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(54) AIR CONDITIONER FOR VEHICLE

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(21) Appl. No.: **12/927,741**

(22) Filed: **Nov. 22, 2010**

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Mar. 5, 2010	(JP)	2010-49179

Publication Classification

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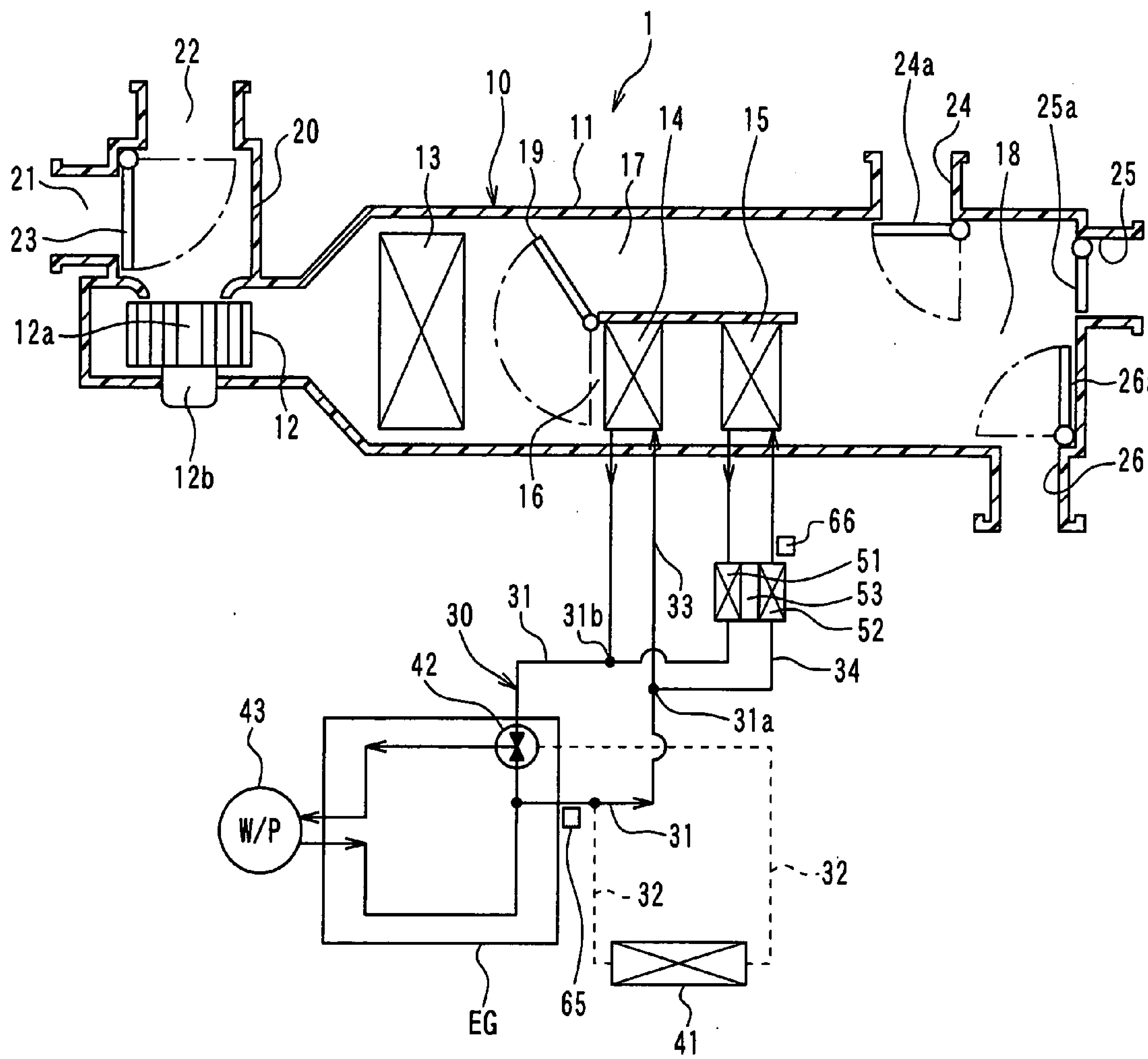
F24F 7/007	(2006.01)
F25B 29/00	(2006.01)

(52) **U.S. Cl.** **62/3.3**; 165/59; 165/64

(57) **ABSTRACT**

An air conditioner for a vehicle includes first and second heating heat exchangers disposed to heat air by using a cooling fluid for cooling an engine as a heat source, a heater disposed to heat the cooling fluid flowing to the second heating heat exchanger, and a controller that outputs an operation request signal to the engine when a temperature of the cooling fluid is lower than a predetermined temperature. The first and second heating heat exchangers are arranged in parallel with respect to a flow direction of the cooling fluid. In the air conditioner, the controller controls a flow amount of the cooling fluid flowing into the second heating heat exchanger to be, smaller than a flow amount of the cooling fluid flowing into the first heating heat exchanger when the heater heats the cooling fluid flowing to the second heating heat exchanger.



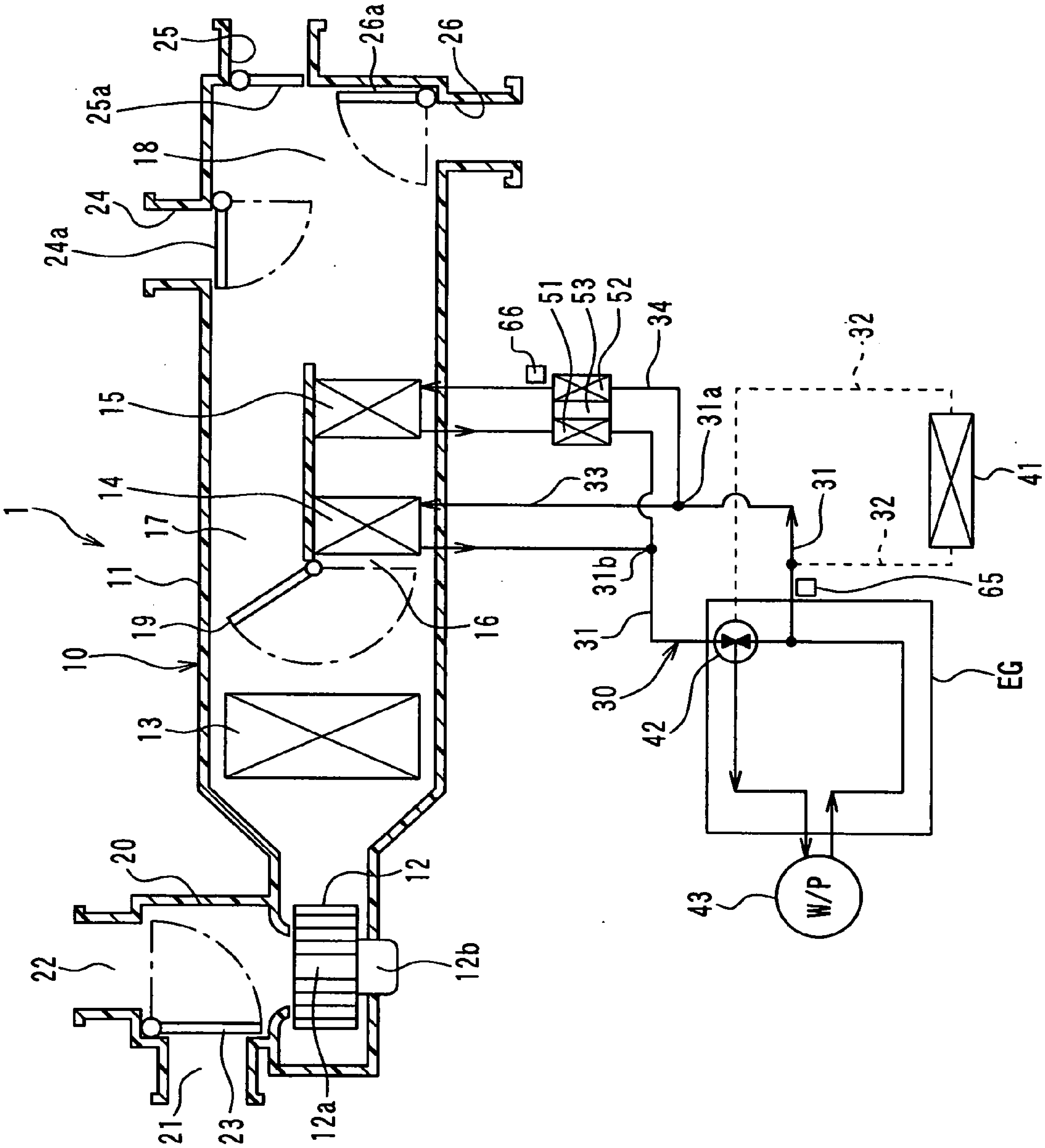

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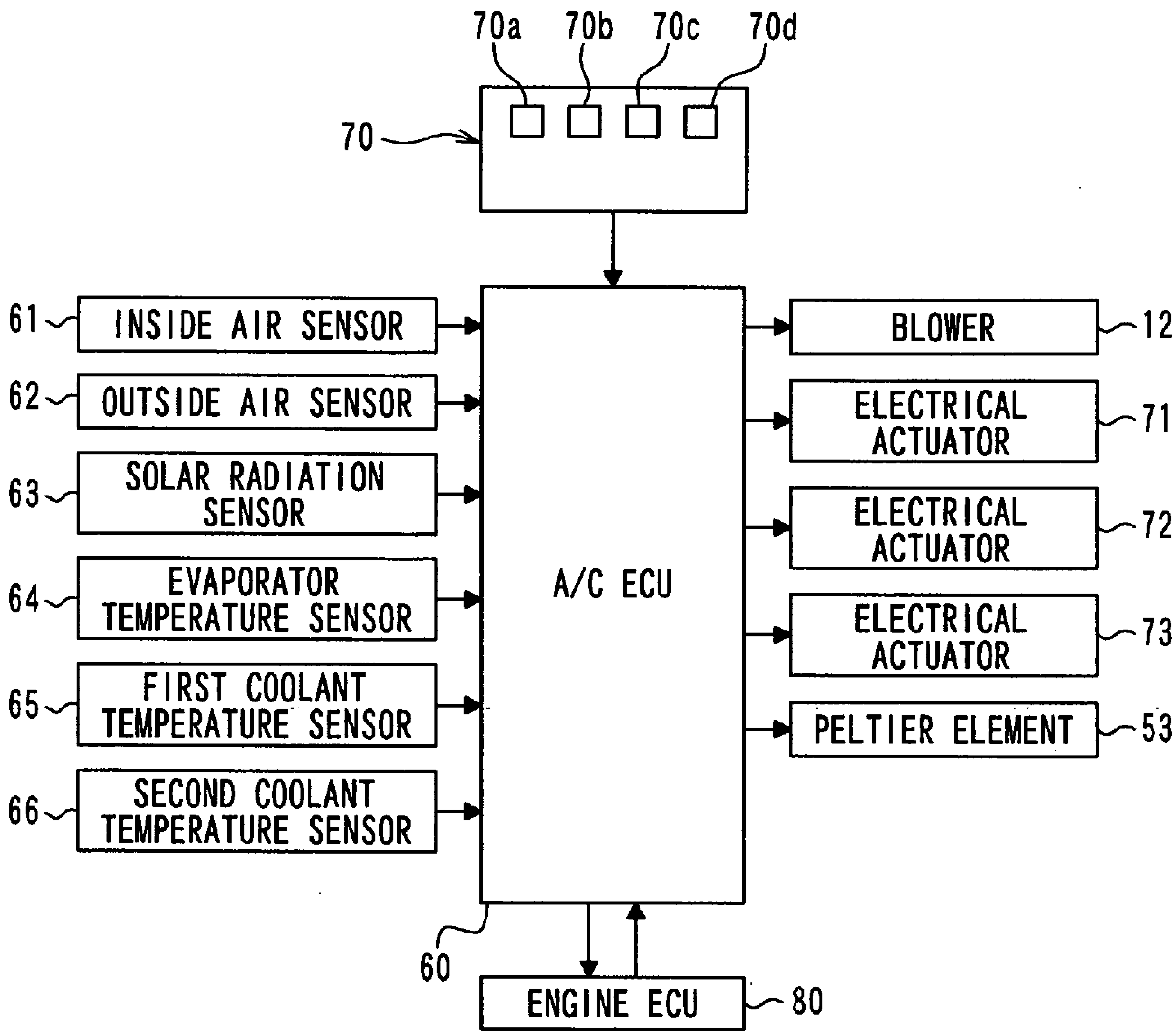
FIG. 1

FIG. 2


70a
70b
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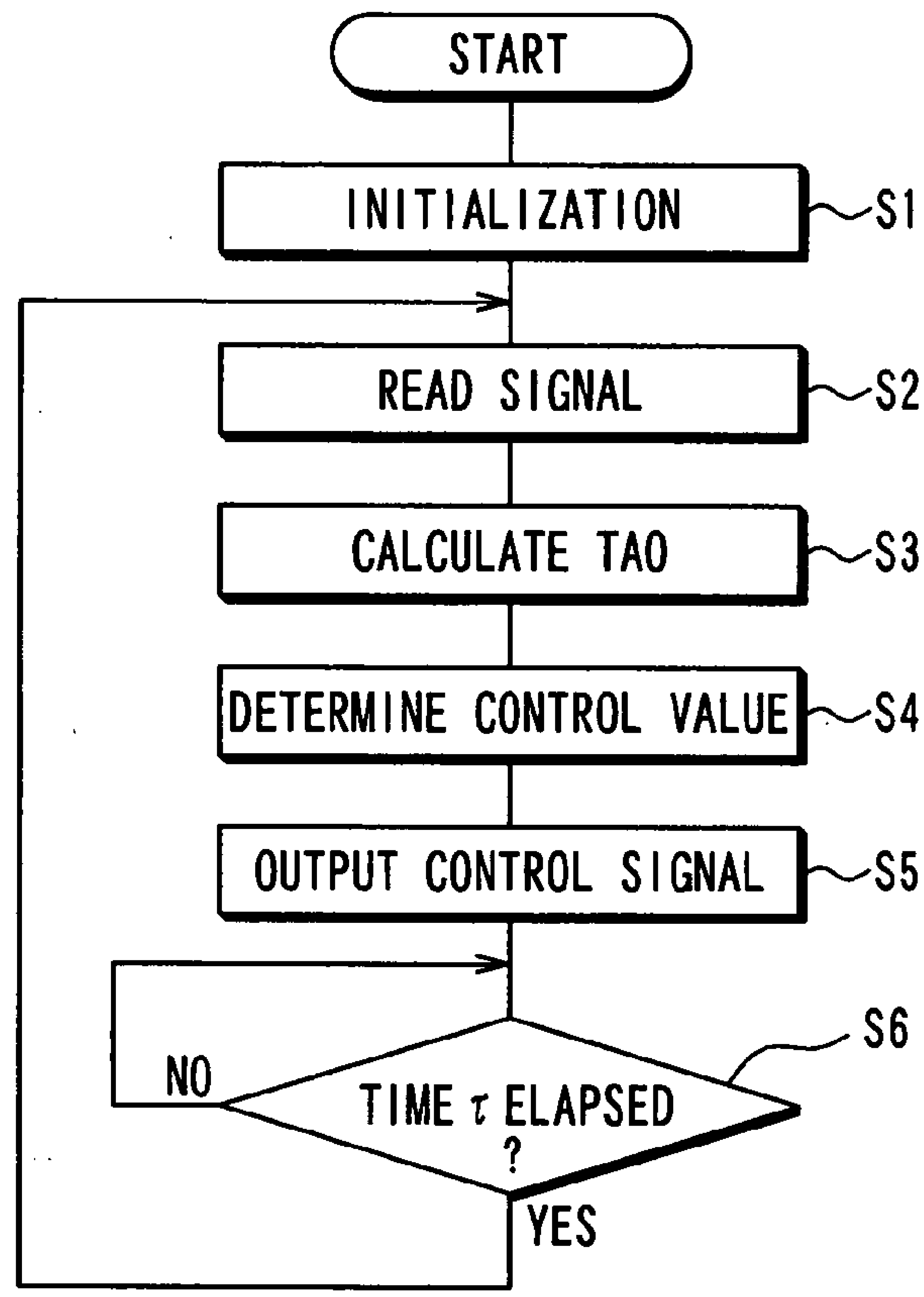
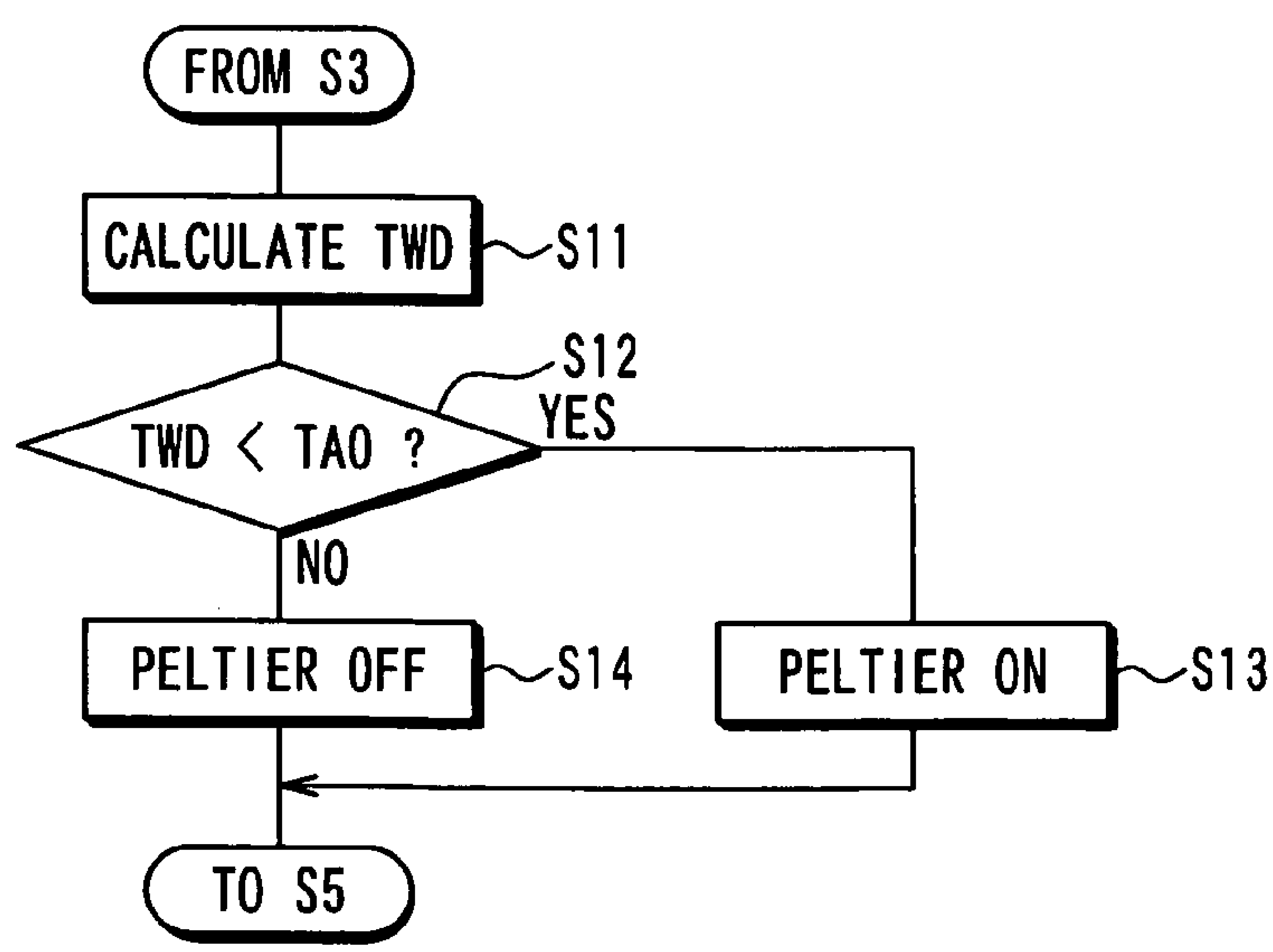
70
61
INSIDE AIR SENSOR
62
OUTSIDE AIR SENSOR
63
SOLAR RADIATION SENSOR
64
EVAPORATOR TEMPERATURE SENSOR
65
FIRST COOLANT TEMPERATURE SENSOR
66
SECOND COOLANT TEMPERATURE SENSOR
A/C ECU
60
BLOWER
12
ELECTRICAL ACTUATOR
71
ELECTRICAL ACTUATOR
72
ELECTRICAL ACTUATOR
73
PELTIER ELEMENT
53
ENGINE ECU
80

