase flow. Thus, in the case in which a liquid refrigerant is necessary, the following shortcomings and problems occur in an air conditioning apparatus:

1. The processing of surplus refrigerant due to necessary refrigerant amount differences that depend on the operation state such as refrigerating operation or heating operation and the like.
2. The refrigerant distribution to a plurality of indoor units.
3. Ensuring a pipe for high pressure liquid in an indoor unit that carries out a mixed refrigerating and heating operation.
4. Ensuring the supercooling refrigerating condenser when reheating and dehumidifying are carried out.
5. Enlargement of the fluid pipe diameter to accommodate pipe pressure loss and increase in the case in which the refrigerant pipe is a long pipe.

[0008] In this manner, in a supercritical refrigerating cycle that uses carbon dioxide as a refrigerant, because the refrigerant after expanding changes to a gas-liquid two phase flow, resolving such problems as the holding of surplus refrigerant produced when a liquid refrigerant is desirable.

In consideration of the problems described above, it is an object of the present invention to provide, in a refrigerant circuit for a supercritical cycle that uses carbon dioxide as a refrigerant, a refrigerant circuit that can hold an amount of surplus refrigerant.

[0009] The invention uses the following solutions to solve the problems described above.

The refrigerant circuit of the present invention includes, in a refrigerant circuit of a refrigerating cycle in which carbon dioxide is used as a refrigerant, an intercooler that is provided at the wake flow side of a condenser and an intermediate pressure receiver provided via a restriction mechanism at the wake flow side of the intercooler.

[0010] According to such a refrigerant circuit, due to providing an intercooler that is provided at the wake flow side of the condenser and an intermediate pressure receiver that is provided via restriction mechanism at the wake flow side of the intercooler, the refrigerant that is cooled by the intercooler is liquefied due to a reduction in pressure caused by the restriction mechanism, and this refrigerant can be held in the receiver as a liquid phase refrigerant.

[0011] In the refrigerant circuit described above, the intercooler and the intermediate pressure receiver are preferably provided with a bridge circuit that forms a predetermined refrigerant path depending on the refrigerant circulation direction that is switched by a four-way valve, and thereby, a liquid phase refrigerant can be held in the receiver during both a refrigerating operation or a heating operation.

[0012] In the refrigerant circuit described above, preferably a reheating condenser is provided at the wake flow side of the intermediate pressure receiver, and thereby, reheating and dehumidifying become possible by using the reheating condenser as a supercooling condenser.

[0013] In the refrigerant circuit described above, preferably two or more evaporators are provided so as to be arranged in parallel, and thereby, the liquid phase refrigerant can be suitably distributed between the plural evaporators.

[0014] In the refrigerant circuit described above, preferably a supercooling heat exchanger is provided at the wake flow side of the intermediate pressure receiver, and thereby, even in the case in which the refrigerant piping is long and the pressure loss in the liquid phase refrigerant piping is large, an appropriate distribution of the liquid refrigerant becomes possible without making the pipe diameter large.

[0015] In a refrigerant circuit of a refrigeration cycle that can carry out a mixed refrigeration and heating operation using carbon dioxide as a refrigerant, the refrigerant circuit of the present invention is provided with an intercooler that is provided at the wake flow side of an outdoor heat exchanger and an intermediate pressure receiver that is provided via a restriction mechanism at the wake flow side of the intercooler, and at the wake flow side of the intermediate pressure receiver, a supercooling heat exchanger is provided in each of the indoor heat exchangers that are arranged in parallel.

[0016] According to such a refrigerant circuit, due to providing an intercooler that is provided at the wake flow side of the outdoor heat exchanger and an intermediate pressure receiver that is provided via a restriction mechanism at the wake flow side of the intercooler, and a supercooling heat exchanger is provided for each of the plural indoor heat exchangers arranged in parallel at the wake flow side of the intermediate pressure receiver, the surplus portion of the refrigerant that has exited from the plural indoor heat exchangers, which are used as evaporators and condensers, can be held in a receiver as a saturated liquid.

[0017] According to the present invention described above, in a refrigerant circuit having a supercritical cycle that uses carbon dioxide as a refrigerant, an amount of surplus refrigerant can be held in a receiver as a liquid single-phase.

Brief Description of Drawings

[0018]

[FIG. 1A]
FIG. 1A is a refrigerant circuit diagram that shows a first embodiment of the refrigerant circuit according to the present invention.
[FIG. 1B]
FIG. 1B is a Mollier diagram of the refrigerant circuit diagram that is shown in FIG. 1A.
[FIG. 2A]
FIG. 2A is a refrigerant circuit diagram that shows a second embodiment of the refrigerant circuit according to the present invention.
[FIG. 2B]
FIG. 2B is a Mollier diagram of the refrigerant circuit diagram that is shown in FIG. 2A.
[FIG. 3A]
FIG. 3A is a refrigerant circuit diagram that shows a third embodiment of the refrigerant circuit according to the present invention.
[FIG. 3B]
FIG. 3B is a Mollier diagram of the refrigerant circuit diagram that is shown in FIG. 3A.
[FIG. 4]
FIG. 4 is a refrigerant circuit diagram that shows a fourth embodiment of the refrigerant circuit according to the present invention.
[FIG. 5A]
FIG. 5A is a refrigerant circuit diagram that shows a fifth embodiment of the refrigerant circuit according to the present invention.
[FIG. 5B]
FIG. 5B is a Mollier diagram of the refrigerant circuit diagram that is shown in FIG. 5A.
[FIG. 6A]
FIG. 6A is a refrigerant circuit diagram in a simultaneous refrigerant state showing a sixth embodiment of the refrigerant circuit according to the present invention.
[FIG. 6B]
FIG. 6B is a Mollier diagram of the refrigerant circuit diagram that is shown in FIG. 6A.
[FIG. 7A]
FIG. 7A is a refrigerant circuit diagram in a simultaneous heating state showing a seventh embodiment of the refrigerant circuit according to the present in-

vention.

[FIG. 7B]

FIG. 7B is a Mollier diagram of the refrigerant circuit diagram that is shown in FIG. 7A.

[FIG. 8A]

FIG. 8A is a refrigerant circuit in a mixed refrigerating and heating state showing a seventh embodiment of the refrigerant circuit according to the present invention.

[FIG. 8B]

FIG. 8B is a Mollier diagram of the refrigerant circuit diagram that is shown in FIG. 8A.

[FIG. 9A]

FIG. 9A is a refrigerant circuit diagram in which a conventional HFC refrigerant is used.

[FIG. 9B]

FIG. 9B is a Mollier diagram of the refrigerant circuit diagram that is shown in FIG. 9A

[FIG. 10A]

FIG. 10A is a refrigerant circuit diagram of a two-stage compression two-phase expansion cycle (gas-liquid separation method) .

[FIG. 10B]

FIG. 10B is a Mollier diagram of the refrigerant circuit diagram that is shown in FIG. 10A.

[FIG. 11A]

FIG. 11A is a refrigerant circuit diagram of a two-stage compression one-stage expansion cycle (intercooler method).

[FIG. 11B]

FIG. 11B is a Mollier diagram of the refrigerant circuit that is shown in FIG. 11A.

Explanation of Reference:

[0019]

1:	compressor
2:	accumulator
3:	condenser
4:	intermediate pressure receiver
5, 5A, 5B:	restriction mechanism
6:	evaporator
7:	intercooler
8:	four-way valve
9:	bridge circuit
10, 10A - E:	refrigerant circuit
20:	reheating condenser
30:	supercooling heat exchanger

Best Mode for Carrying Out the Invention

[0020] Below, embodiments of the refrigerant circuit according to the present invention will be explained with reference to the figures. Note that the refrigerant circuits in each of the embodiments described below forms a refrigeration cycle that uses carbon dioxide as the refrigerant.

First Embodiment

[0021] In the refrigerant circuit 10 for the refrigeration cycle that is shown in FIG. 1A, reference numeral 1 indicates a compressor, 2 indicates an accumulator, 3 indicates a condenser, 4 indicates a receiver, 5, 5A, and 5B indicate a restriction mechanism, 6 indicates an evaporator, and 7 indicates an intercooler. Note that the state at the positions that are indicated by "a" to "h" in FIG. 1A corresponds to those in the Mollier diagram that is shown in FIG. 1B.

[0022] In the illustrated refrigerant circuit 10, the gas-phase refrigerant that has been compressed to a supercritical state "a" by the compressor 1 changes from state "a" to state "b" after the enthalpy has decreased by heat exchange being carried out by the condenser 3 at an equal pressure.

The flow of the refrigerant in state "b" is divided into the main refrigerant flow that is directly conducted to the intercooler 7 and then toward the restriction mechanism 5A, and reduced pressure refrigerant flow that is conducted to the intercooler 7 via the restriction mechanism 5B.