FIG. 3



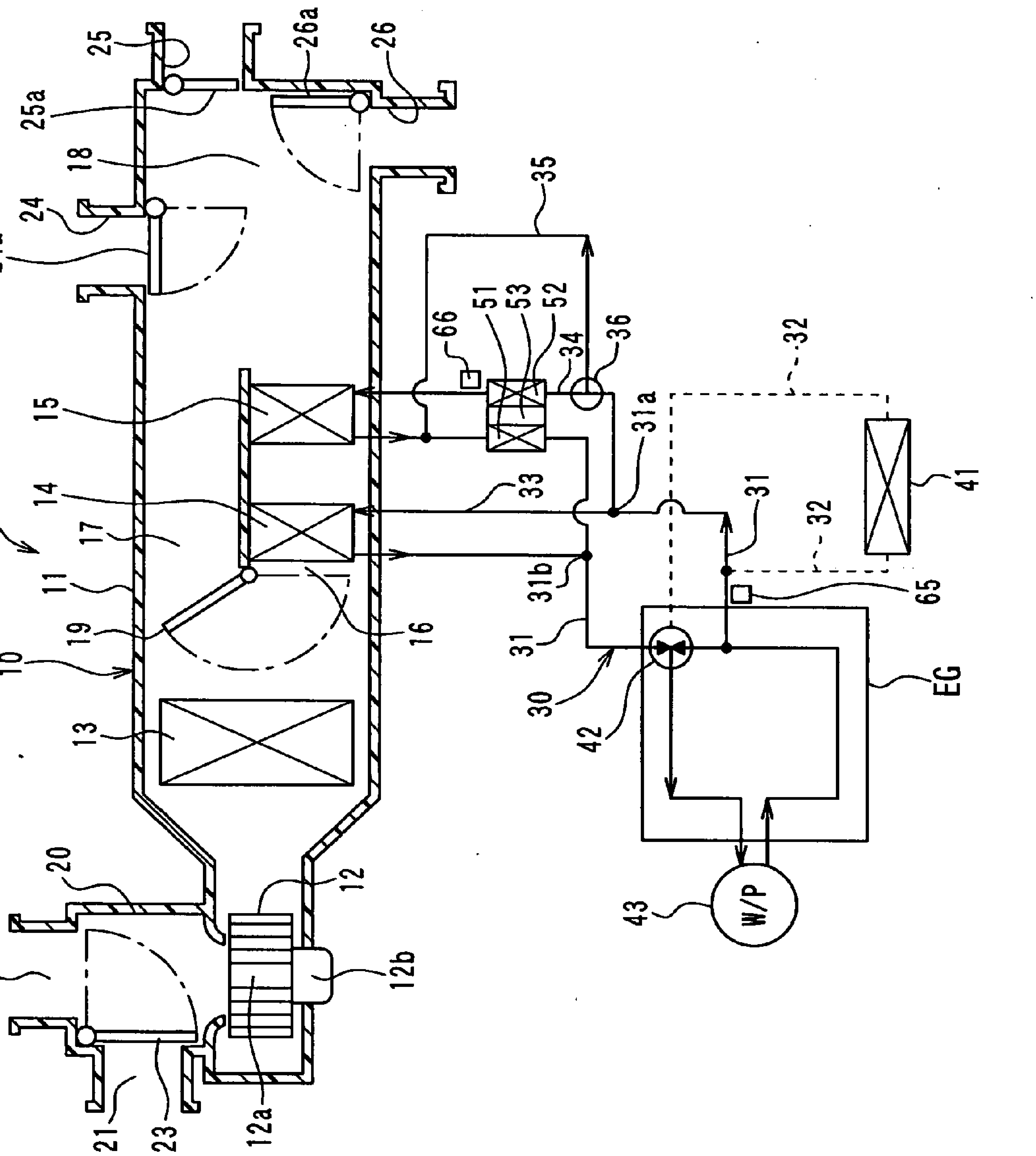
START
INITIALIZATION
S1
READ SIGNAL
S2
CALCULATE TAO
S3
DETERMINE CONTROL VALUE
S4
OUTPUT CONTROL SIGNAL
S5
S6
NO
TIME τ ELAPSED ?
YES

FIG. 4



FROM S3
CALCULATE TWD
S11
S12
YES
TWD < TAO ?
NO
PELTIER OFF
S14
PELTIER ON
S13
TO S5

FIG. 5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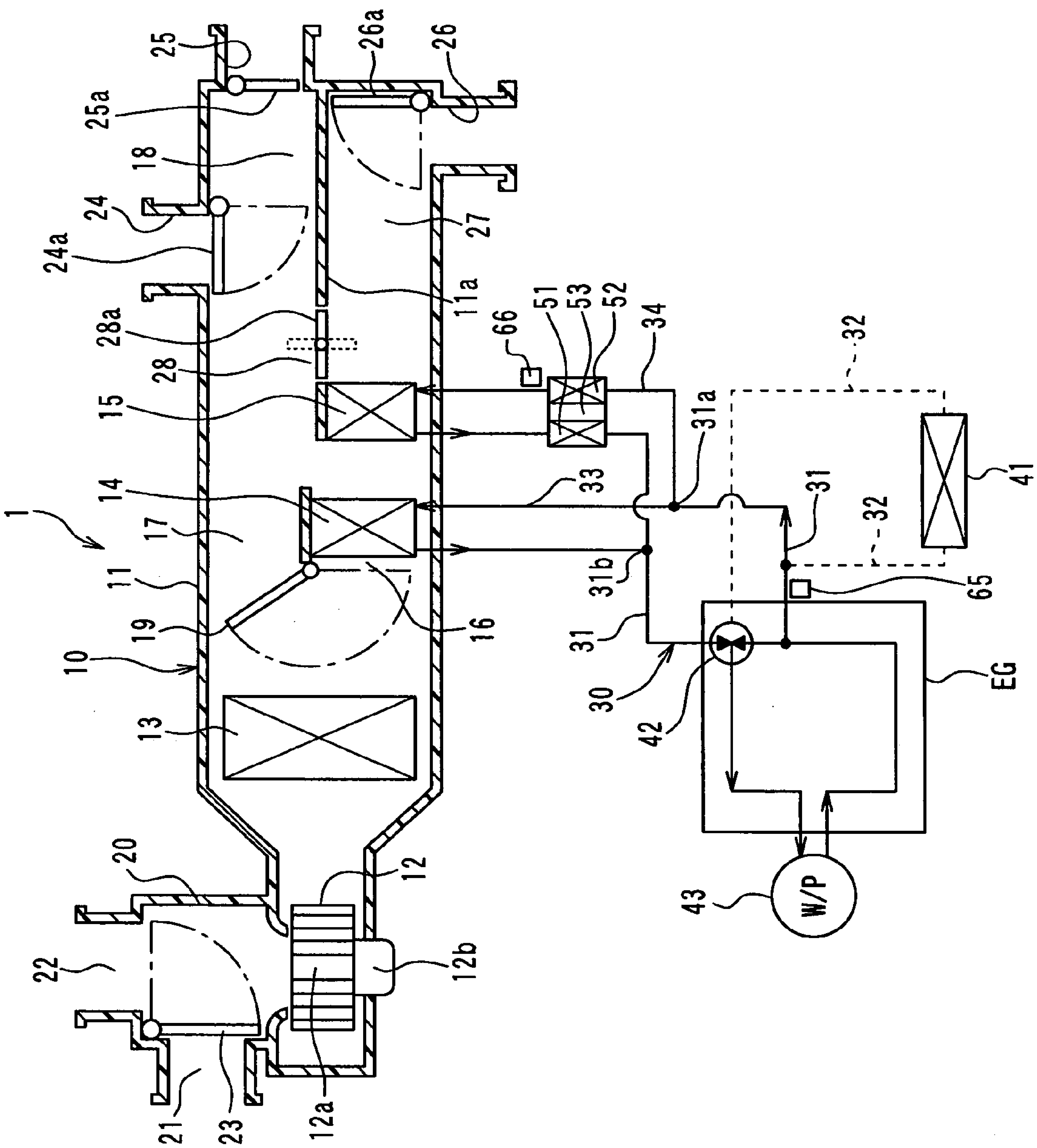
EG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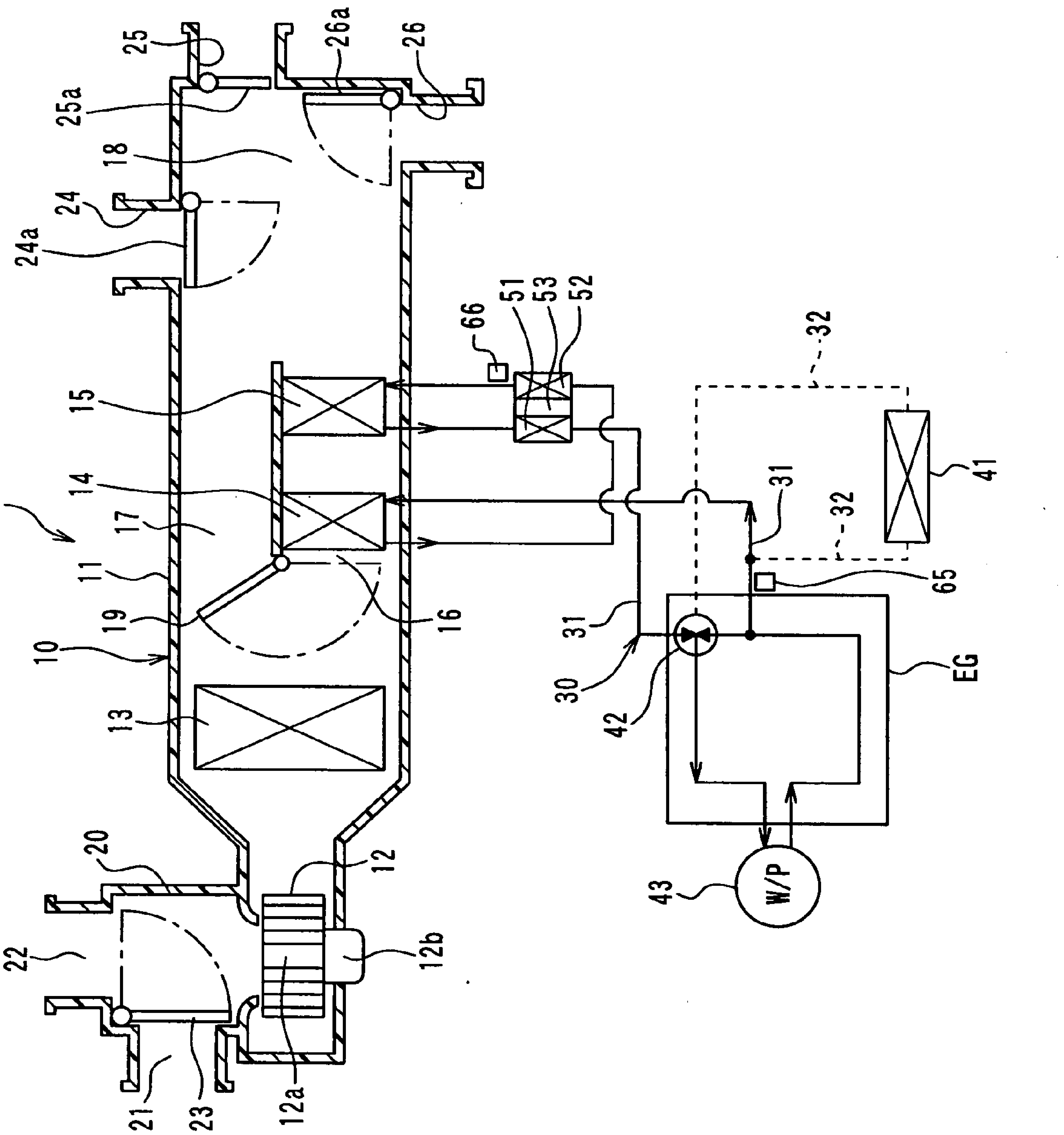
EG

FIG. 6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W/P
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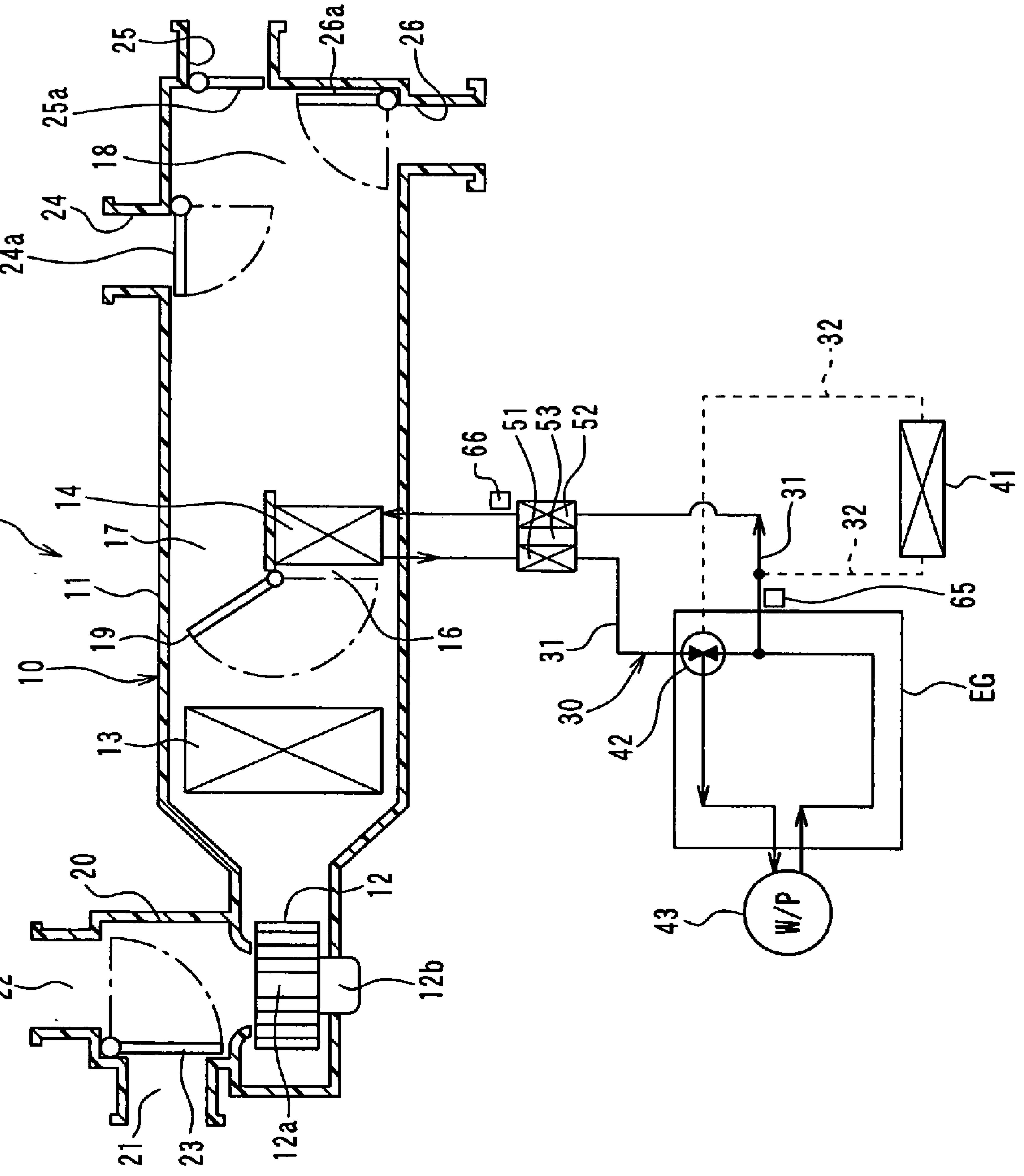
EG

FIG. 7

FIG. 8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EG

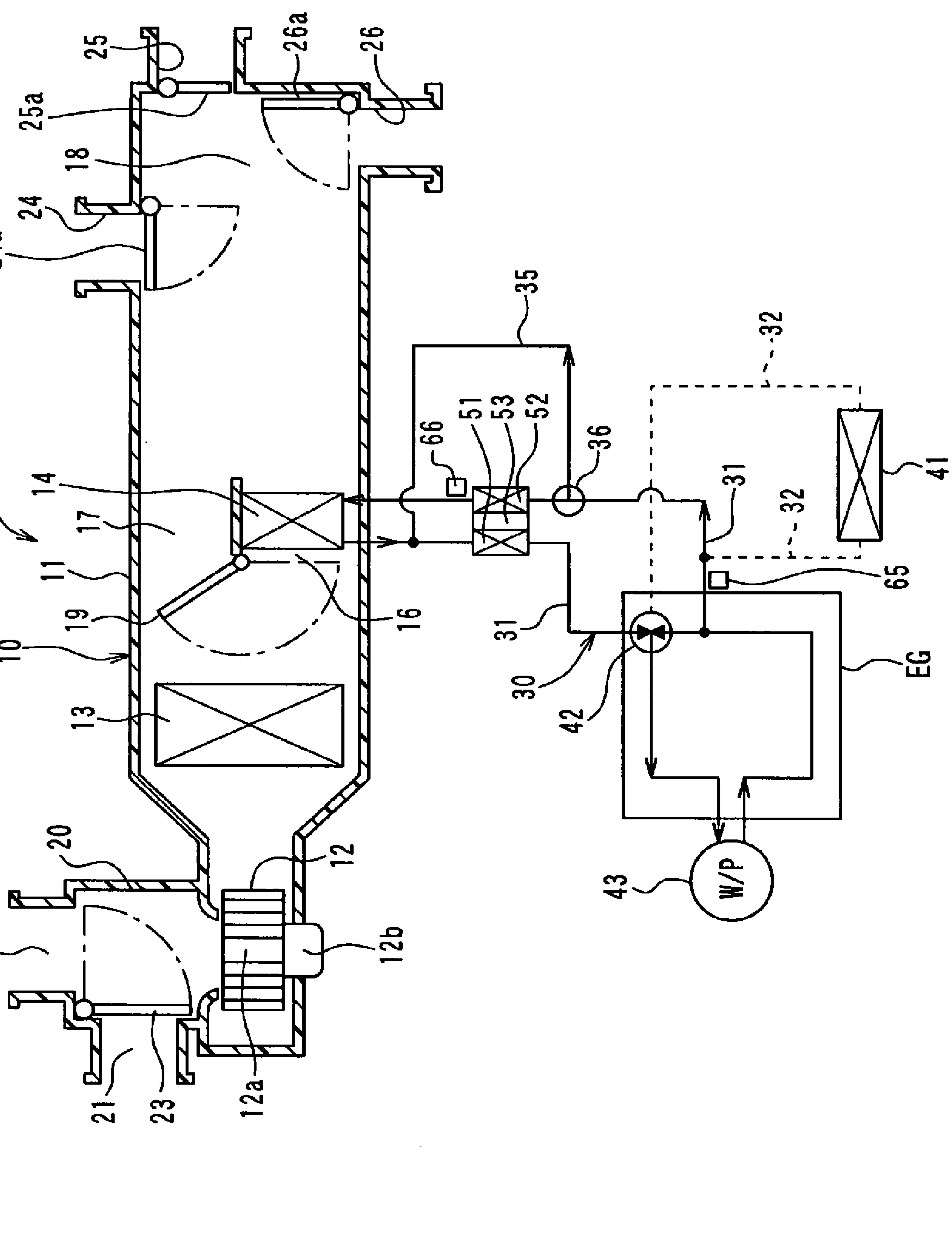
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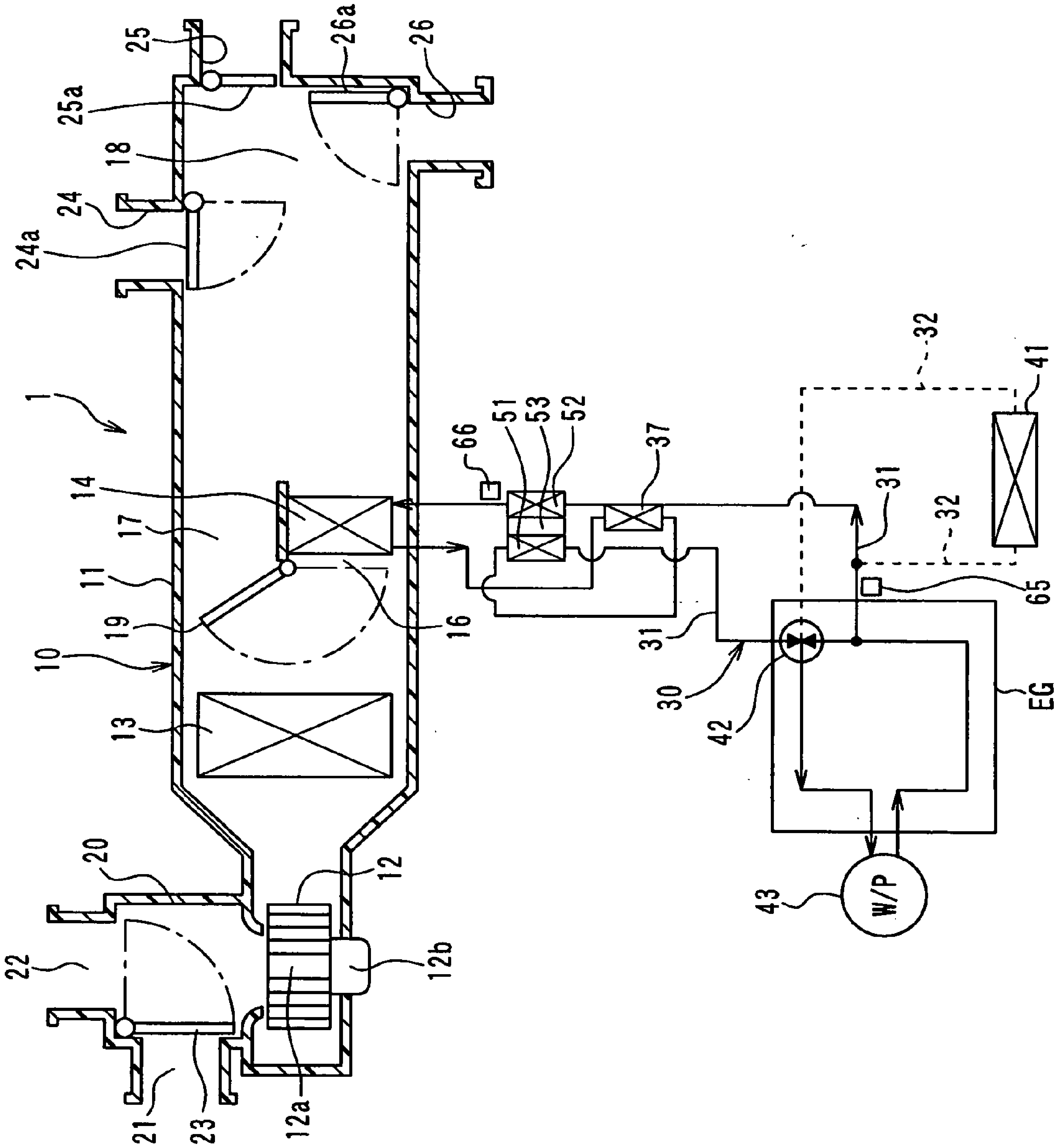
FIG. 9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W/P
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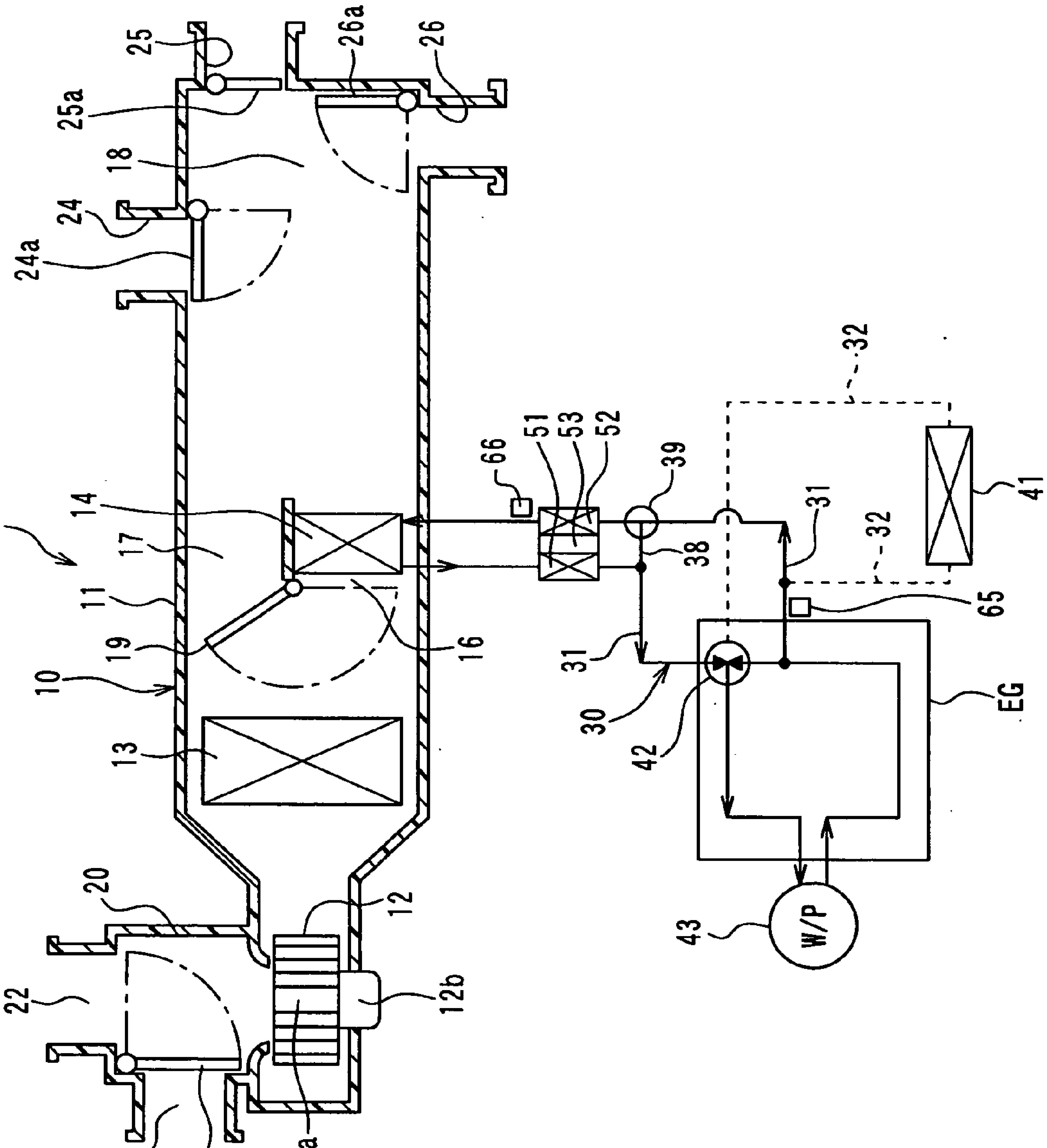
FIG. 10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25a
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W/P
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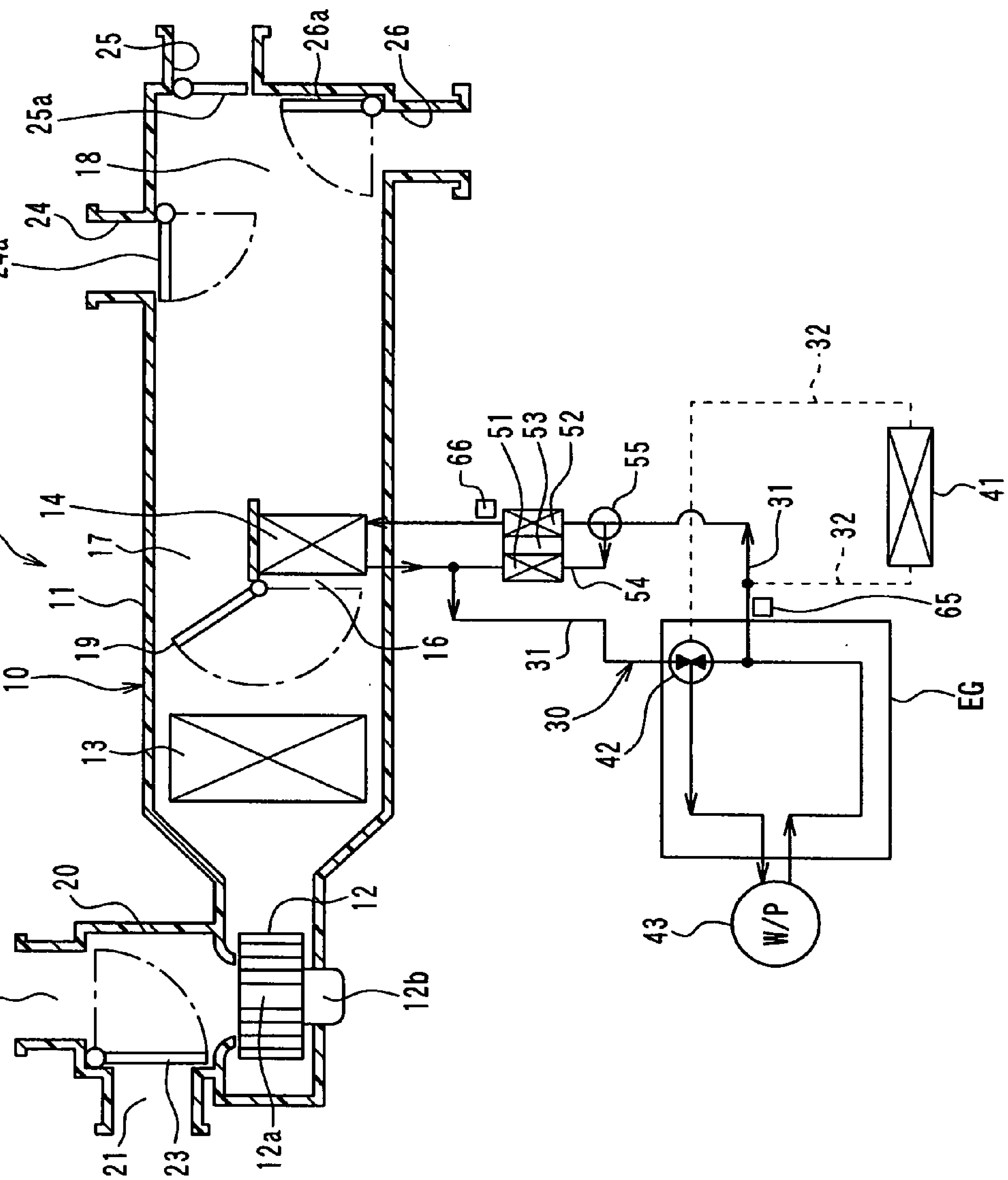
EG

FIG. 11

FIG. 12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24a
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25a
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26a
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42
43
W/P
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54
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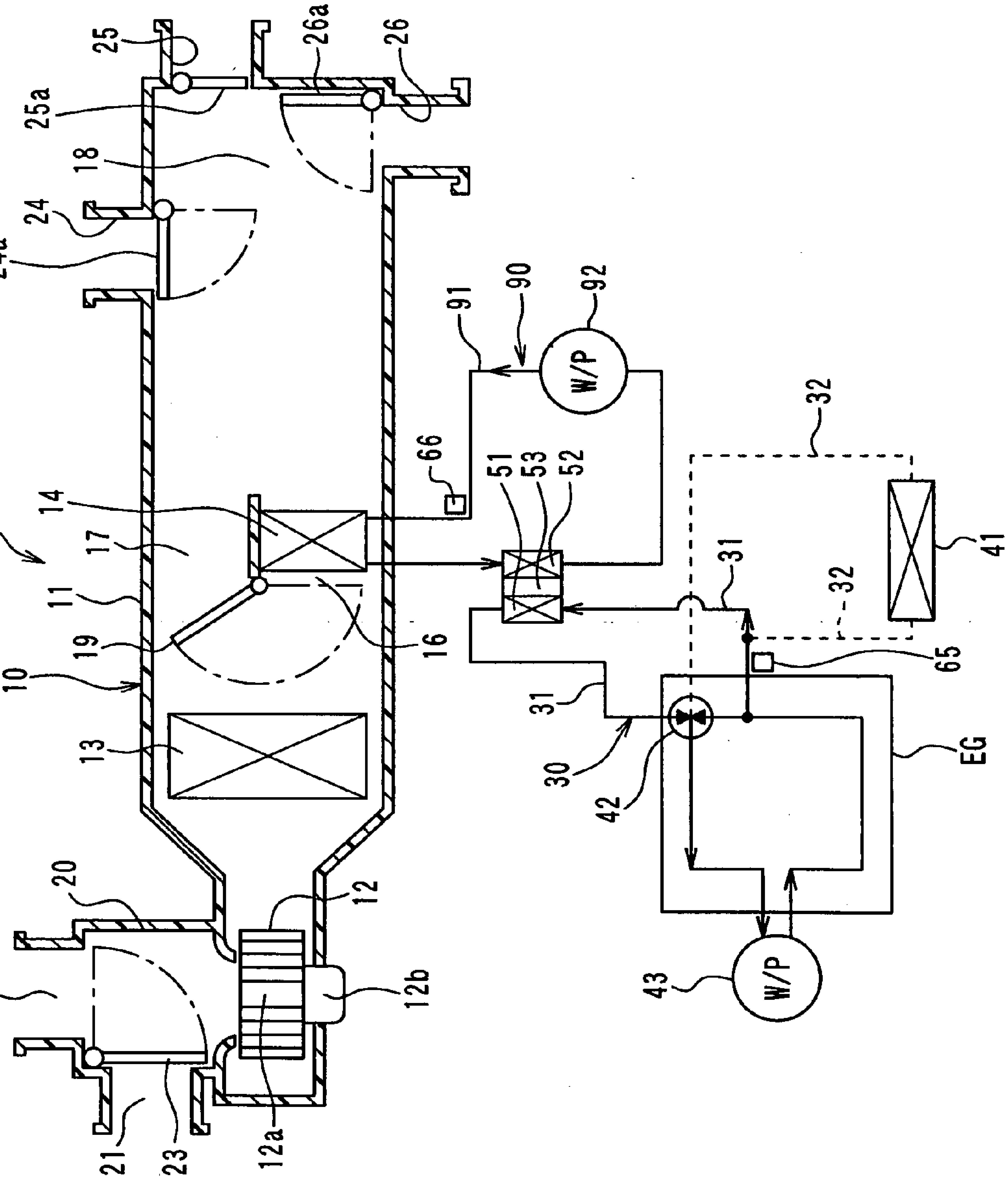
66
EG