[0023] In the intercooler 7, the main refrigerant flow and the reduced pressure refrigerant flow undergo heat exchange. During this heat exchange, the pressure of the main refrigerant flow is reduced to a state "c" by the restriction mechanism 5B, and this main refrigerant flow is cooled to a state "e" due to the reduced pressure refrigerant flow which has imparted thereto a two-phase gas-liquid state, and the enthalpy is thereby reduced.

The temperature of the two-phase gas-liquid reduced pressure refrigerant flow that cooled the main refrigerant flow is raised due to heat adsorption, and thus, the main refrigerant flow is drawn into the compressor 1 after changing to the gas-phase "d".

[0024] The main refrigerant flow in state "e", which has been cooled by the intercooler 7, changes to the liquid-phase state "f" by expanding after an initial pressure reduction due to the restriction mechanism 5A. Because the intermediate pressure receiver 4 is provided at the wake flow side of the restriction mechanism 5A, at which the main refrigerant flow becomes state "f", when there is surplus refrigerant in the liquid-phase main refrigerant flow, this surplus refrigerant is held in the intermediate pressure receiver 4 as surplus refrigerant.

In addition, the main refrigerant flow, which excludes the refrigerant that is held in the intermediate pressure receiver 4 as surplus refrigerant, expands to state "g" due to another pressure reduction by the restriction mechanism 5 after passing through the intermediate pressure receiver 4. The temperature of this main refrigerant flow of this state "g" increase because of absorbing heat due to heat exchange in the process of passing through the evaporator 6, and enters the compressor 1 after becoming a gas-phase state "h".

[0025] Thus, the gas-phase refrigerant (state "d" and state "h") that is drawn into the compressor 1 is compressed to the supercritical state "a" due to being pressurized by the compressor 1.

Therefore, the refrigerant in state "a" circulates through the refrigerant circuit 10 after passing through subsequent similar processes, and thus, a refrigeration cycle is formed by carrying out refrigerating by the evaporator using refrigerant that has repeatedly circulated through the state changes 6. In addition, the refrigerant circuit 10 formed in this manner arranges an intermediate pressure receiver 4 at the wake flow side, in which the refrigerant that has been cooled by the intercooler 7 expands to an intermediate pressure due to the restriction mechanism 5A, and thus, liquid-phase surplus refrigerant can be held in the intermediate pressure receiver 4.

Second Embodiment

[0026] Next, a second embodiment of the refrigerant circuit according to the present invention will be explained with reference to FIG. 2A and 2B. Note that identical reference symbols indicate parts that are identical to those of the embodiment described above, and the detailed explanations thereof are omitted.

The refrigerant circuit 10A of the refrigeration cycle that is shown in FIG. 2A can selectively switch between, for example, a refrigerating operation and a heating operation of an air conditioner. Thus, a four-way valve 8 and a bridge circuit 9 are added to the refrigerant circuit 10 described above. In this refrigerant circuit 10 as well, the refrigerant states during the refrigerating operation, which are indicated by "a" to "h" in FIG. 2A, correspond to those in the Mollier diagram that is shown in FIG. 2B.

[0027] This refrigerant circuit 10 reverses the functions of the condenser 3 and the evaporator 6 by reversing the circulation direction of the refrigerant, and thus, switching between the refrigerating operation and the heating operation becomes possible. Specifically, the circulation direction of the gas-phase refrigerant that is fed from the compressor 1, after being changed to a supercritical state "a", is switched by the operation of the four-way valve 8. As shown by the arrows in the figures, during a refrigerating operation, the refrigerant flows from the four-way valve 8 toward the condenser 3, and after passing through the condenser 3, flows so as to be divided between the intercooler 7 and the restriction mechanism 5B after passing through the bridge circuit 9, which is a combination of check valves.

[0028] In contrast, during a heating operation, the four-way valve 8 is operated, and the refrigerant in state "a", having been compressed by the compressor 1, flows toward the evaporator 6 side, and thus, in this case, the evaporator 6 serves as a heat exchanger that functions as a condenser. Therefore, the refrigerant radiates heat when passing through the heat exchanger (the evaporator 6 in the figure) that functions as a condenser, and after the temperature thereof falls to state "b", passes through the bridge circuit 9 and flows so as to be divided between the intercooler 7 and the restriction mechanism 5B. Note that during the heating operation, the condenser 3 in the figure serves as a heat exchanger that absorbs heat as an evaporator.

[0029] The liquid-phase surplus portion of the refrigerant that has been distributed between the intercooler 7 and the restriction mechanism 5B is held in the receiver 4 after passing through processes similar to those in the first embodiment described above. Specifically, in either of the operation states during the heating operation or the refrigerating operation, the liquid-phase surplus refrigerant can be held in the intermediate pressure receiver 4.

Note that in the refrigerant circuit 10A, in the case in which the refrigerant states during a heating operation differs from that during a refrigerating operation, the positions "a" to "h" of the refrigerant states corresponding to those in the Mollier diagram are shown in parentheses in FIG. 2A.

Third Embodiment

[0030] Next, a third embodiment of the refrigerant circuit according to the present invention will be explained with reference to FIG. 3A and FIG. 3B. Note that identical reference symbols indicate parts that are identical to those of the embodiment described above, and the detailed explanations thereof are omitted.

The refrigerant circuit 10B of the refrigeration cycle that is shown in FIG. 3A adds a reheating condenser 20 to the first embodiment described above. This reheating condenser 20 is arranged between the receiver 4 and the restriction mechanism 5. In this refrigerant circuit 10B as well, the refrigerant states during the refrigerating operation, which are indicated by "a" to "i" in FIG. 3A, correspond to those in the Mollier diagram that is shown in FIG. 3B.

[0031] The reheating condenser 20 that is added in this embodiment is a heat exchanger having the function of a condenser that absorbs heat from the refrigerant in the state "f", which is a liquid-phase state, to lower the temperature to the state "g". As a result, in the case of an air-conditioning apparatus that dehumidifies, the reheating condenser 20 can be used as a supercooling condenser. Specifically, in an air conditioning apparatus that uses carbon dioxide refrigerant, by adding the reheating condenser 20, in addition to holding surplus refrigerant, dehumidification becomes possible.

Fourth embodiment

[0032] Next, a fourth embodiment of the refrigerant circuit according to the present invention will be explained with reference to FIG. 4. Note that identical reference symbols indicate parts that are identical to those of the embodiment described above, and the detailed explanations thereof are omitted.

In the refrigerant circuit 10C shown in this embodiment, plural sets of restriction mechanisms 5 and evaporators

6 are arranged in parallel at the wake flow side of the receiver 4. Specifically, in contrast to the refrigerant circuit 10 in FIG. 1, a structure is used in which the restriction mechanism 5' and the evaporator 6' are arranged parallel to the restriction mechanism 5 and the evaporator 6, and plural indoor units are arranged in parallel.

[0033] In this manner, because the refrigerant circuit 10C, in which two or more sets of restriction mechanisms 5 and evaporators 6 are arranged at the wake flow side of the intermediate pressure receiver 4, can supply a liquid single-phase from the intermediate pressure receiver 4, refrigerant can be suitably distributed. Therefore, by applying this refrigerant circuit 10C to an air conditioning apparatus in which plural indoor units are arranged in parallel, operation in which suitable refrigerant distribution is carried out becomes possible.
In addition, this embodiment may be formed such that the reheating condenser 20, which was explained in the third embodiment described above, is added between the restriction mechanisms 5 and 5' and the intermediate pressure receivers 4 that are disposed in parallel.

Fifth Embodiment

[0034] Next, a fifth embodiment of the refrigerant circuit according to the present invention will be explained with reference to FIG. 5A and FIG. 5B. Note that identical reference symbols indicate parts that are identical to those of the embodiment described above, and the detailed explanations thereof are omitted.
In the refrigerant circuit 10C that is exemplified in this embodiment, a supercooling heat exchanger 30 is added along with the restriction mechanism 5C downstream of the intermediate pressure receiver 4. This supercooling heat exchanger 30 is a heat exchanger that applies supercooling by refrigerating the liquid phase refrigerant downstream of the intermediate pressure receiver 4.

[0035] The refrigerant circuit 10D having such a structure is capable of an operation in which liquid refrigerant is appropriately distributed without the diameter of pipes for the liquid refrigerant enlarging even in an air conditioning apparatus disposed such that pressure loss increases because the refrigerant pipes through which the liquid refrigerant flows becomes long due to providing a supercooling heat exchanger 30 downstream of the intermediate pressure receiver 4.

Sixth embodiment

[0036] Next, a sixth embodiment of the refrigerant circuit according to the present invention will be explained with reference to FIG. 6A to FIG. 8B. Note that identical reference symbols indicate parts that are identical to those of the embodiment described above, and the detailed explanations thereof are omitted.
This embodiment is applied, in an indoor unit disposed in plurality, to a refrigerant circuit 10E that enables mixed refrigerating and heating operation, in which a different operation for each unit is selected from among the refrigerating operation and the heating operation, and operated simultaneously. Note that in this embodiment, the condenser 3 is referred to as an "indoor heat exchanger", and the evaporators 6 and 6' are referred to as "outdoor heat exchangers".