FIG. 13


1
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26a
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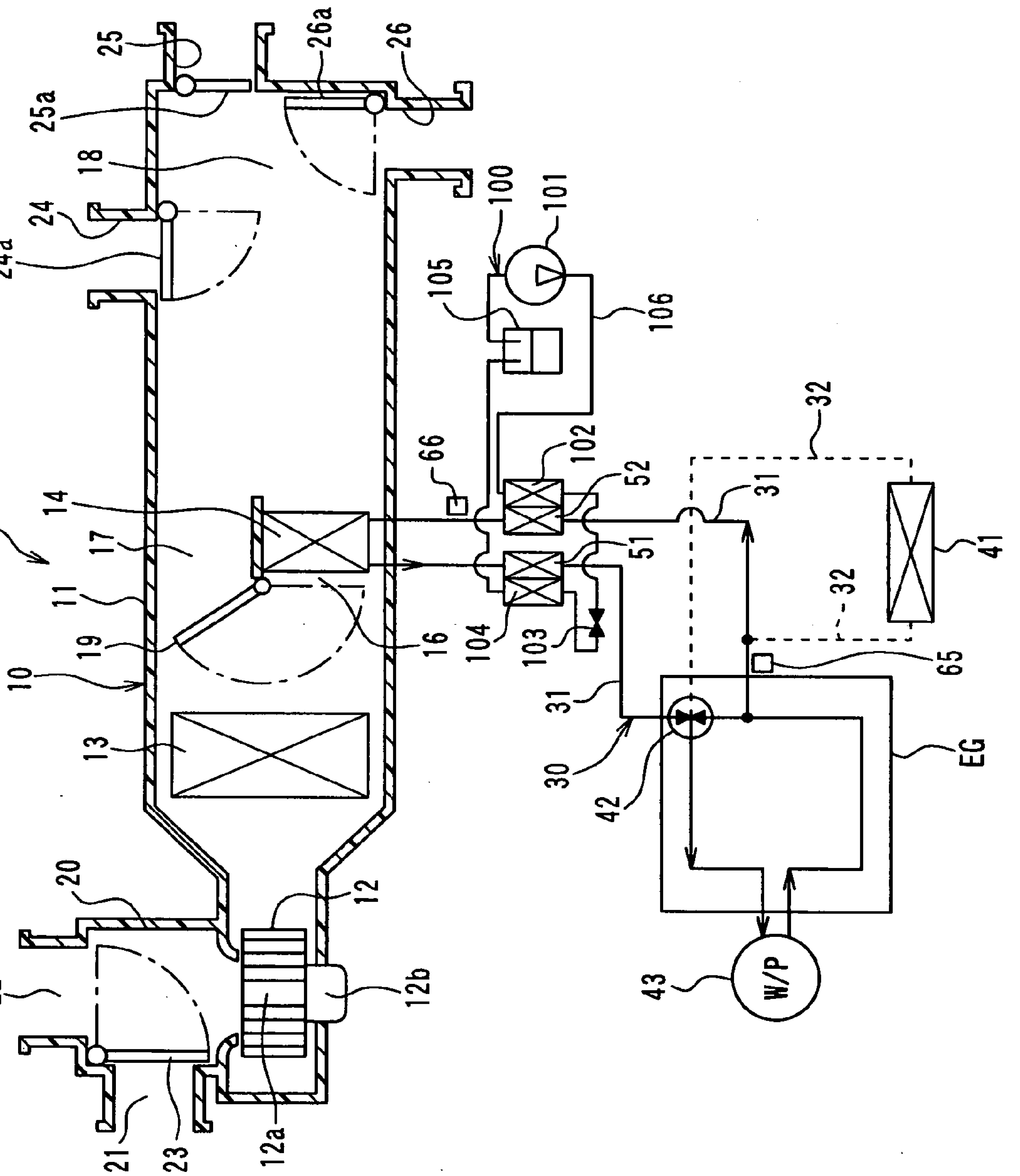
43
51
52
53
65
66
90
91
92
W/P
EG

FIG. 14


1
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24a
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25a
26
26a
30
31
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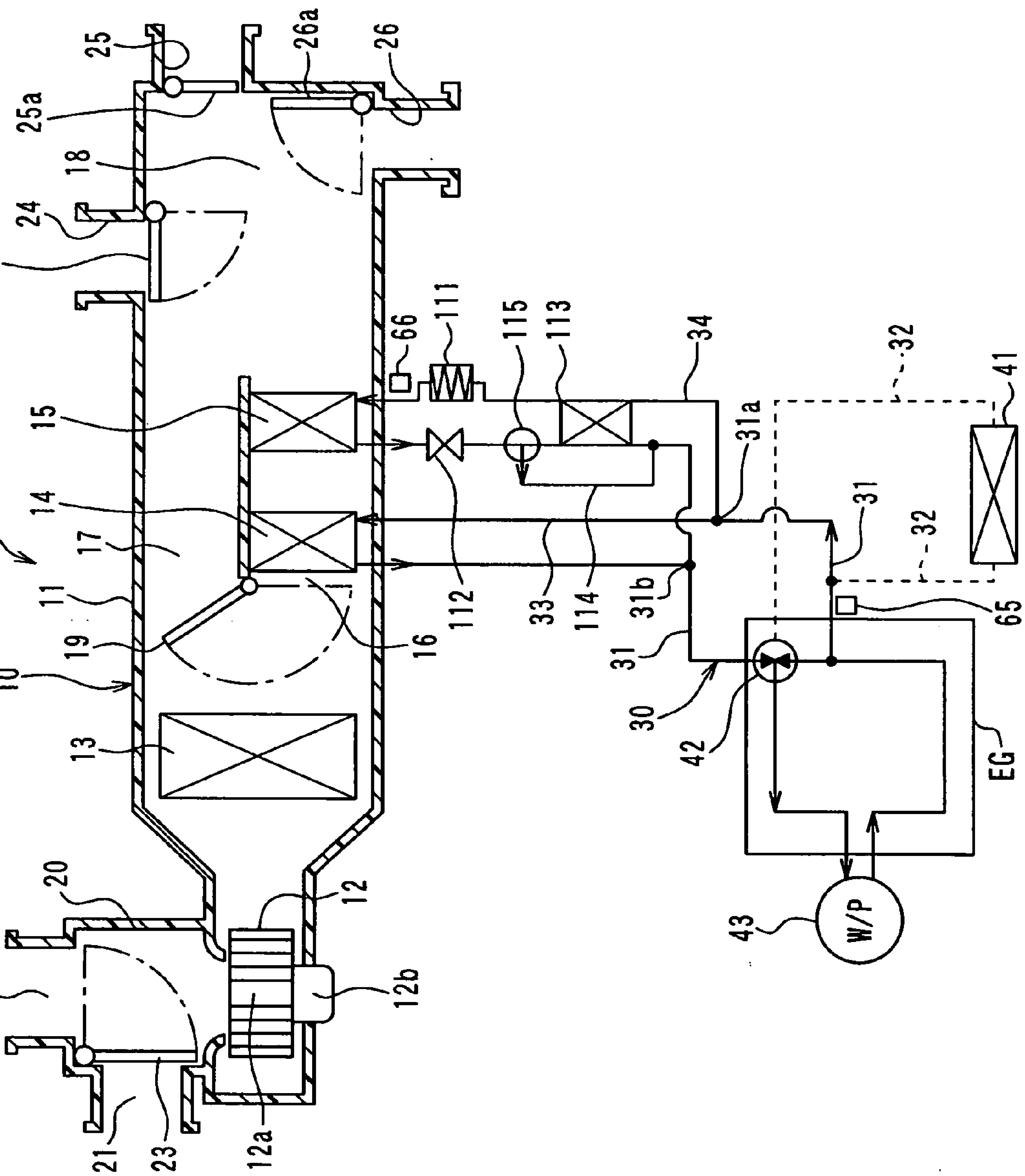
42
43
W/P
51
52
65
66
100
101
102
103
104
105
106
EG

FIG. 15



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25a
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26a
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31a
31b
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41
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43
W/P
EG
65
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111
112
113
114
115

FIG. 16

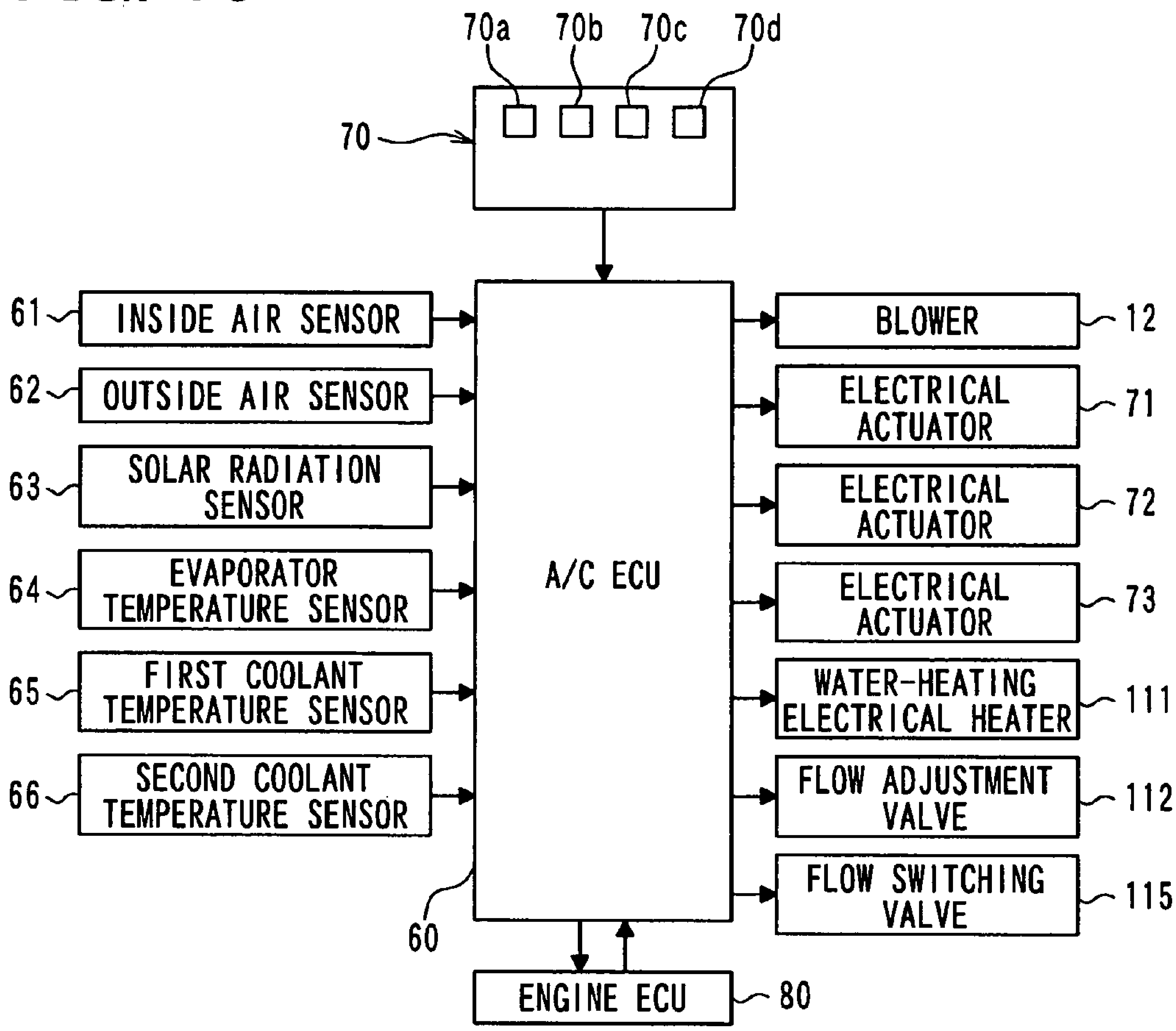
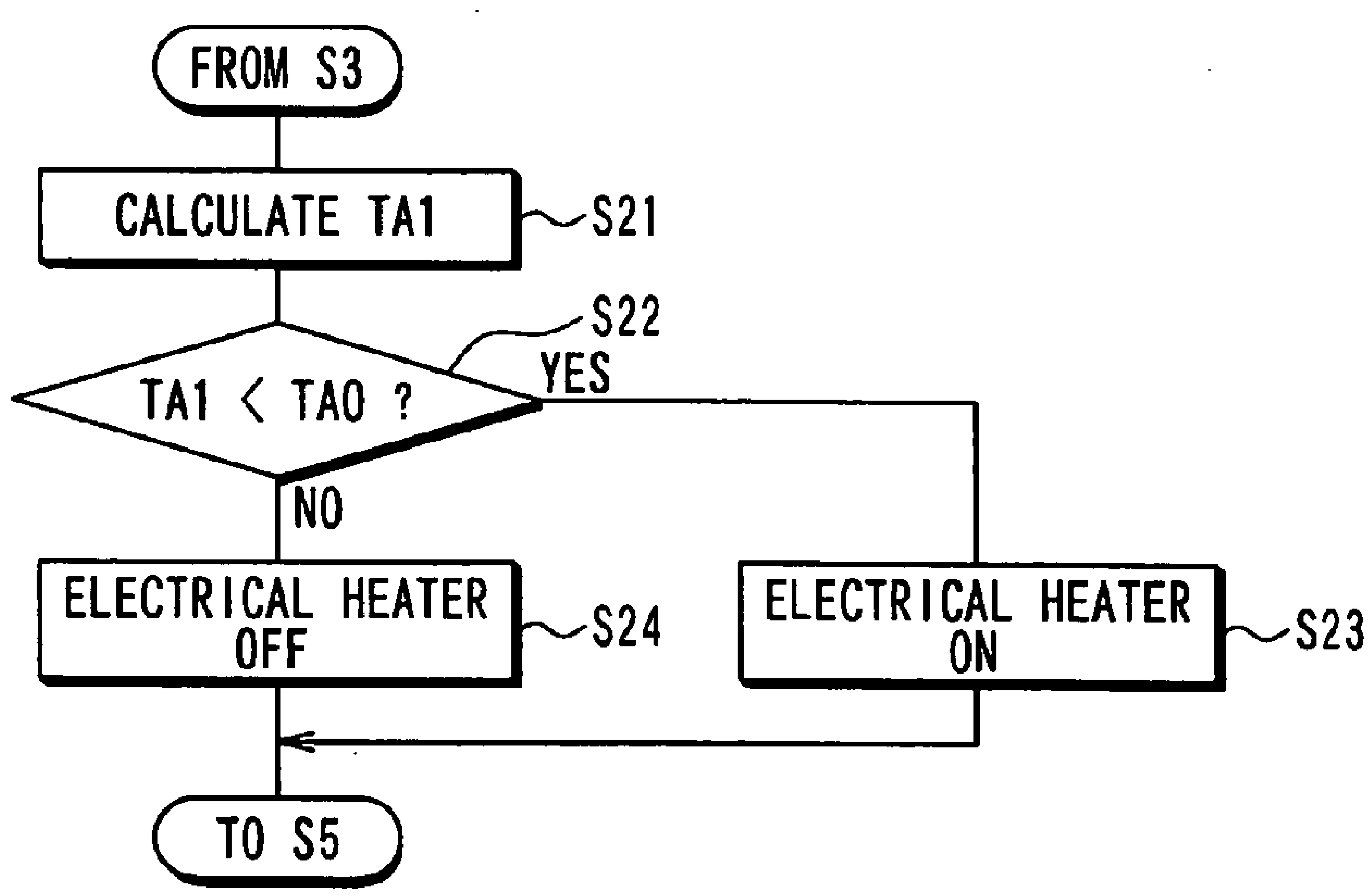
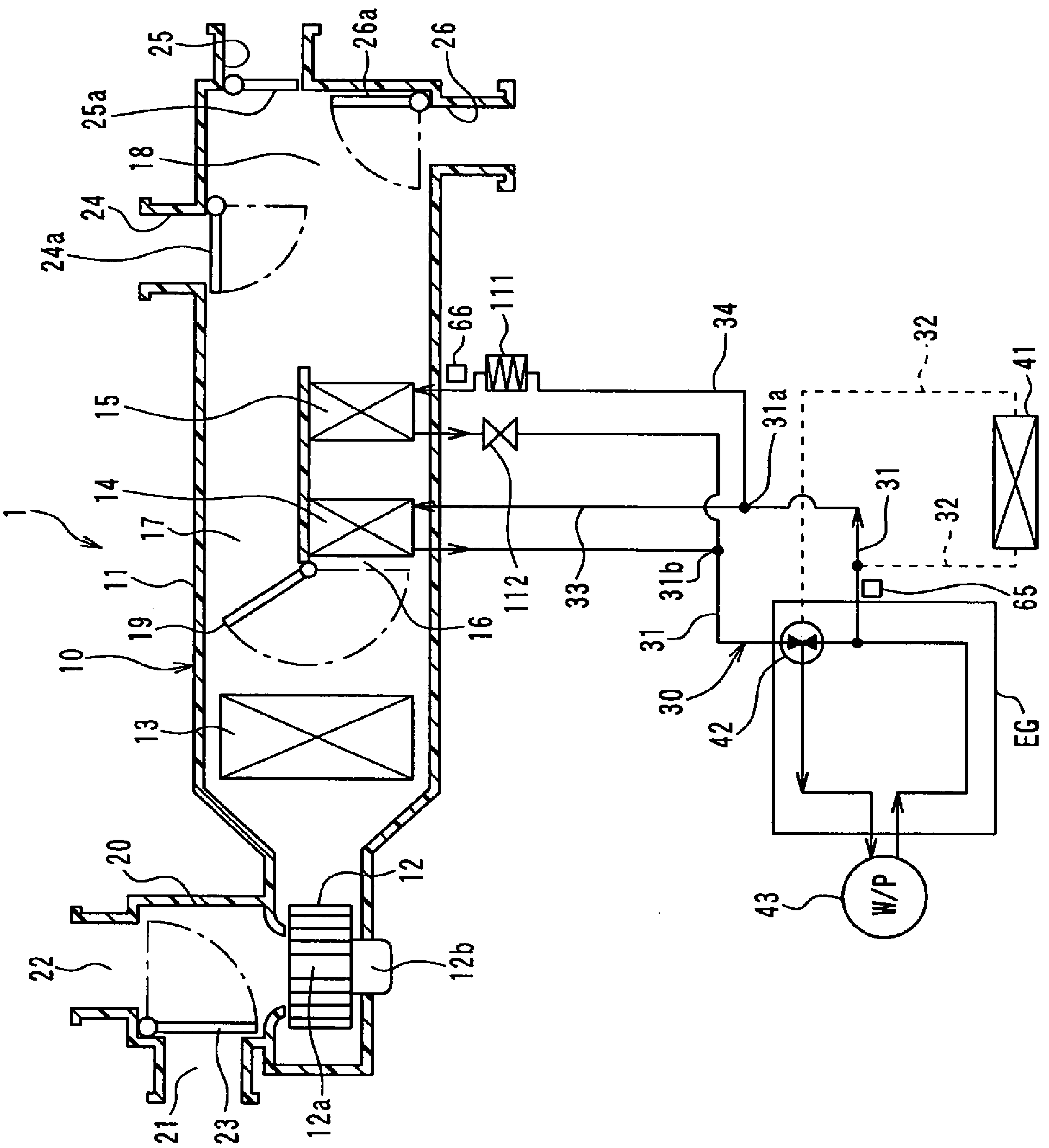

70a
70b
70c
70d
70
61
INSIDE AIR SENSOR
62
OUTSIDE AIR SENSOR
63
SOLAR RADIATION SENSOR
64
EVAPORATOR TEMPERATURE SENSOR
65
FIRST COOLANT TEMPERATURE SENSOR
66
SECOND COOLANT TEMPERATURE SENSOR
A/C ECU
60
BLOWER
12
ELECTRICAL ACTUATOR
71
ELECTRICAL ACTUATOR
72
ELECTRICAL ACTUATOR
73
WATER-HEATING ELECTRICAL HEATER
111
FLOW ADJUSTMENT VALVE
112
FLOW SWITCHING VALVE
115
ENGINE ECU
80

FIG. 17


FROM S3
CALCULATE TA1
S21
S22
TA1 < TAO ?
YES
NO
ELECTRICAL HEATER OFF
S24
ELECTRICAL HEATER ON
S23
TO S5


1
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12a
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25a
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26a
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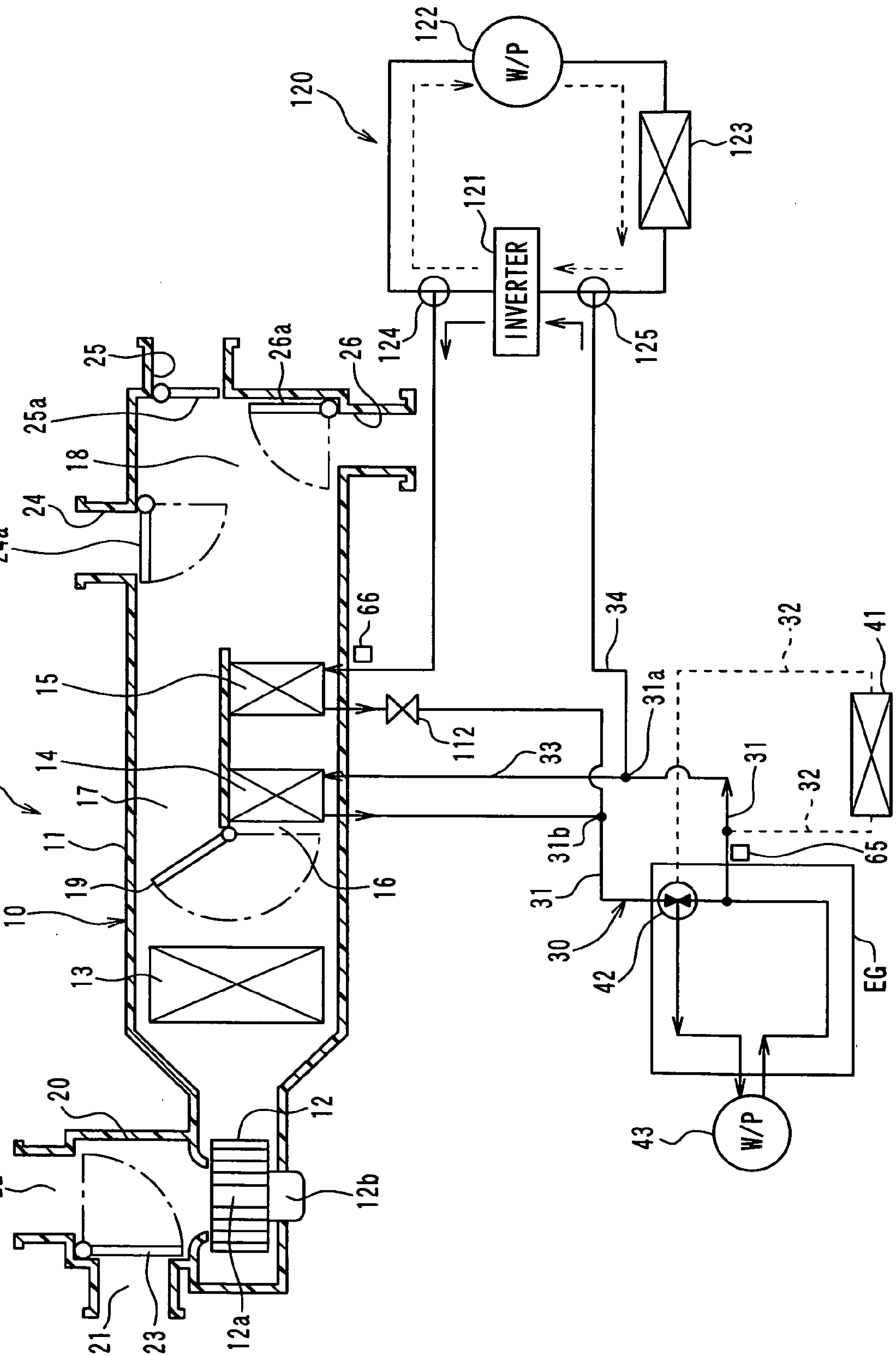
31a
31b
32
33
34
41
42
43
W/P
EG
65
66
111
112

FIG. 18

FIG. 19



W/P
INVERTER
EG
W/P
1
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12a
12b
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24a
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25a
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112
120
121
122
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124
125

FIG. 20

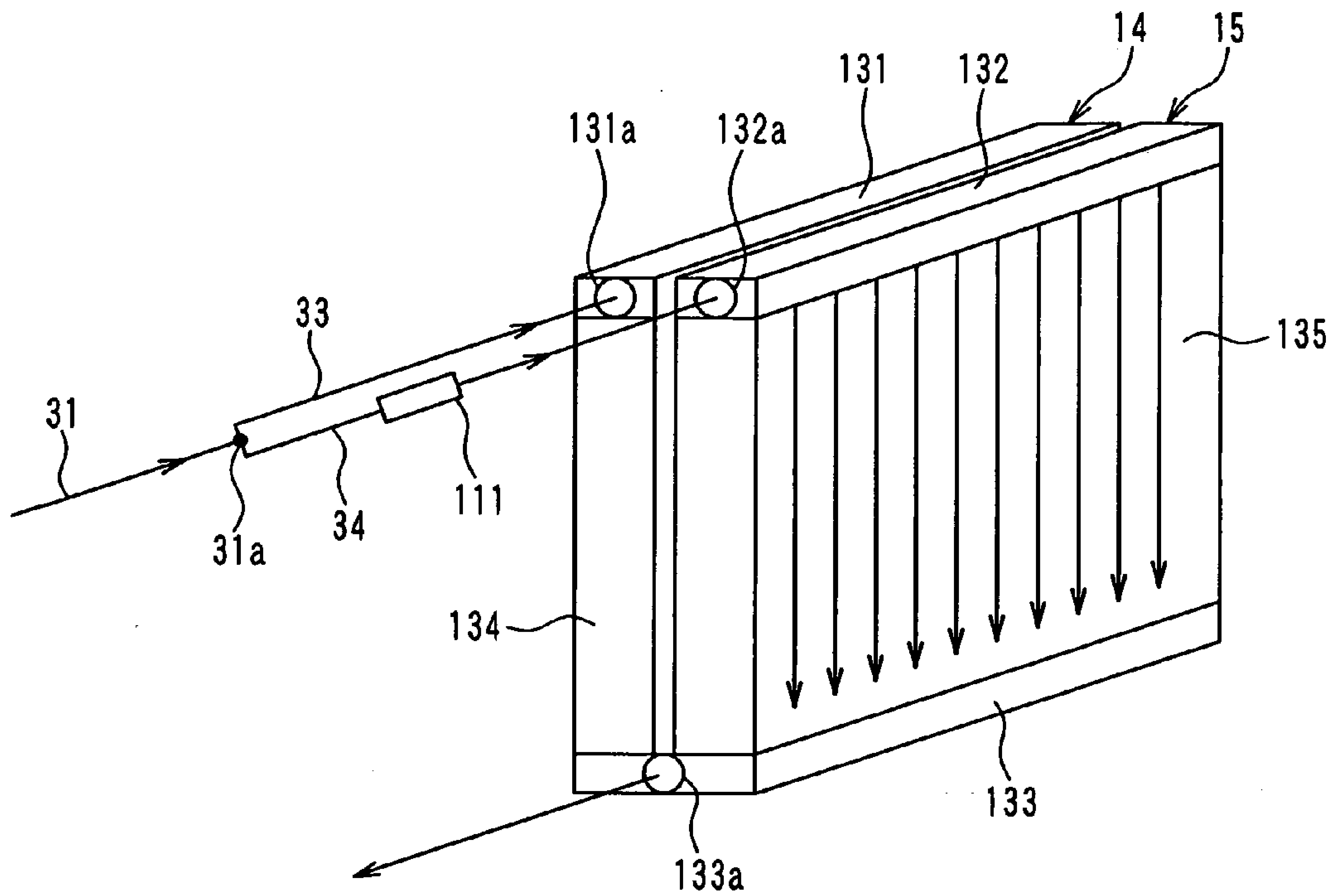


FIG. 21

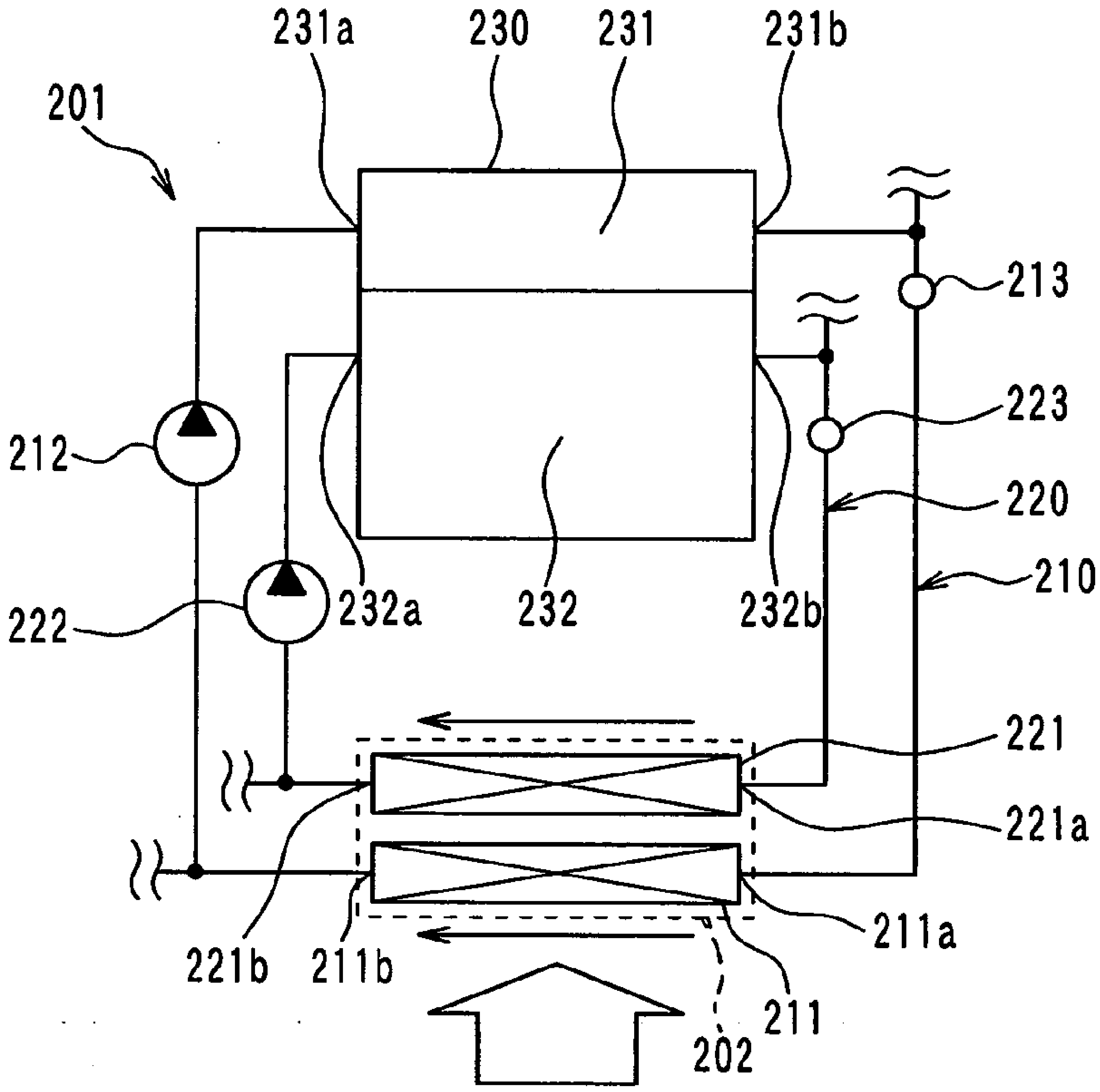

231a
230
231
231b
201
213
223
212
220
210
222
232a
232
232b
221
221a
211a
221b
211b
211
202