[0037] In order to enable the mixed refrigeration and heating operation, the illustrated refrigerant circuit 10E connects one side of the outdoor heat exchanger 3 to two refrigeration paths provided with flow path switching valves 41 and 42, and in addition, the two refrigerant flow paths, which are provided with flow path switching valves 43, 44, 45, and 46, are respectively connected to one among two indoor heat exchangers 6 and 6' arranged in parallel. In addition, the refrigerant circuit 10E is provided with an intercooler 7 that is provided at the wake flow side of the outdoor heat exchanger 3, and an intermediate pressure receiver 4 that is provided via the restriction mechanism 5A at the wake flow side of the intercooler 7. Furthermore, the refrigerant circuit 10E is provided with supercooling heat exchangers 30 and 30', which are provided in each of the indoor heat exchangers 6 and 6' that are arranged in parallel at the wake flow side of the intermediate pressure receiver 4.

[0038] In the refrigerant circuit 10E that is structured in this manner, in the case in which the two indoor heat exchangers 6 and 6' both carry out refrigerating operations (refer to FIG. 6A), the refrigerant flows as shown by the arrows in the figure. The open and closed state of each of the flow path switching valves 41 and 44 at this time is shown, where a closed valve is shown in black. In this refrigerant circuit 10E as well, the refrigerant states during the refrigeration operation, which are indicated by "a" to "i" in FIG. 6A, correspond to those in the Mollier diagram that is shown in FIG. 6B.
During such plural and simultaneous refrigeration operations, the refrigerant flows in a manner that is substantially identical to that of the fifth embodiment described above, and thus, the Mollier diagram that shows the refrigerant states is also identical. Therefore, the liquid phase surplus refrigerant can be held in the intermediate pressure receiver 4.

[0039] The refrigerant circuit 10E shown in FIG. 7A illustrates the case in which two indoor heat exchangers 6 and 6' both carry out the refrigeration operation, and the refrigerant flows as shown by the arrows. The open and closed state of each of the flow path switching valves 42, 43, and 45 at this time are shown, where a closed valve is shown in black. In this refrigerant circuit 10E as well, the refrigerant states during the heating operation, which are shown by "a" to "f" in FIG. 7A, correspond to those in the Mollier diagram shown in fig. 7B.
During such plural simultaneous heating operation, the refrigerant that has passed through the indoor heat exchangers 6 and 6', which function as condensers, is cooled by the supercooling heat exchangers 30 and 30', and the refrigerant changes to a supercooled liquid phase. Therefore, if there is a surplus of this refrigerant,

this surplus can be held in the intermediate pressure receiver 4 at the wake flow side of the supercooling heat exchangers 30 and 30'.

[0040] The refrigerant circuit 10E that is shown in FIG. 8A illustrates the case of a mixed refrigeration and heating operation, in which two indoor heat exchangers 6 and 6' are respectively carrying out a refrigeration operation and a heating operation, and the refrigeration and heating loads are substantially identical. The refrigerant flows as shown by the arrows in the figure. In the illustrated example, the indoor heat exchanger 6 is carrying out a refrigeration operation and the indoor heat exchanger 6' is carrying out a heating operation. The open and closed states of each of the flow path switching valves 41, 42, 44, 45, and 5A at this time are shown, where a closed valve is shown in black. In this refrigerant circuit 10E as well, the refrigerant states during a mixed refrigeration and heating operation, which are shown by "a" to "f" in FIG. 8A, correspond to those in the Mollier diagram that is shown in FIG. 8B.

During such mixed refrigeration and heating operation, in the case in which the refrigeration and the heating loads are balanced, the indoor heat exchanger 6' radiates heat as a condenser, and the indoor heat exchanger 6 absorbs heat as an evaporator. In addition, the refrigerant that has passed through the indoor heat exchanger 6', which functions as a condenser, is cooled by the supercooling heat exchanger 30', and thus, at the outlet of the supercooling heat exchanger 30', the refrigerant changes from a two-phase to a supercooled liquid phase due to the amount of heat exchange. Thus, if there is surplus refrigerant, this surplus refrigerant can be held in the intermediate pressure receiver 4, which is at the wake flow side of the supercooling heat exchanger 30'.

[0041] In this manner, according to the present invention described above, in a critical cycle refrigerant circuit that uses carbon dioxide as a refrigerant, an intercooler is provided at the wake flow side of the condenser, and the refrigerant that has been cooled forms a region (liquid phase) of saturated fluid due to the pressure being reduced by the added restriction mechanism. Thus, an amount of surplus refrigerant can be held as a liquid single-phase in an intermediate pressure receiver that is located at the wake flow of the restriction mechanism.

Note that the present invention is not limited by the embodiments described above, and suitable modifications are possible within a range that do not depart from the spirit of the present invention.

Claims

1. A refrigerant circuit for a refrigerating cycle that uses carbon dioxide as a refrigerant, comprising an intercooler that is provided downstream of a condenser and an intermediate pressure receiver that is provided via a restricting mechanism downstream of the intercooler.

2. A refrigerant circuit according to claim 1, wherein the intercooler and the intermediate pressure receiver comprise a bridge circuit that forms a predetermined refrigerant path depending on a refrigerant circulation direction that is switched by a four-way valve.

3. A refrigerant circuit according to claim 1, wherein a reheating condenser is provided downstream of the intermediate pressure receiver.

4. A refrigerant circuit according to any one of claims 1 to 3, wherein two or more evaporators are provided so as to be arranged in parallel.

5. A refrigerant circuit according to any one of claims 1 to 4, wherein a supercooling heat exchanger is provided downstream of the intermediate pressure receiver.

6. A refrigerant circuit in a refrigerating cycle that allows mixed refrigeration and heating operation using carbon dioxide as a refrigerant, comprising
an intercooler that is provided downstream of an outdoor heat exchanger and an intermediate pressure receiver that is provided via a restricting mechanism downstream of the intercooler,
wherein a supercooling heat exchanger is provided for each of indoor heat exchangers arranged in parallel downstream of the intermediate pressure receiver.

FIG. 1A

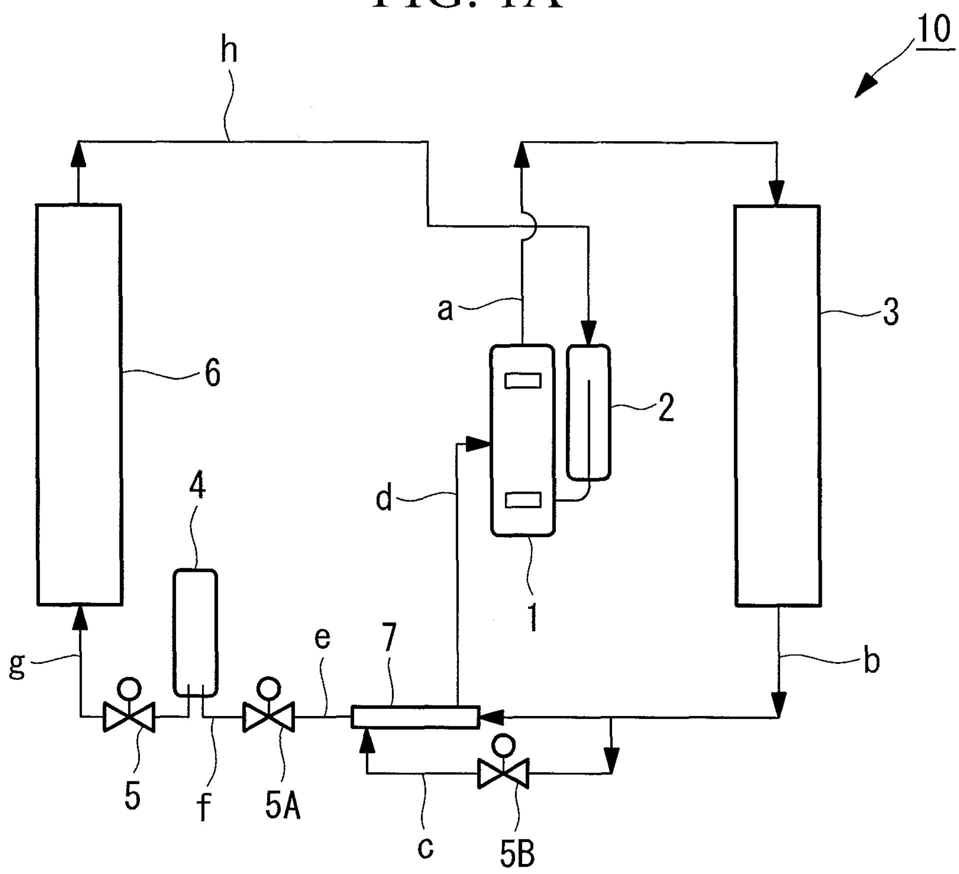


FIG. 1B

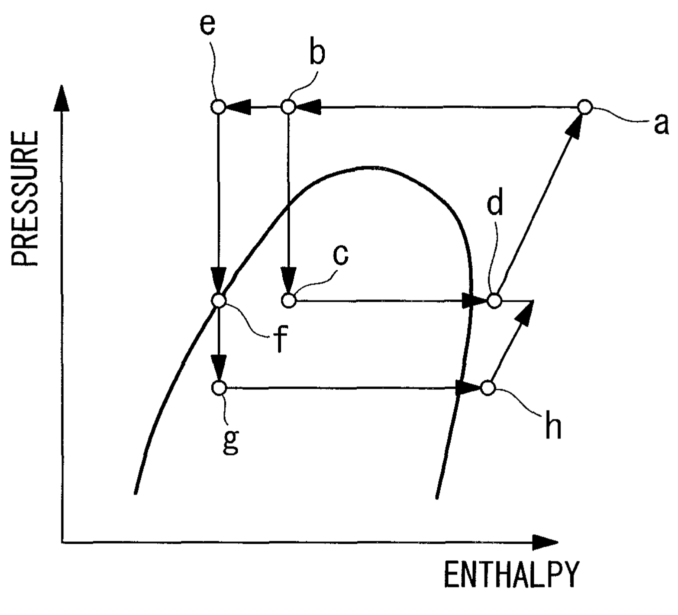


FIG. 2A

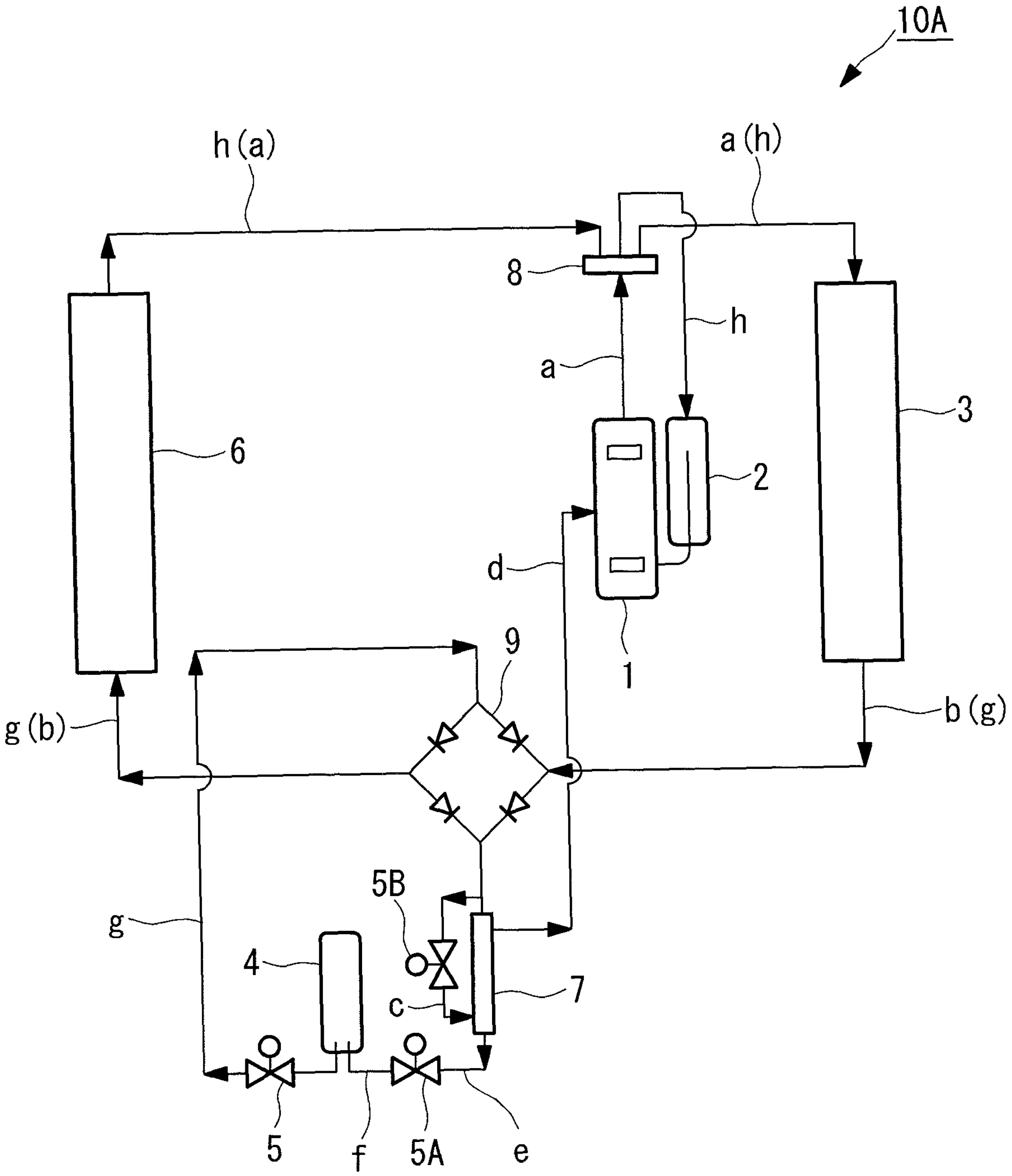


FIG. 2B

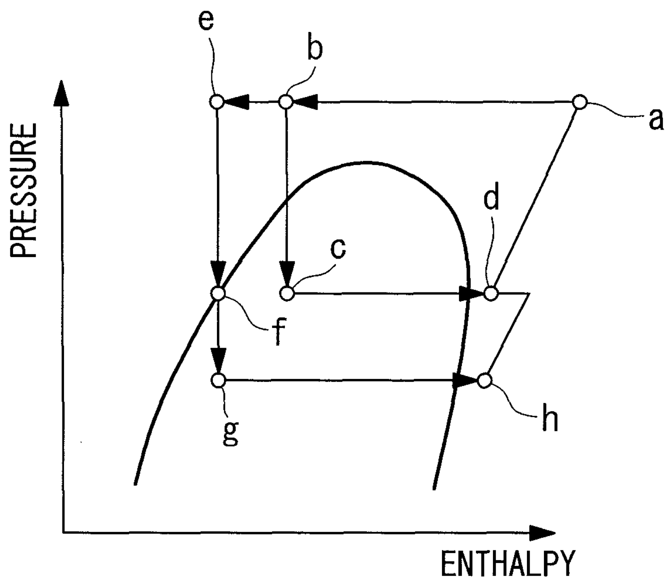


FIG. 3A

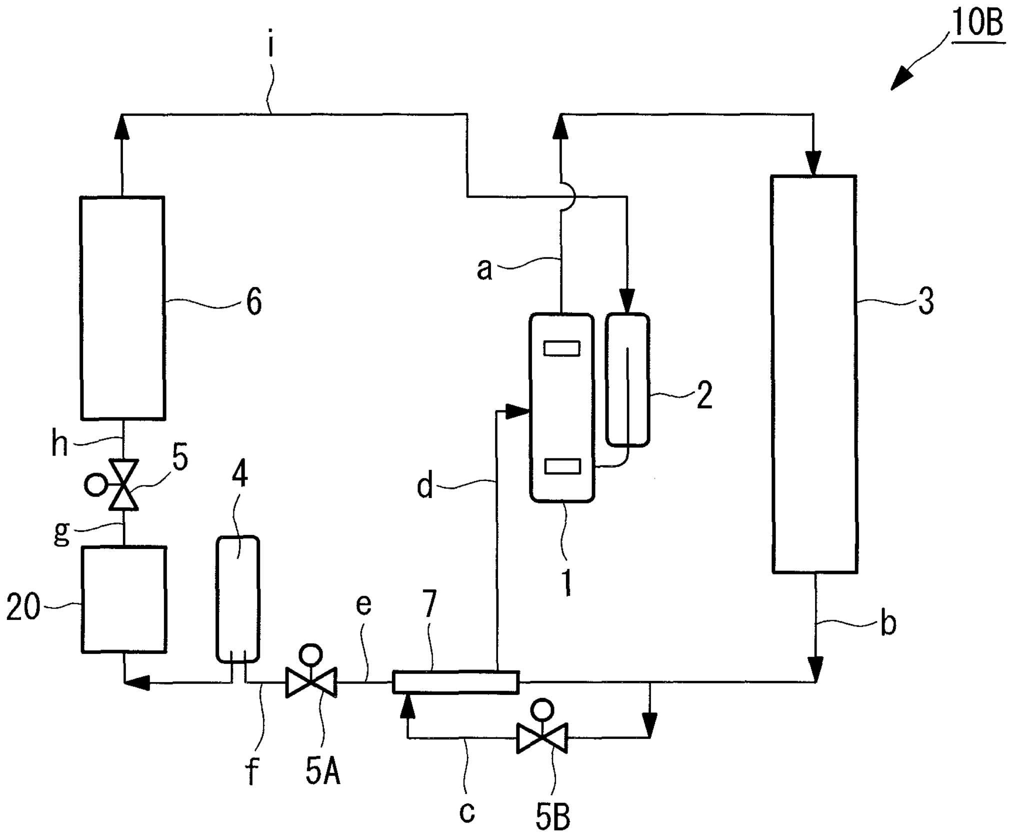


FIG. 3B

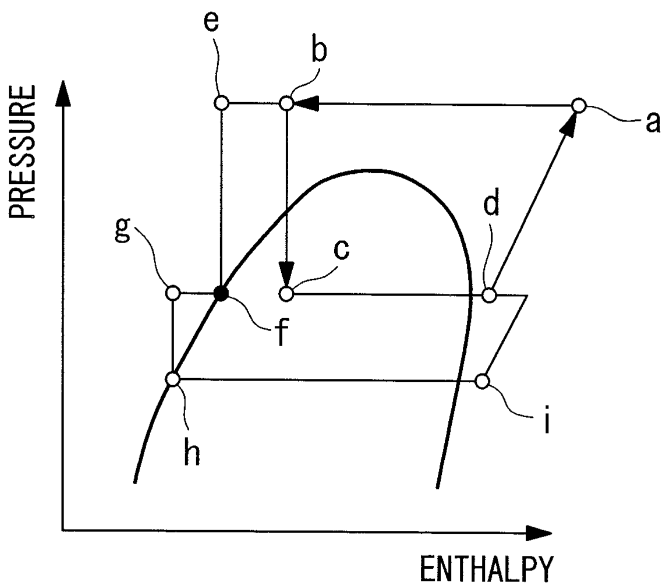