FIG. 22

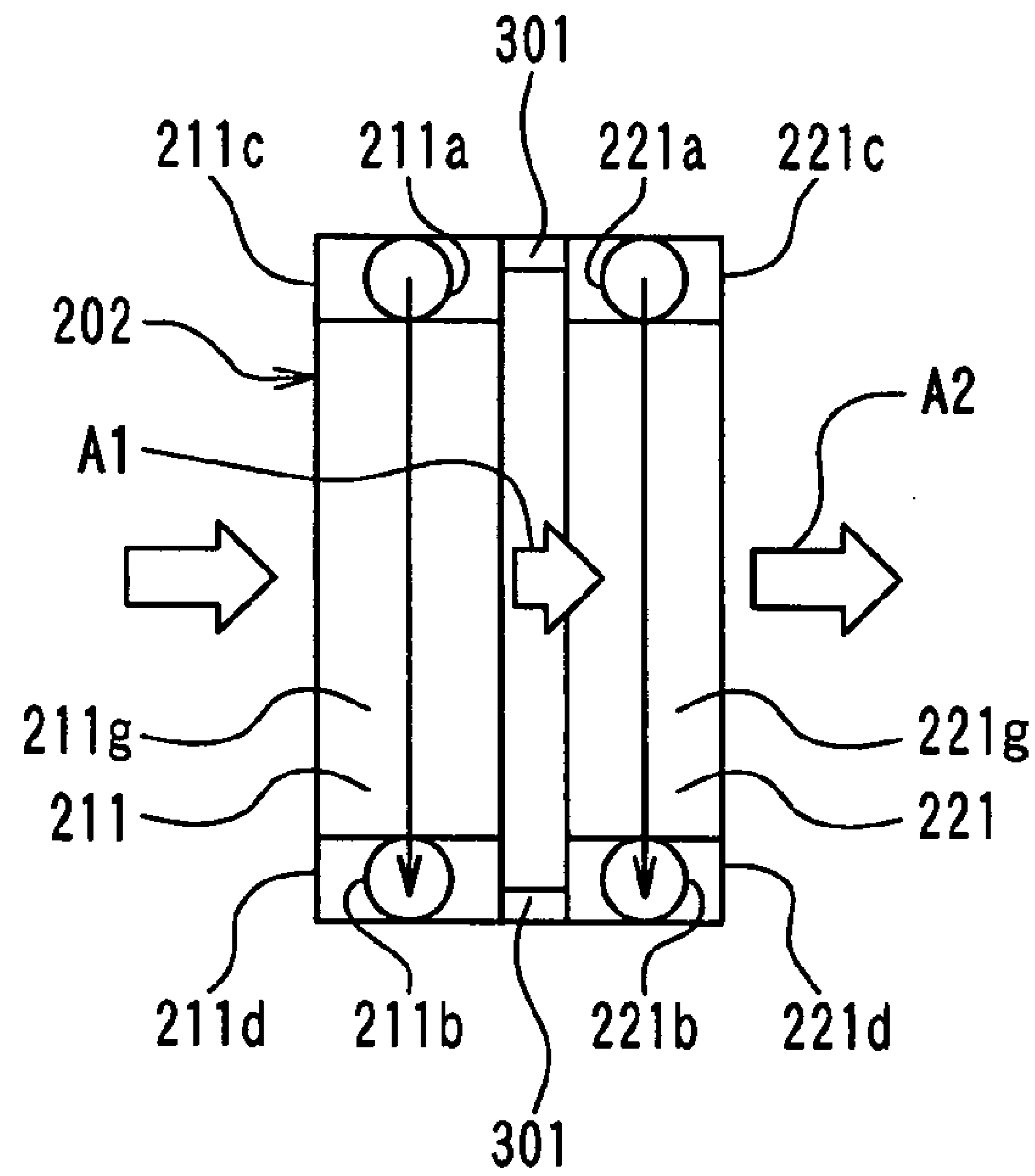

301
211c
211a
221a
221c
202
A2
A1
211g
221g
211
221
211d
211b
221b
221d
301

FIG. 23

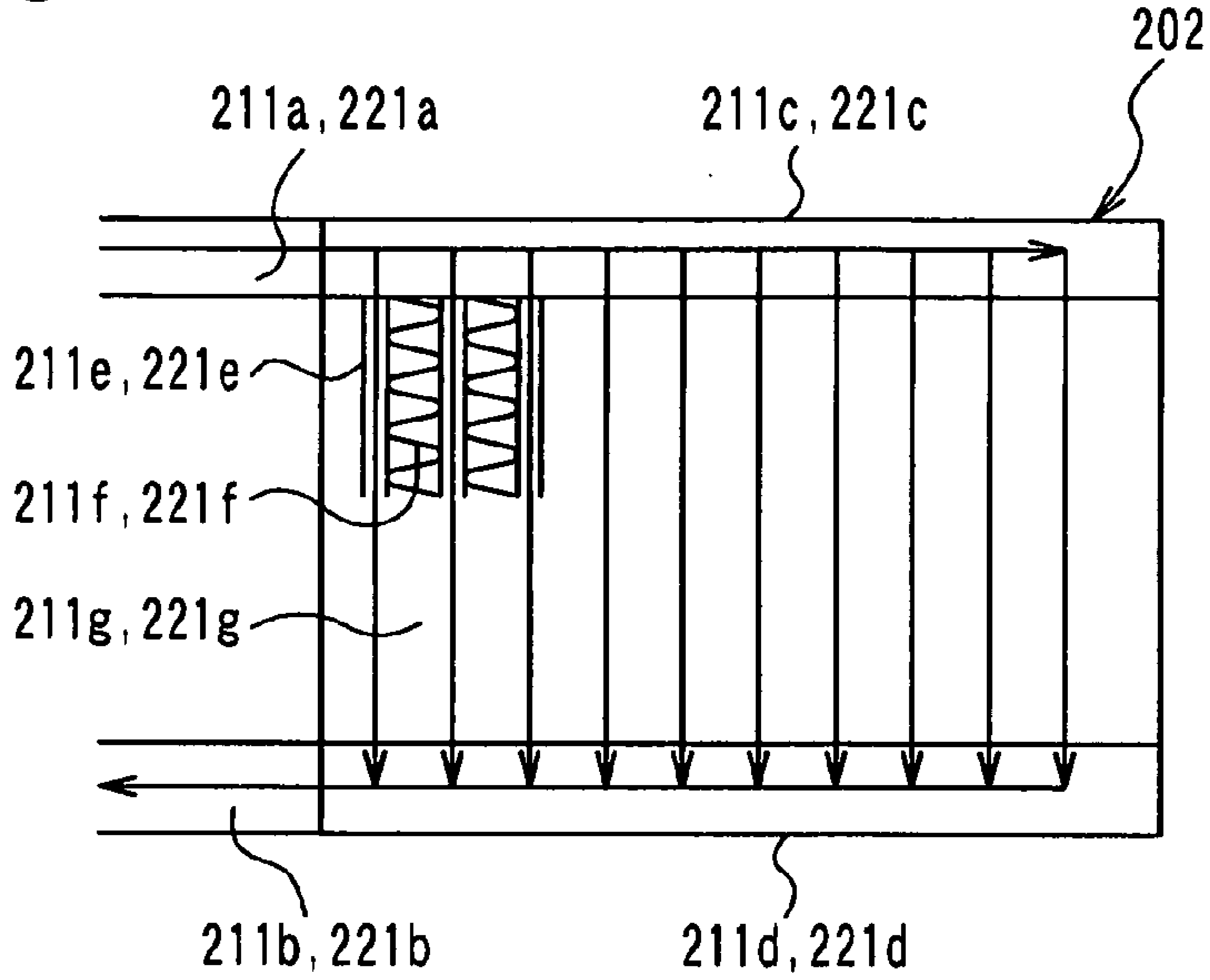

202
211a,221a
211c,221c
211e,221e
211f,221f
211g,221g
211b,221b
211d,221d

FIG. 24

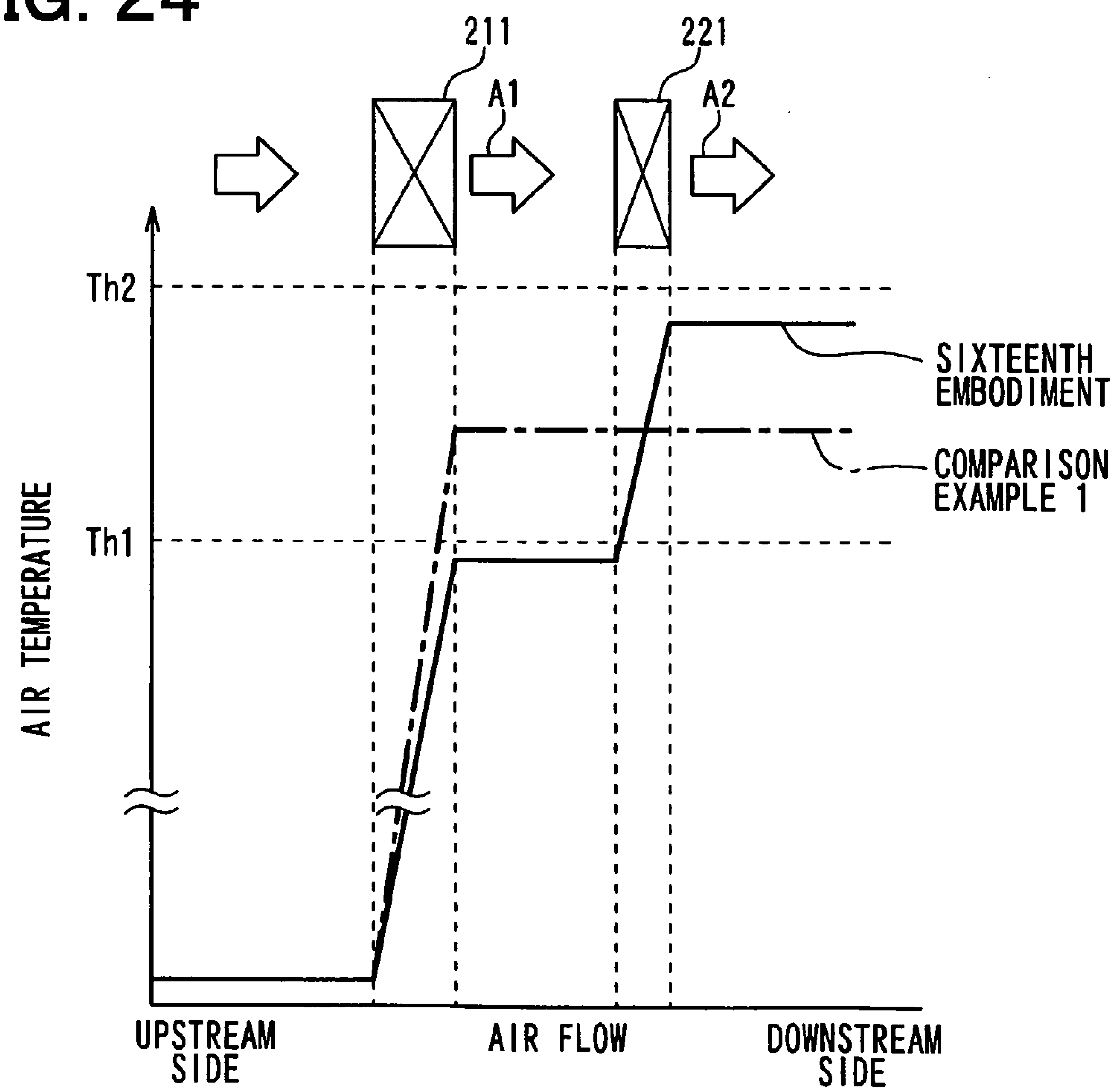

211
221
A1
A2
Th2
Th1
AIR TEMPERATURE
SIXTEENTH EMBODIMENT
COMPARISON EXAMPLE 1
UPSTREAM SIDE
AIR FLOW
DOWNSTREAM SIDE

FIG. 25A

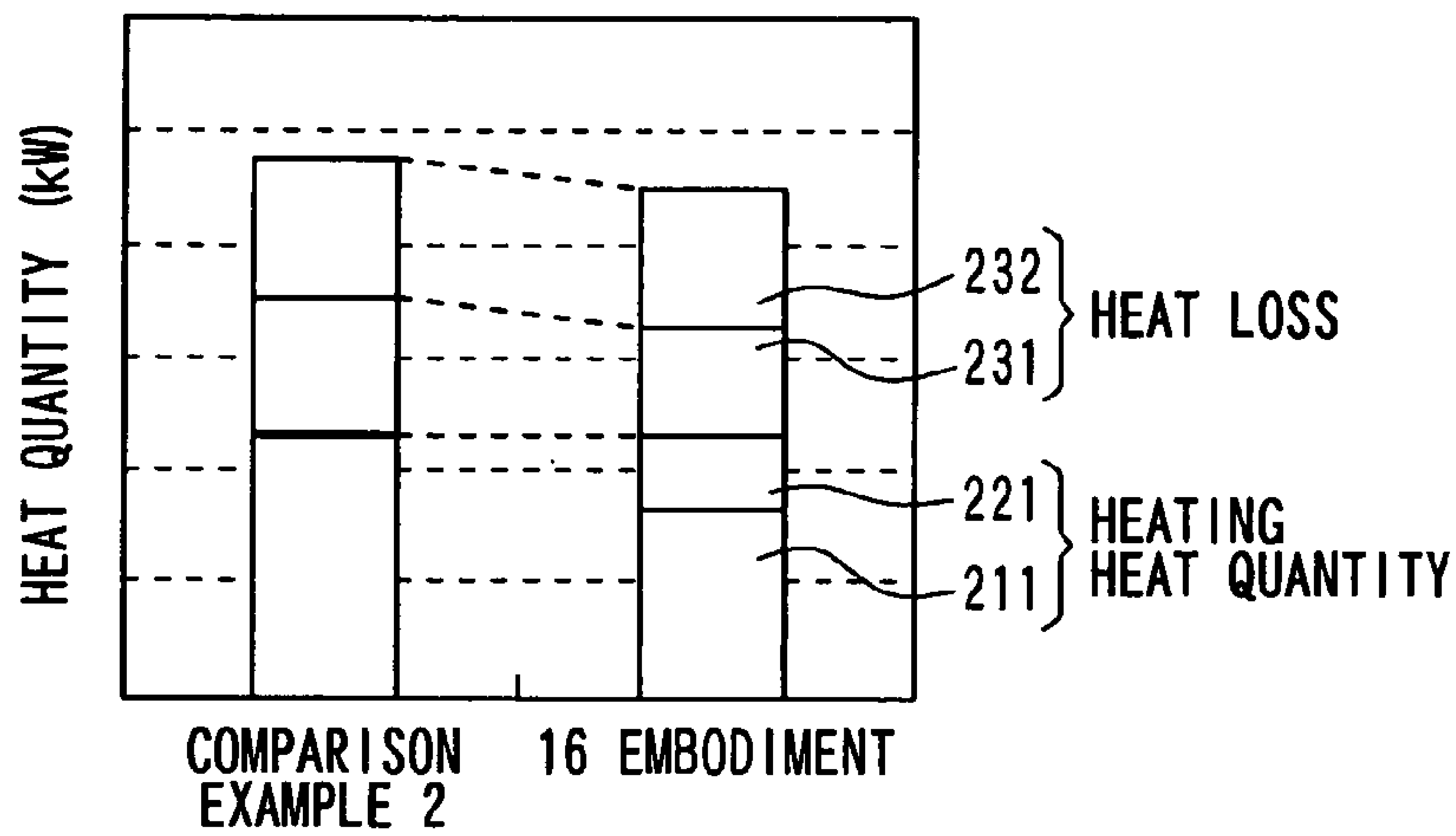


FIG. 25B

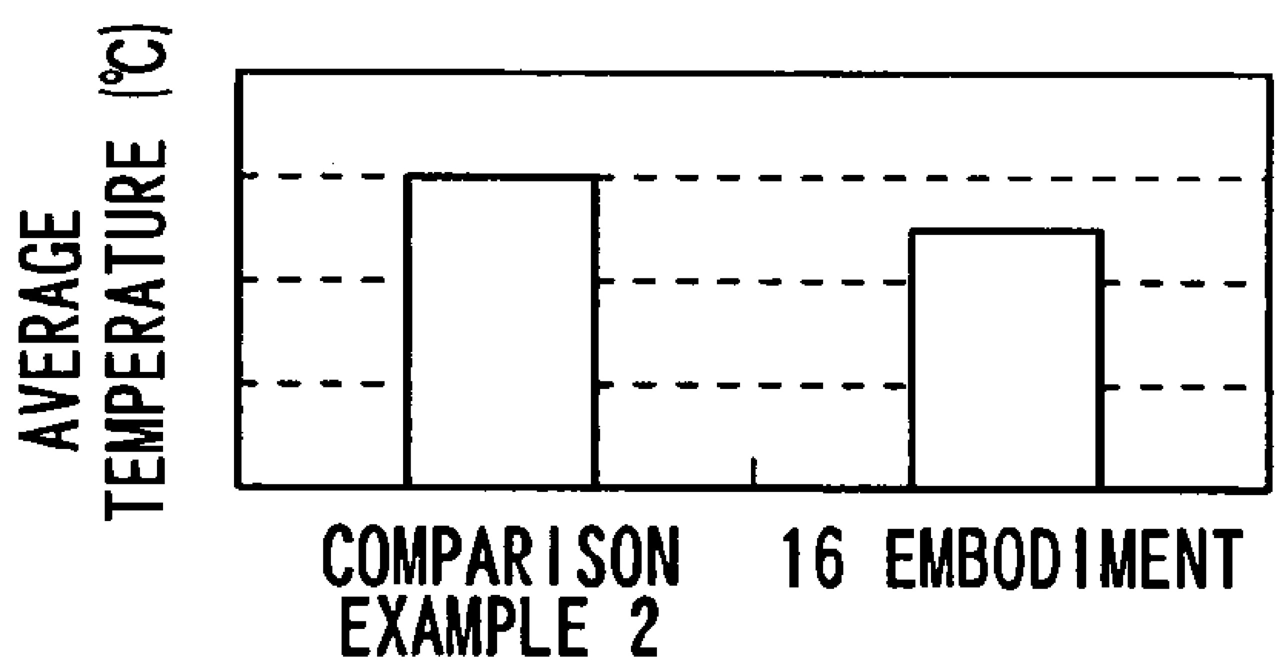


FIG. 25C

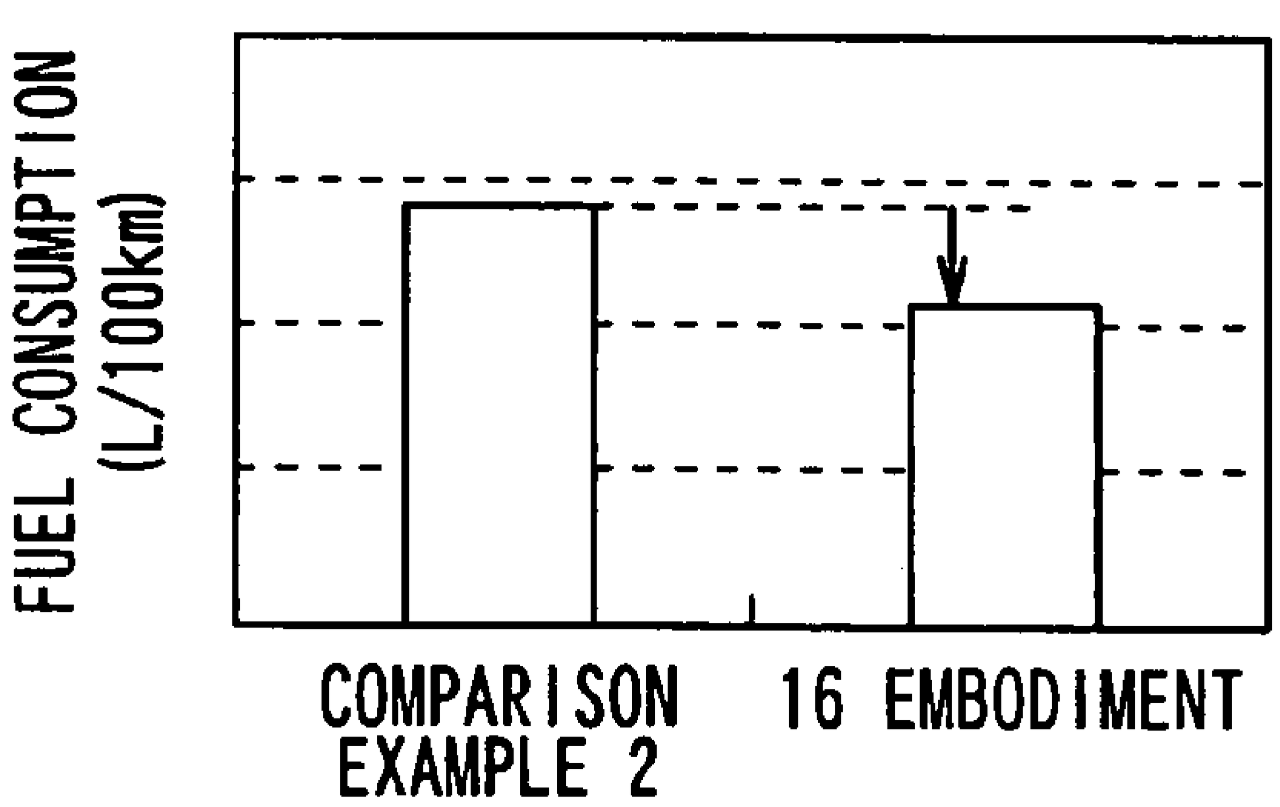


FIG. 26

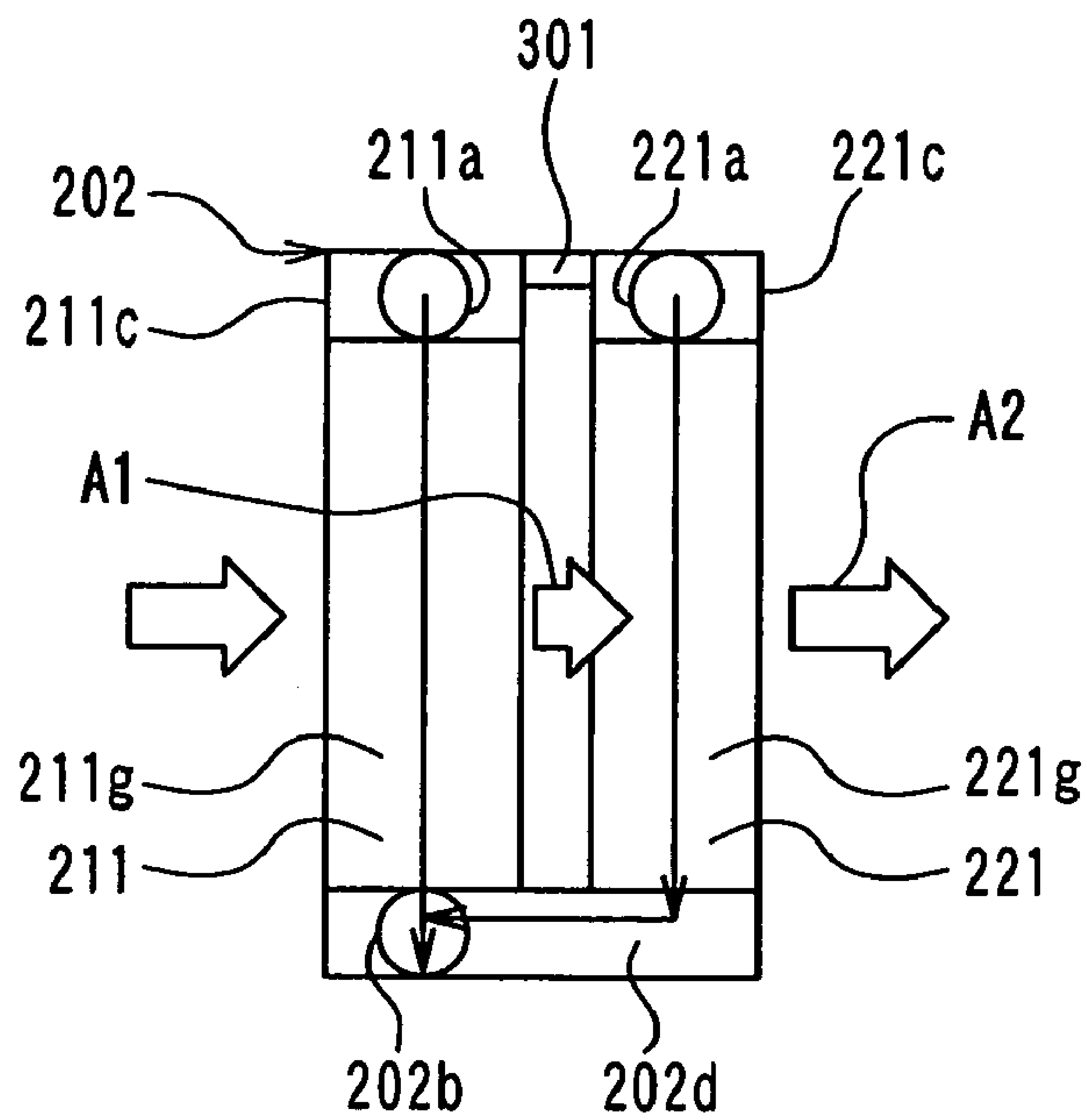

301
202
211a
221a
221c
211c