FIG. 4

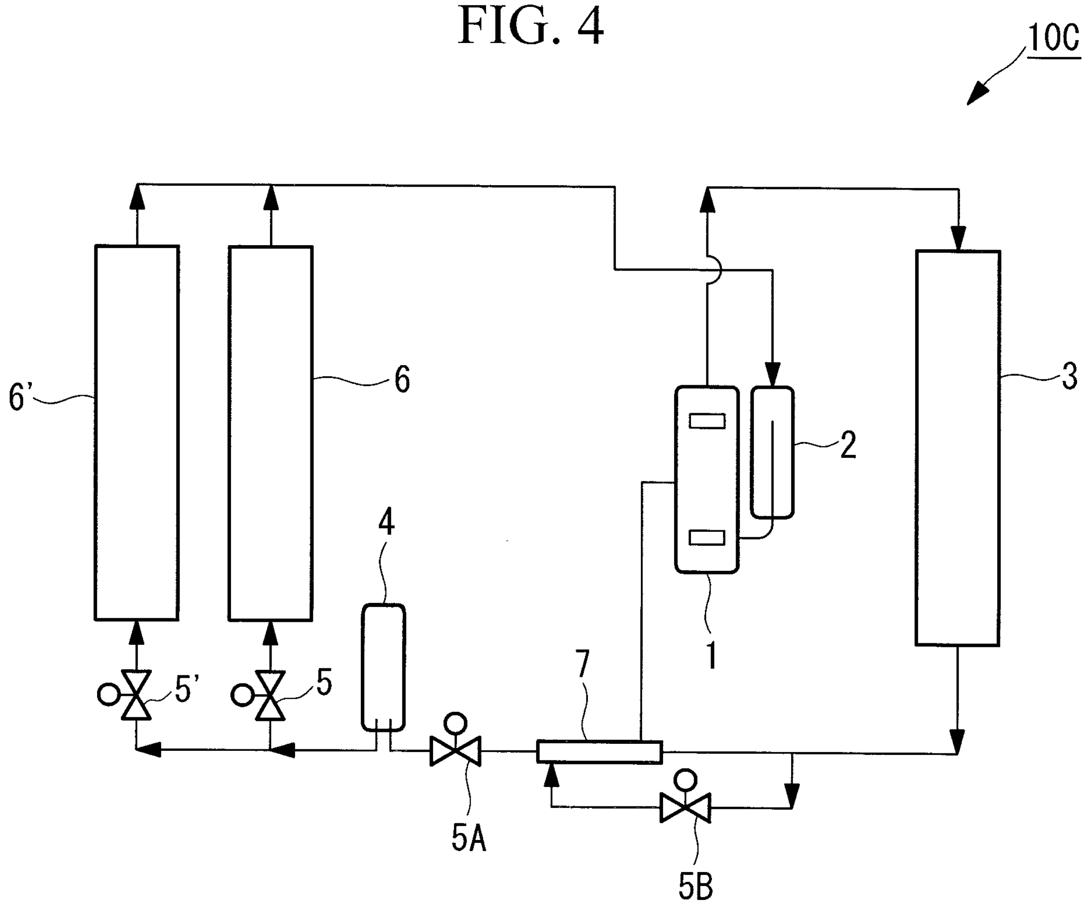


FIG. 5A

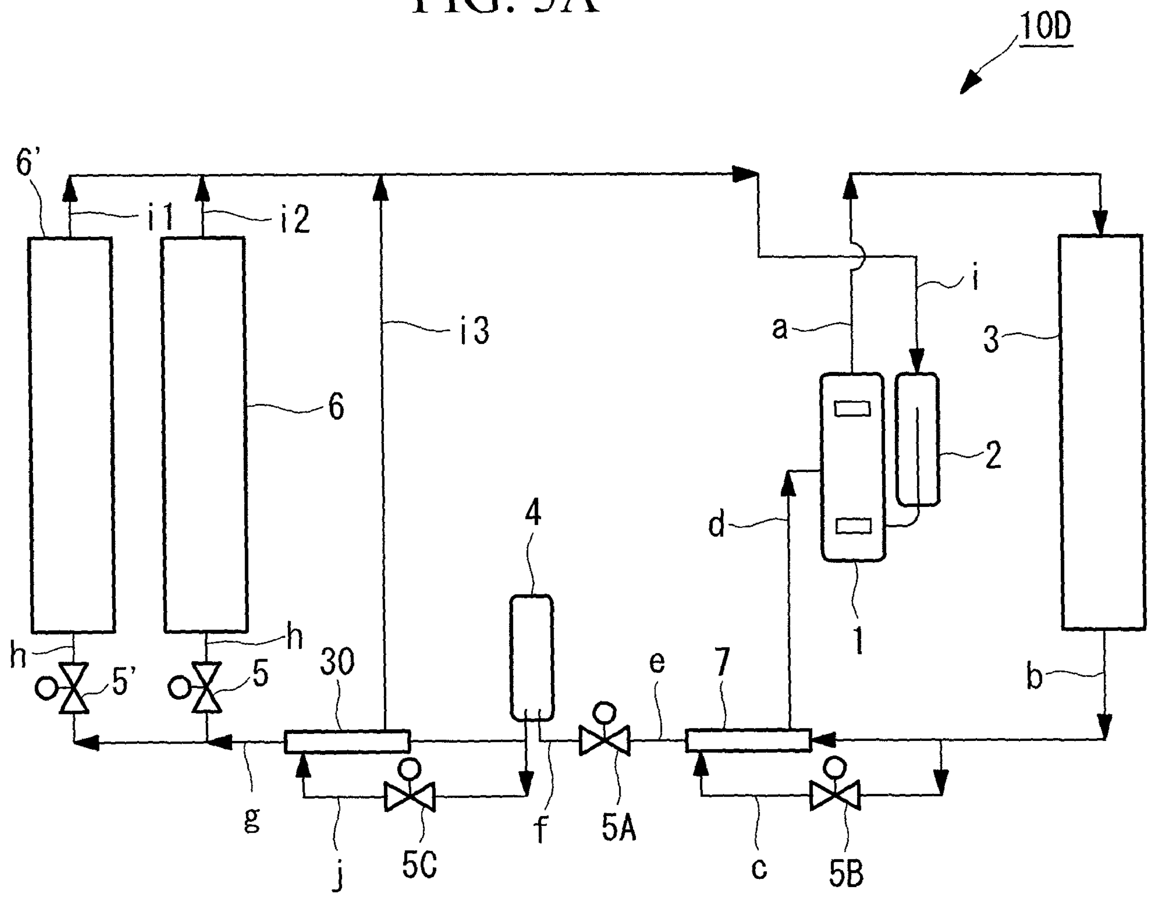

10D
6'
i1
i2
i3
i
a
3
6
2
4
d
1
h
h
5'
5
30
e
7
b
g
j
5C
f
5A
c
5B

FIG. 5B

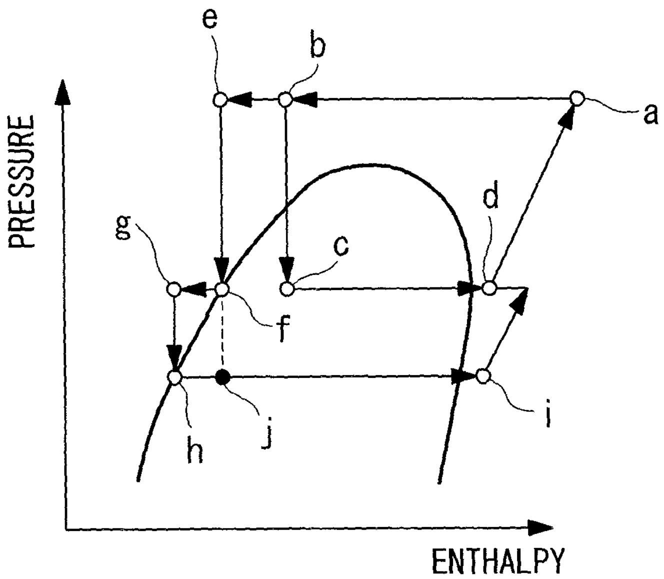

e
b
a
PRESSURE
d
g
c
f
h
j
i
ENTHALPY

FIG. 6A

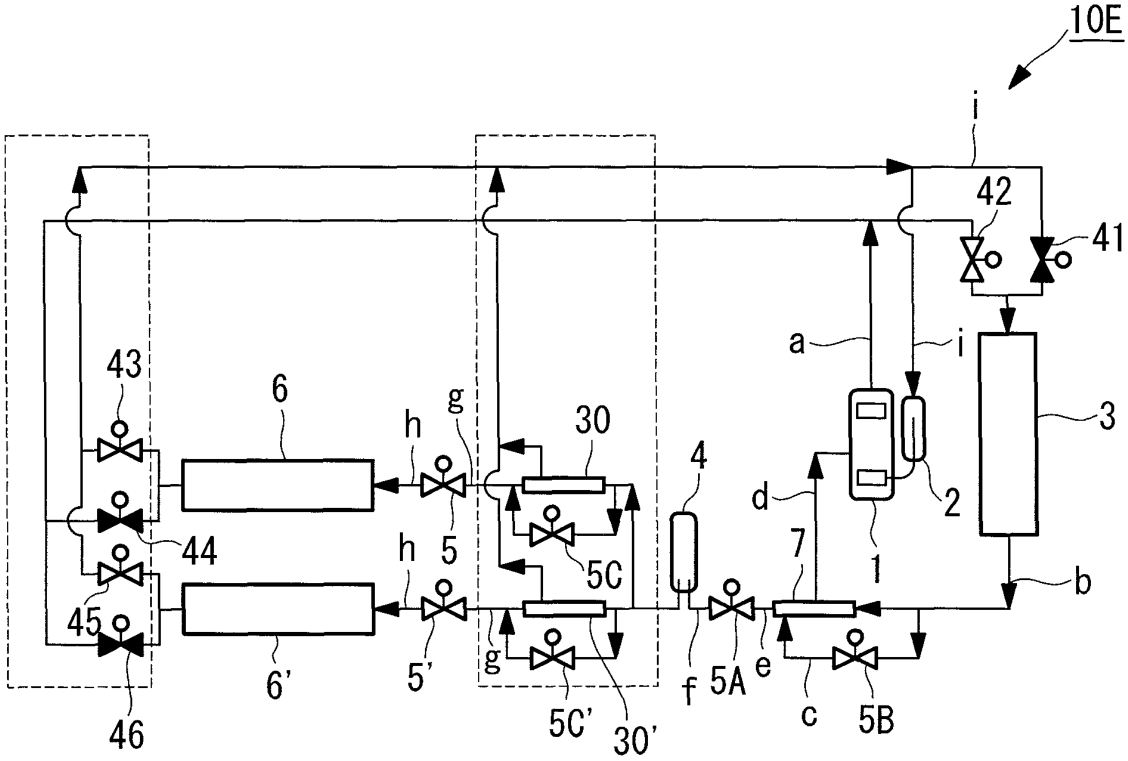

10E
i
42
41
a
i
43
6
h
g
30
3
4
d
2
44
h
5
5C
7
1
b
45
5'
g
f
5A
e
c
5B
46
6'
5C'
30'

FIG. 6B

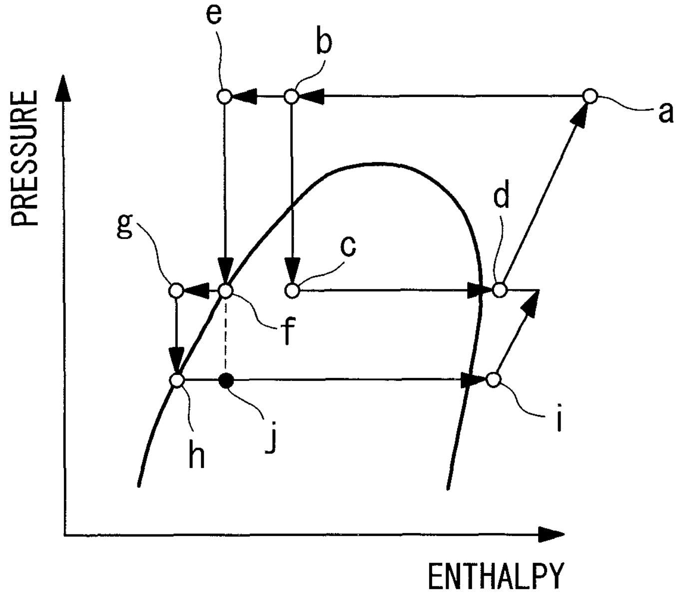

e
b
a
PRESSURE
d
c
g
f
i
h
j
ENTHALPY

FIG. 7A

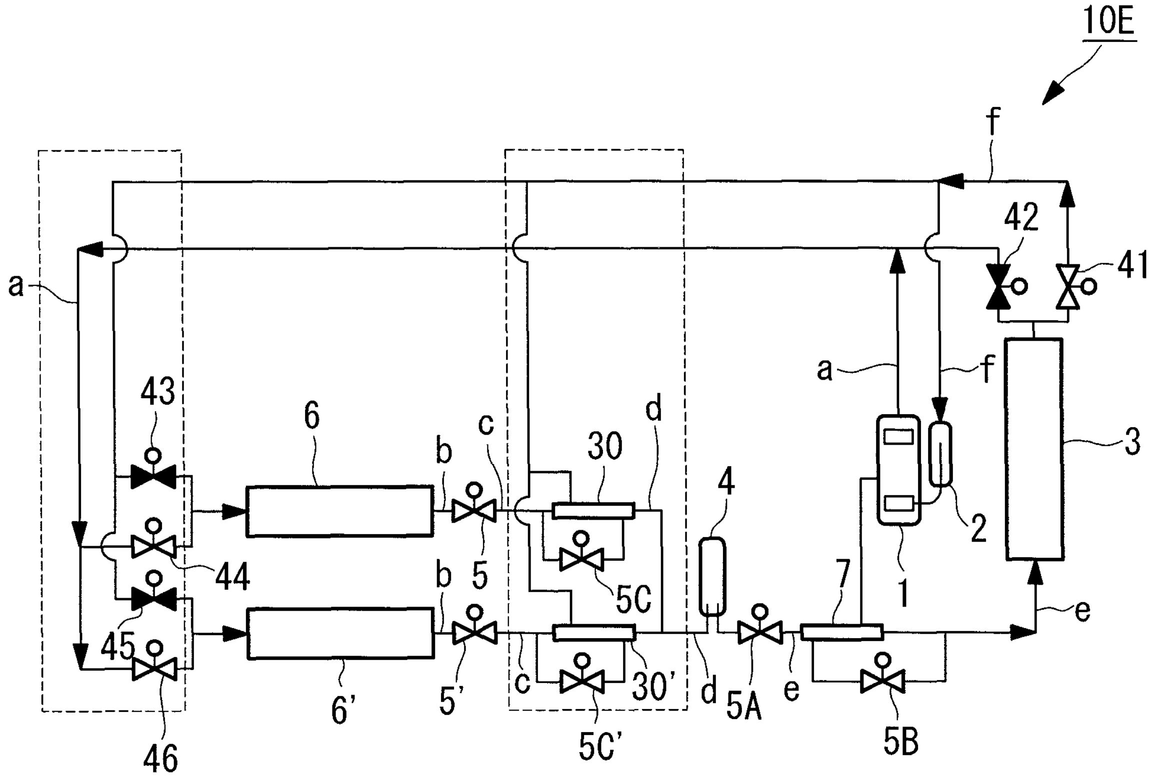

10E
f
42
41
a
a
f
43
6
b
c
30
d
4
3
44
b
5
5C
2
1
7
e
45
c
30'
d
5A
e
46
6'
5'
5C'
5B