A1
A2
211g
221g
211
221
202b
202d

FIG. 27

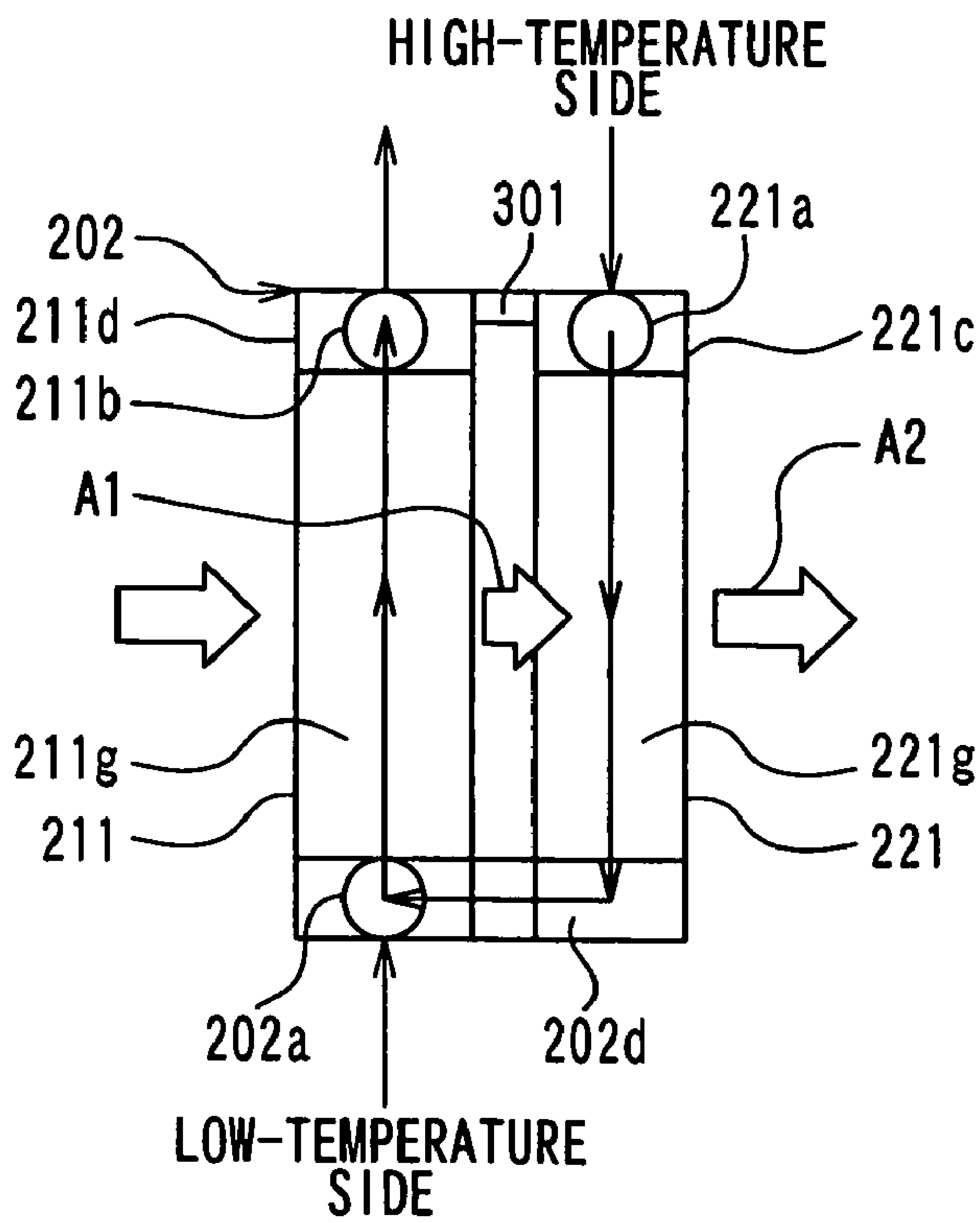

HIGH-TEMPERATURE SIDE
301
221a
202
211d
221c
211b
A1
A2
211g
221g
211
221
202a
202d
LOW-TEMPERATURE SIDE

FIG. 28

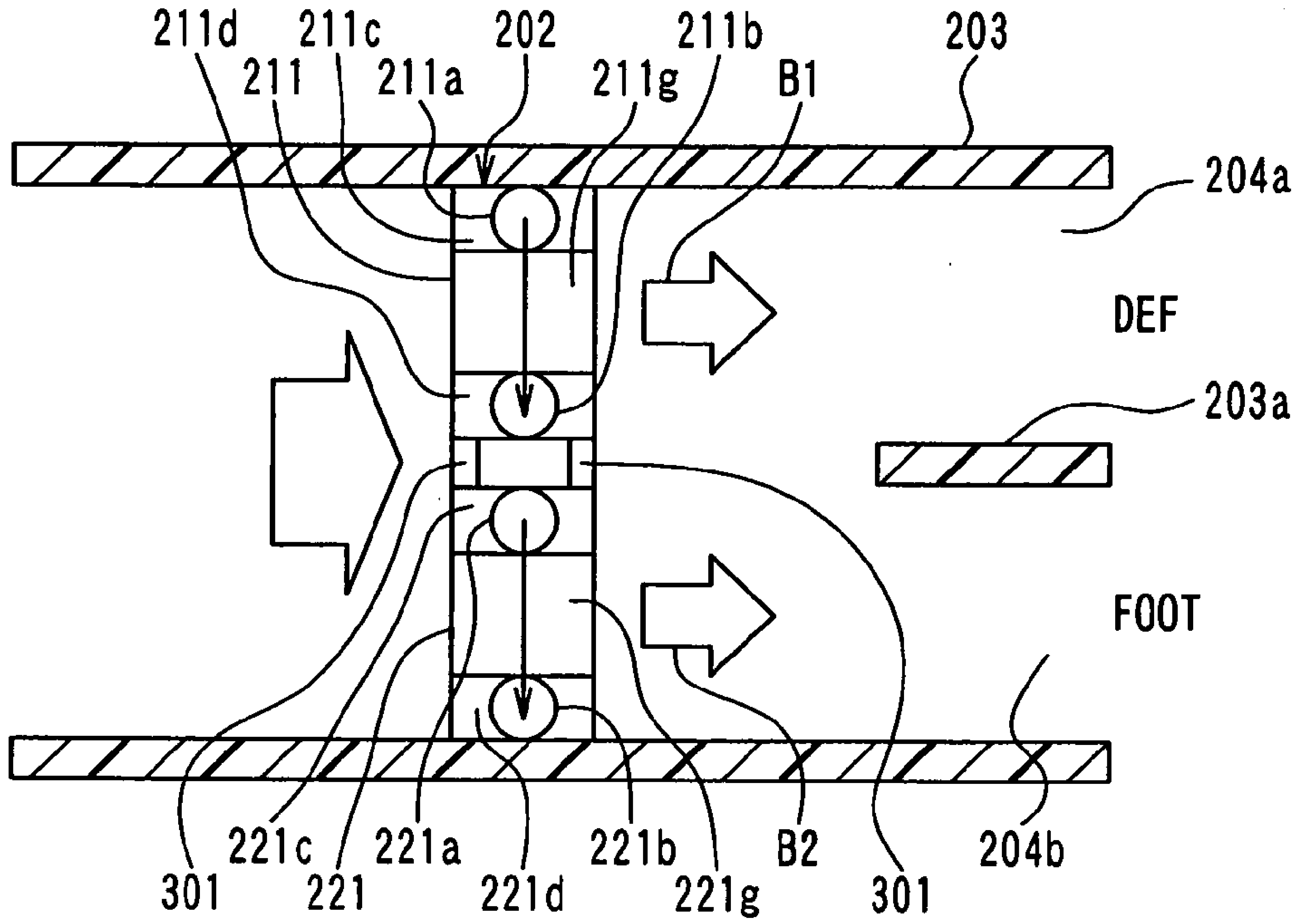
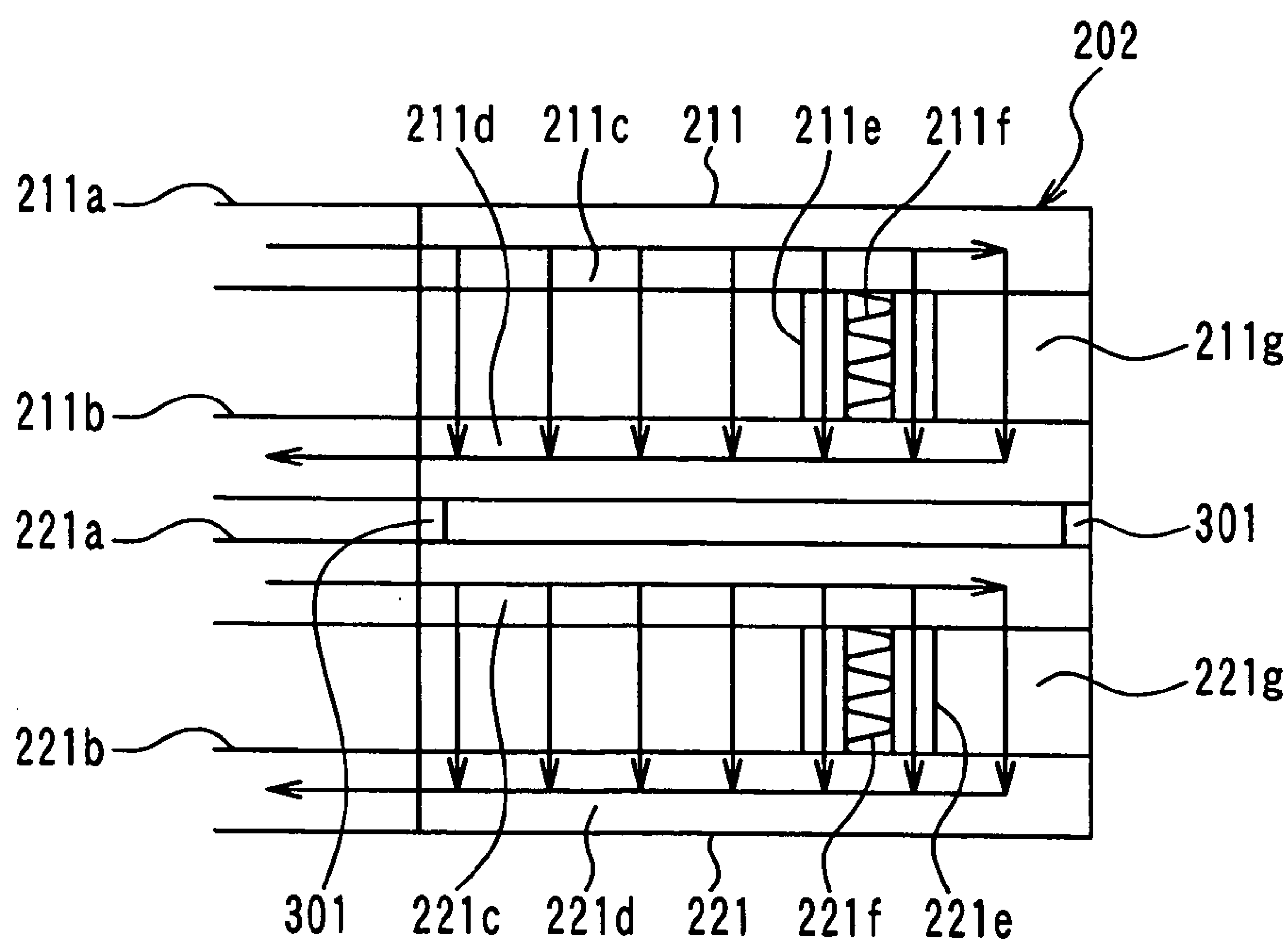

211d
211c
202
211b
203
211
211a
211g
B1
204a
DEF
203a
FOOT
301
221c
221a
221b
B2
204b
221
221d
221g
301

FIG. 29


202
211d
211c
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211f
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211b
221a
301
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221d
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221f
221e