FIG. 7B

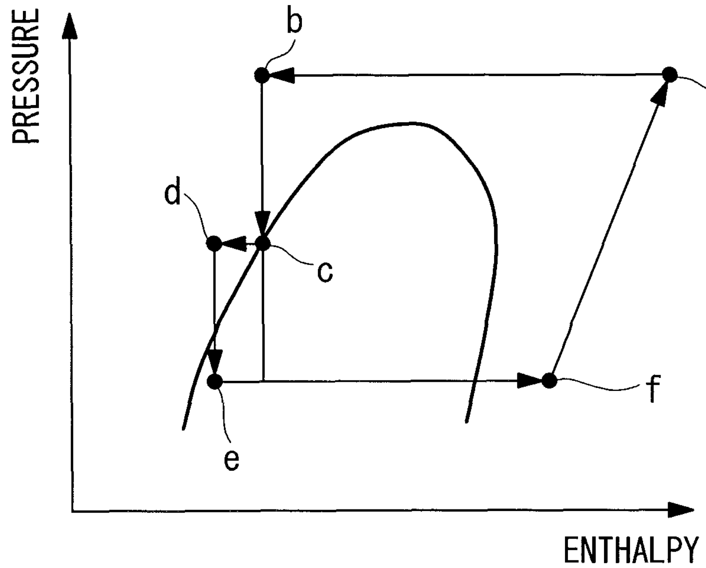

PRESSURE
b
a
d
c
f
e
ENTHALPY

FIG. 8A

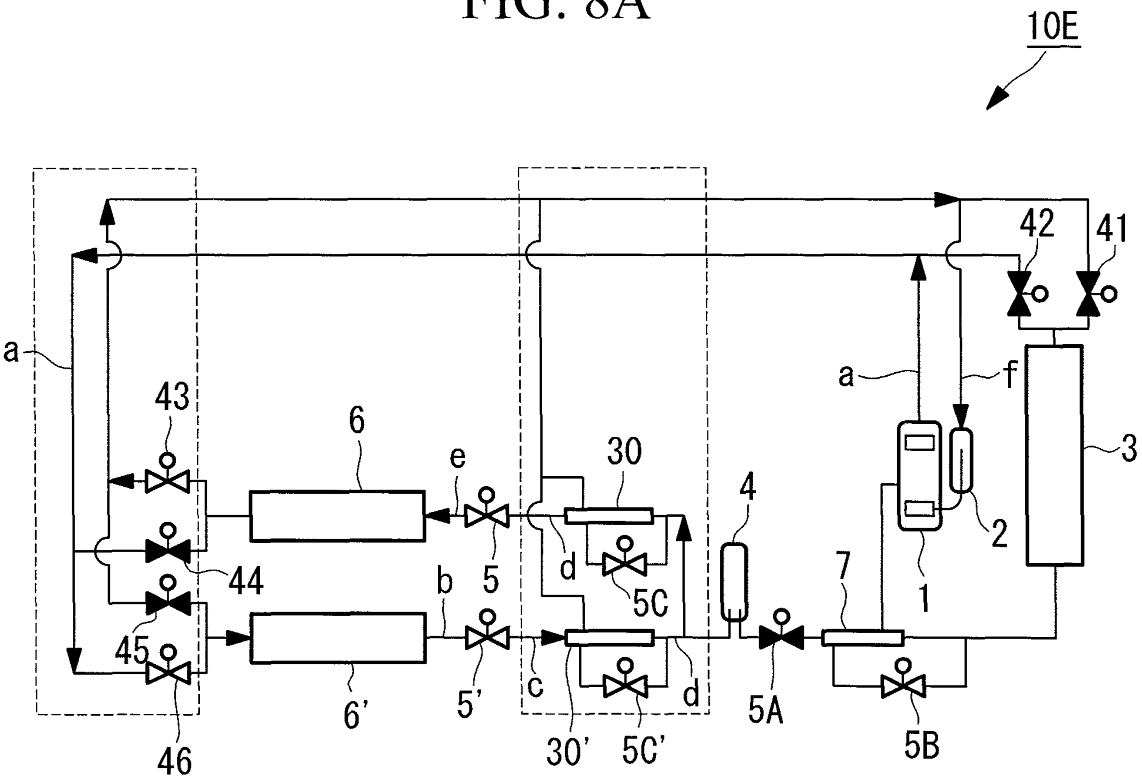

10E
42
41
a
43
6
e
30
a
f
3
4
2
44
d
5
b
5C
1
7
45
c
d
5A
46
6'
5'
30'
5C'
5B

FIG. 8B

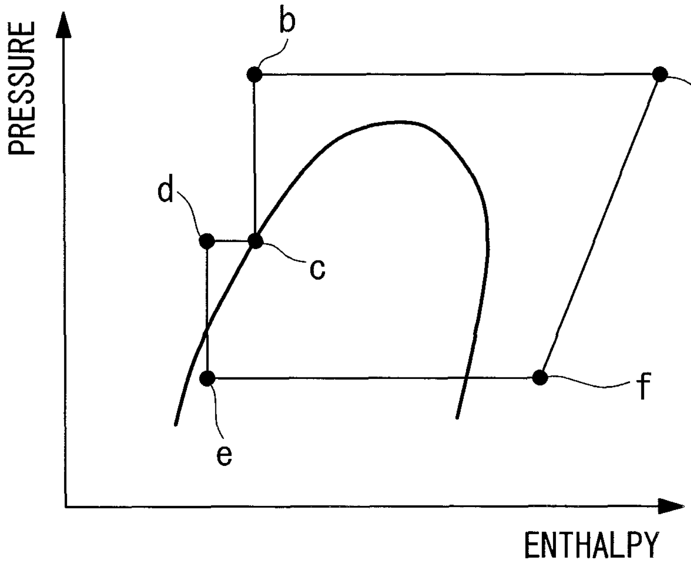

PRESSURE
b
a
d
c
f
e
ENTHALPY

FIG. 9A

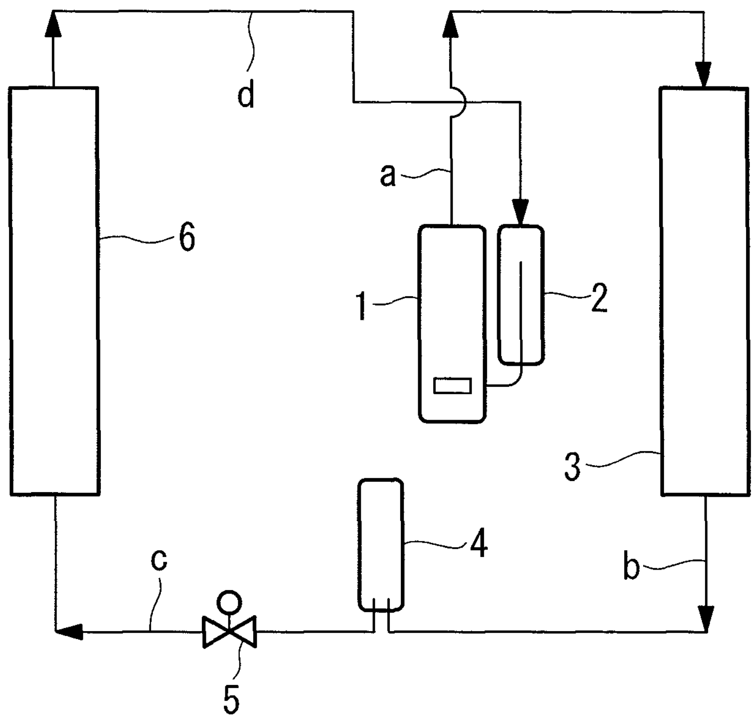


FIG. 9B

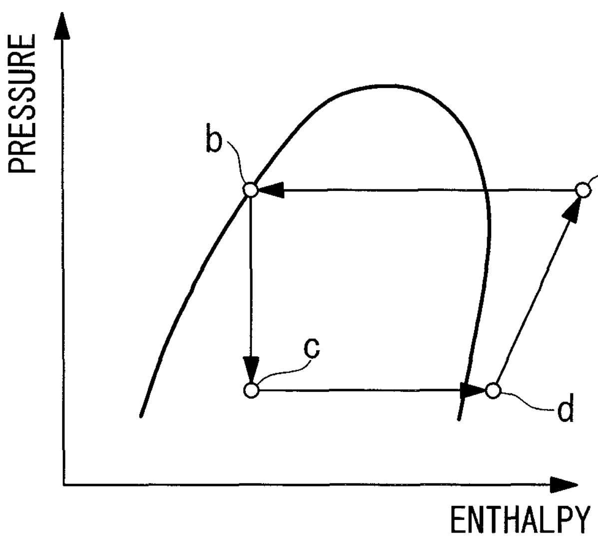


FIG. 10A

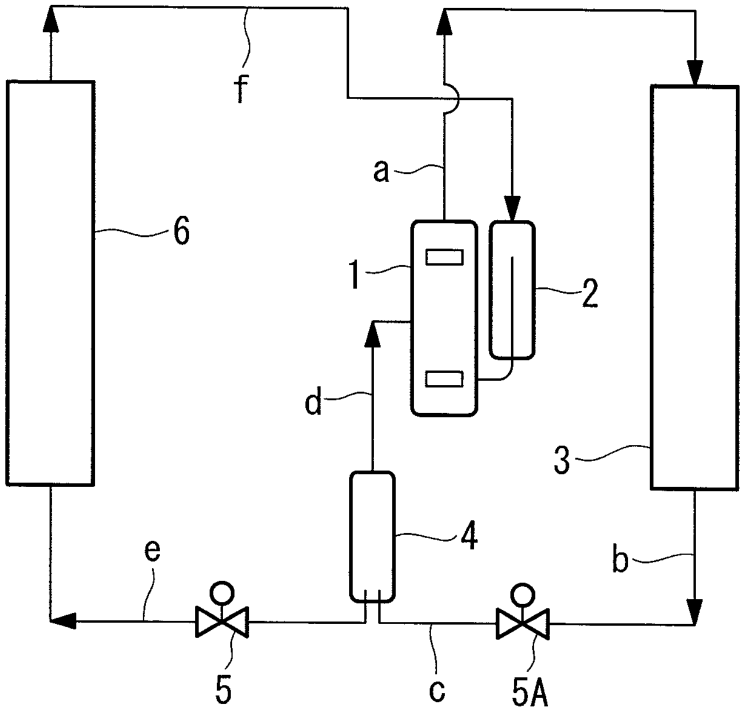


FIG. 10B

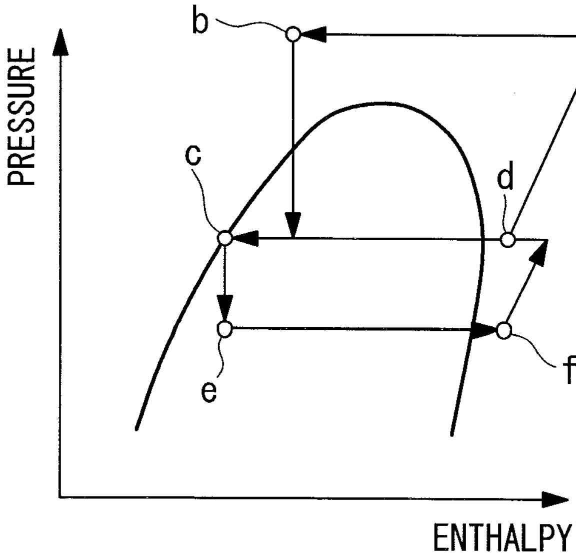


FIG. 11A

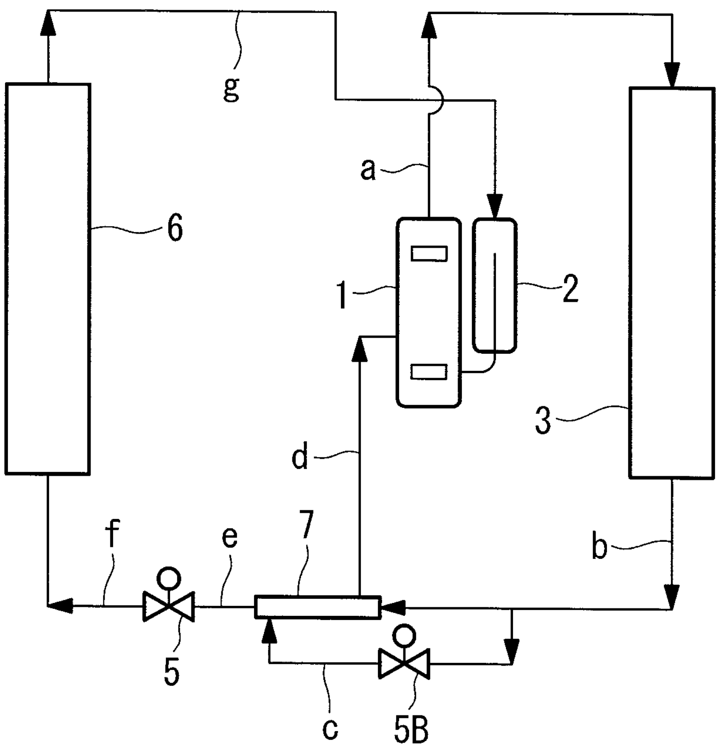
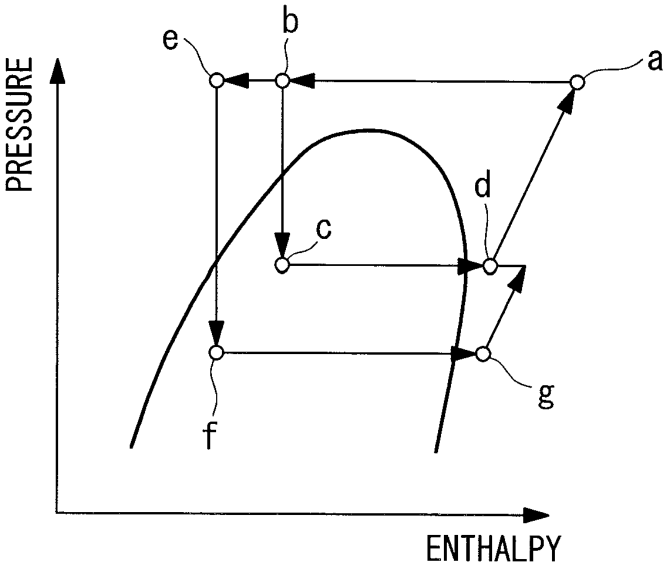


FIG. 11B



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/070655

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(2006.01)i, *F25B5/02*(2006.01)i, *F25B6/04*(2006.01)i, *F25B43/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B1/00, F25B5/02, F25B6/04, F25B43/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

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 Y	JP 2002-228275 A (Mitsubishi Heavy Industries, Ltd.), 14 August, 2002 (14.08.02), Claims; Par. Nos. [0061] to [0064]; Figs. 8 to 9 (Family: none)	1 2,5
Y	JP 2006-220351 A (Hitachi, Ltd.), 24 August, 2006 (24.08.06), Claim 4 (Family: none)	2,5
Y	JP 2006-214610 A (Daikin Industries, Ltd.), 17 August, 2006 (17.08.06), Claim 3 (Family: none)	2,5

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
30 January, 2009 (30.01.09)	10 February, 2009 (10.02.09)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/070655

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 58-145859 A (Hitachi, Ltd.), 31 August, 1983 (31.08.83), Claims; page 2, upper right column, line 8 to lower right column, line 4; Fig. 2 (Family: none)	5
A	JP 2006-242557 A (Thermal Analysis Partners, L.L.C.), 14 September, 2006 (14.09.06), Full text; all drawings & US 2006/0191288 A1 & EP 1703229 A2 & CN 1847750 A	1,2,5
A	JP 7-18602 B2 (Sinvent A/S), 06 March, 1995 (06.03.95), Full text; all drawings & US 5245836 A & EP 424474 B2 & WO 90/007683 A1 & DE 68908181 T4 & NO 903903 A & DK 2146/90 A & RU 2039914 C1 & KR 0126550 B1 & HU 213995 B & AU 56968/90 B & CA 2018250 C & ES 2025443 A6	1,2,5

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/070655

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: Claims 1, 2, 5

Remark on Protest the

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/070655

Continuation of Box No.III of continuation of first sheet(2)

The matter common to the inventions in claims 1-5 is a matter to define the invention as stated in claim 1.

However, the search has revealed that the invention in claim 1 is the invention stated in document 1 and makes no contribution over the prior art.

Therefore, the common matter is not a special technical feature in the meaning of the second sentence of PCT rule 13.2.

Since there is no one or corresponding special technical feature in both claims 1-5 and claim 6 not referring to claim 1, and also there is no other common matter considered to be a special technical feature in the meaning of the second sentence of PCT rule 13.2, any technical relation in the meaning of PCT rule 13 cannot be found.

Even when claim 2 for which examination has been substantially completed in the process of the investigation on the special technical feature and a portion of claim 5 which refers only to claims 1 and 2 are considered exceptional, the first invention and the second to fourth inventions shown in the Remark column are not so linked as to form a single general inventive concept. As a result, the inventions in claims 1-6 do not satisfy the requirement of unity of invention.

Remark:
First invention: Claim 1, claim 2, and a portion of claim 5 which refers to only claims 1 and 2
Second invention: Claim 3, and portions of all the other claims which refer to claim 3
Third invention: A portion of claim 4 which refers only to claim 1, and a portion of claim 5 which refers only to that portion
Fourth invention: Claim 6

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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 2006242557 A **[0006]**
- JP H718602 B **[0006]**