FIG. 30

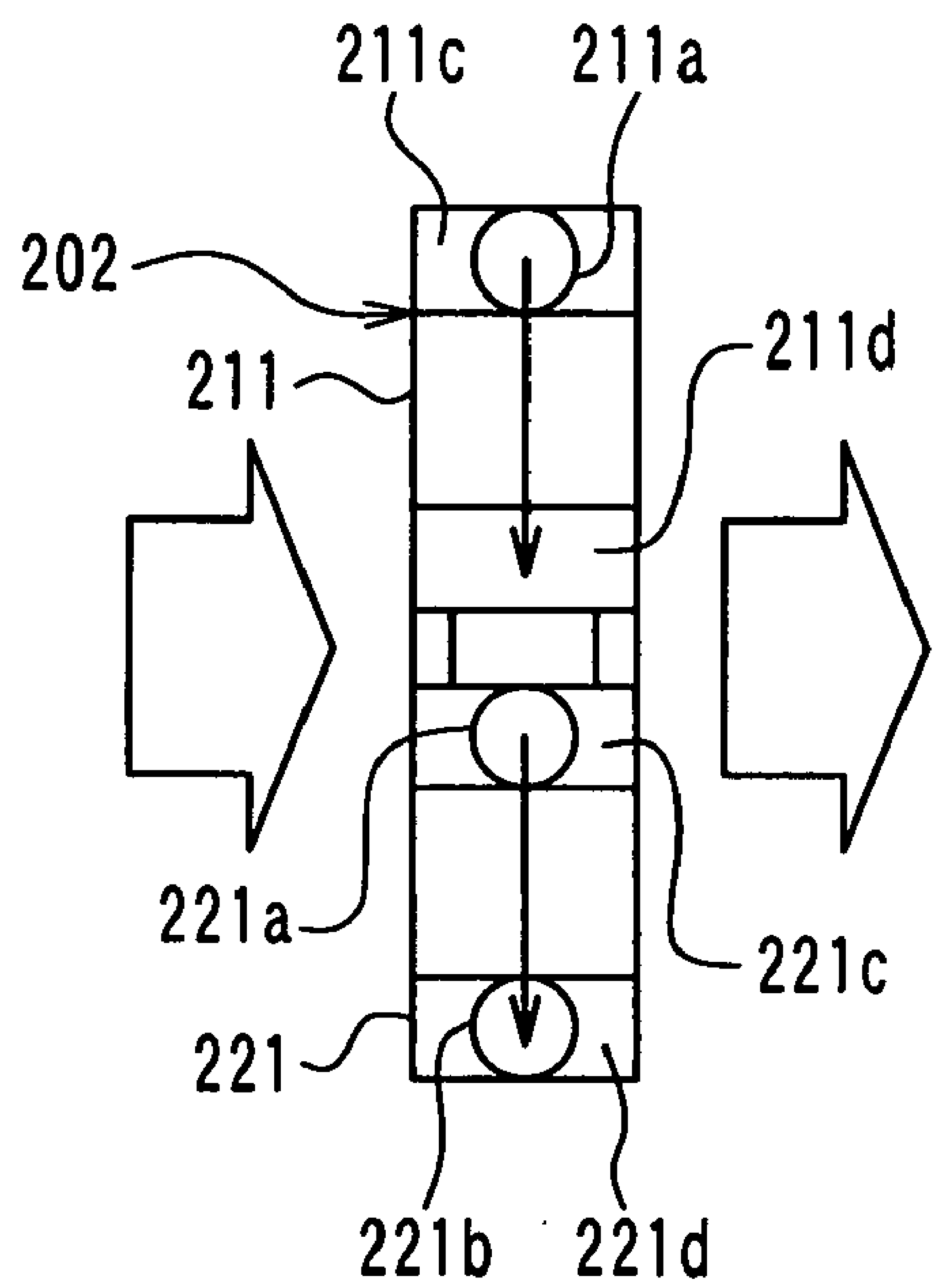
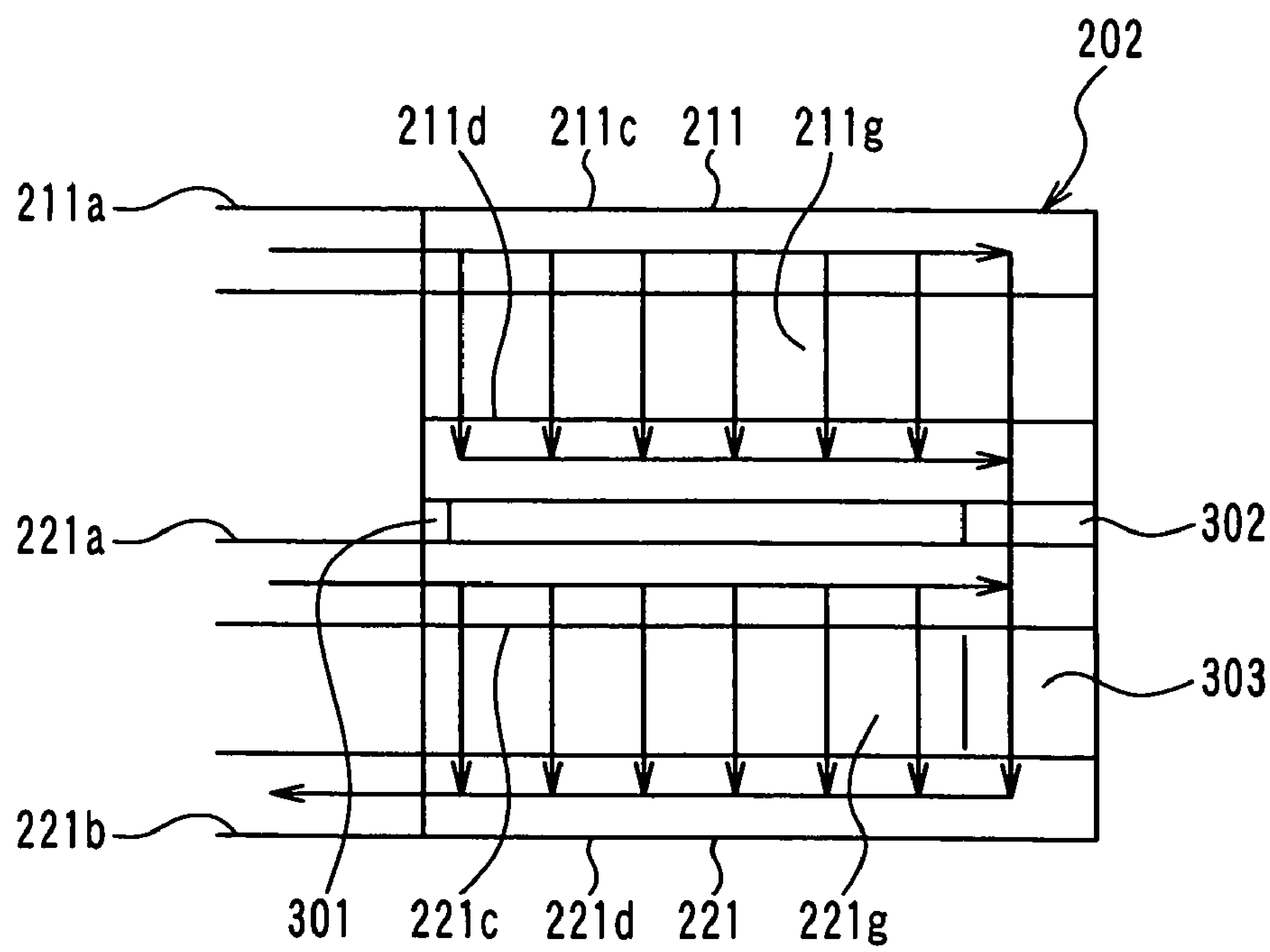

211c
211a
202
211
211d
221a
221c
221
221b
221d

FIG. 31


202
211d
211c
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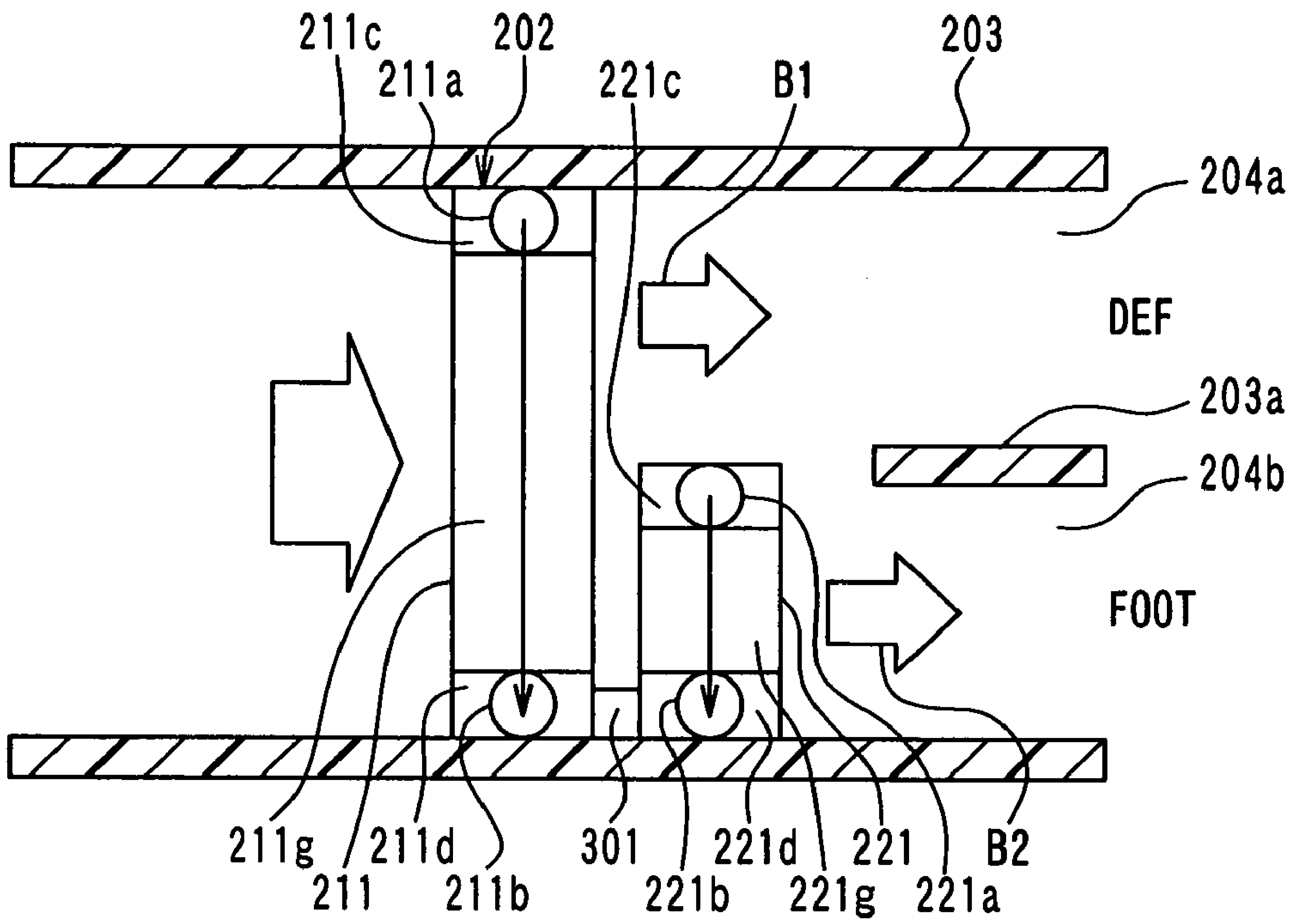
211g
211a
221a
302
303
221b
301
221c
221d
221
221g

FIG. 32


211c
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221c
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DEF
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FOOT
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211b
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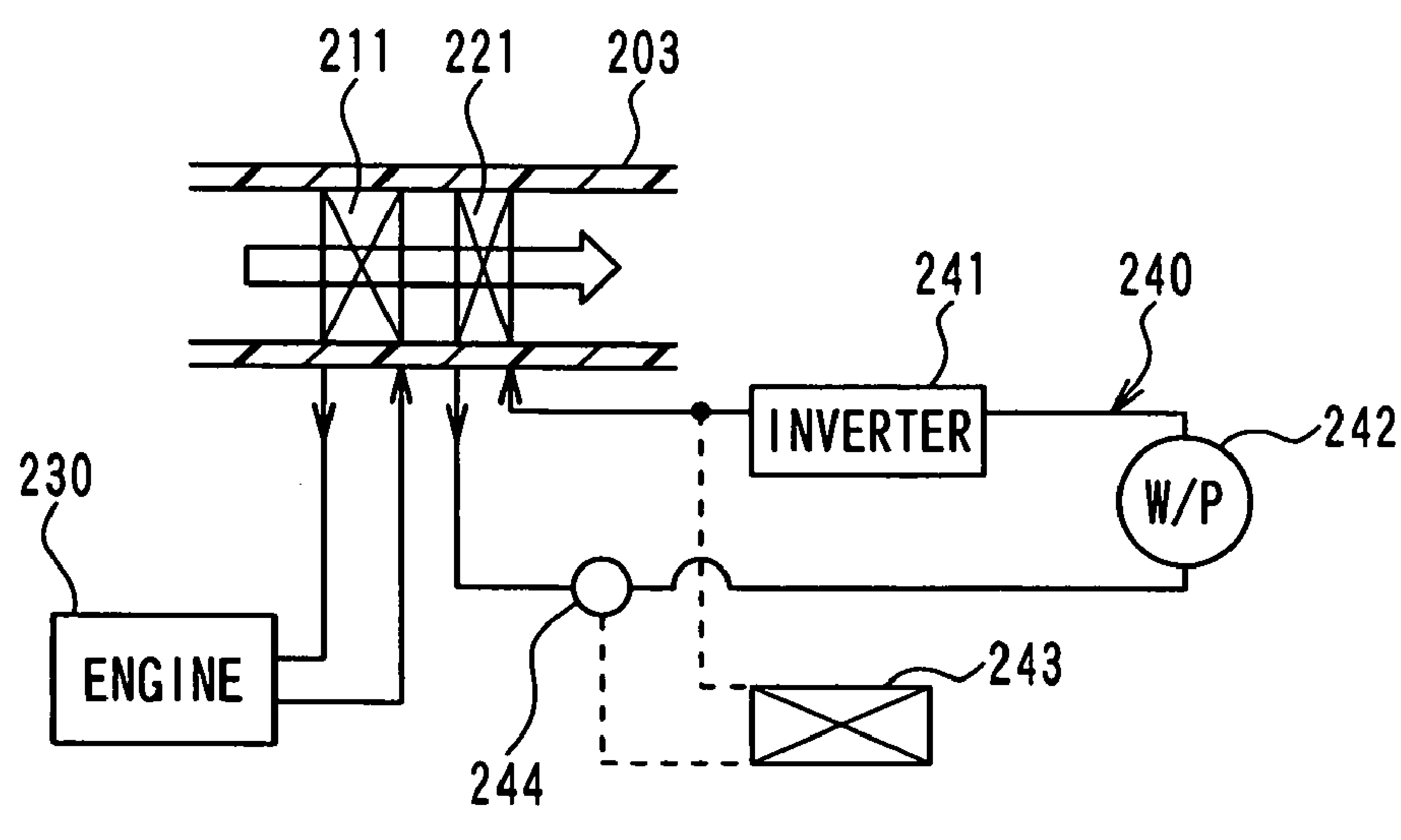
221d
221
B2
221b
221g
221a

FIG. 33


211
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203
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240
INVERTER
242
W/P
230
ENGINE
243
244

AIR CONDITIONER FOR VEHICLE

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is based on Japanese Patent Applications No. 2009-267179 filed on Nov. 25, 2009, No. 2010-049178 filed on Mar. 5, 2010, and No. 2010-049179 filed on Mar. 5, 2010, the contents of which are incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to an air conditioner for a vehicle.

BACKGROUND OF THE INVENTION

[0003] Conventionally, a vehicle air conditioner is provided with a heating heat exchanger that heats air to be blown into a vehicle compartment by using engine coolant as a heat source, for example, as in Patent Document 1 (JP 2007-278624A) or Patent Document 2 (JP 2008-126820A).

[0004] In this kind vehicle air conditioner, when the temperature of engine coolant is lower than a predetermined temperature, an operation request signal is output to an engine, even in a vehicle such as a hybrid vehicle or an idling-stop vehicle. In the vehicle such as the hybrid vehicle or the idling-stop vehicle, the engine stops in accordance with a vehicle traveling state. When the engine stops, the temperature of the engine coolant becomes lower, and it may be difficult to secure the heating capacity of air in the heating heat exchanger by using the engine coolant as the heat source. In this case, the engine is operated only for the air conditioning, so as to obtain the heating capacity of air due to the heating heat exchanger.

[0005] For example, in the vehicle air conditioner described in Patent Document 1, heat is absorbed from air in a heat pump cycle, and the engine coolant to be supplied to the heating heat exchanger is heated by using the absorbed heat of the heat pump cycle.

[0006] In the vehicle air conditioner described in Patent Document 2, an auxiliary heater using a PTC element is located downstream of the heating heat exchanger which heats air to be blown into the vehicle compartment by using the engine coolant as a heat source.

[0007] However, in the vehicle air conditioner where the operation request signal is output to the engine when the temperature of the engine coolant is lower than the predetermined temperature, fuel consumption efficiency may be deteriorated:

[0008] Furthermore, when the temperature of the engine coolant is low, the heat pump cycle may be operated instead of the engine operation, as in Patent Document 1.

[0009] When the heat pump cycle is operated for heating the engine coolant, energy is consumed by the operation of the heat pump cycle, and thereby consumed energy consumed for the heating of the engine coolant is increased.

[0010] Furthermore, when the temperature of the engine coolant is low, an auxiliary heater such as a PTC heater may be operated to directly heat air, instead of the engine operation, as in Patent Document 2. However, when the auxiliary heater is located downstream of the heating heat exchanger in an air flow, the auxiliary heater becomes a resistance in the flow of air blown into the vehicle compartment.

[0011] Alternatively, when the temperature of the engine coolant is low, the engine coolant may be heated by using a heating means other than the engine while the resistance of air blown into the vehicle compartment is not increased.

[0012] However, in a case where the engine coolant is simply heated by the heating means other than the engine, the heat quantity without being heat-exchanged with air in the heating heat exchanger may be radiated from the surface of the engine, and the heated quantity may be uselessly consumed.

[0013] This problem may be caused not only in an air conditioner for a vehicle provided with the engine, but also in an air conditioner for a vehicle provided with a driving device other than the engine, such as a fuel cell for traveling or an electrical motor for traveling.

[0014] In the air conditioner for a fuel cell vehicle provided with a fuel cell and an electrical motor, air to be blown into the vehicle compartment is heated by using coolant of the fuel cell as a heat source. In this case, when the temperature of the coolant of the fuel cell is lower than a predetermined temperature, the fuel cell is operated to generate an electrical power, and thereby energy consumed in the fuel cell becomes larger.

[0015] Furthermore, in a vehicle air conditioner described in Patent Document 3 (U.S. Pat. No. 5,337,704), as a coolant passage inside of an engine, a cylinder head passage for cooling a cylinder head and a cylinder block passage for cooling a cylinder block are used. The coolant passing through the cylinder head passage flows through a single heating heat exchanger, and is used as a heat source for a heating of a vehicle compartment.

[0016] In a vehicle air conditioner described in Patent Document 4 (EP 1008471A), two heating heat exchangers are provided for heating air, such that coolant flowing out of a single coolant outlet of an engine is branched and flows respectively into the two heating heat exchanger.

[0017] Generally, in order to reduce the size of the engine mounted to a vehicle while maintaining a required output of an engine, a compression ratio is increased, or a changing pressure is increased in the engine with a supercharger. However, if the compression ratio is increased or the charging pressure is increased in the engine with the supercharger, knocking may be caused. Thus, it may be considered to cool the cylinder head, in order to improve knocking-preventing performance.

[0018] On the other hand, it is necessary to keep the temperature of the cylinder block to be higher than a predetermined temperature, in order to reduce a friction of the cylinder block in the engine. Accordingly, the cylinder head passage and the cylinder block passage may be provided as the coolant passage of the engine, such that the flow amount of the coolant flowing in the cylinder head passage is larger than the flow amount of the coolant flowing in the cylinder block passage, as in Patent Document 3.

[0019] However, in this case, the temperature of the coolant after cooling the cylinder head may be lower than the lowest temperature required for the heating, and the temperature of air to be blown into the vehicle compartment cannot be sufficiently increased by using the coolant after passing through the cylinder head as the heat source.

[0020] Furthermore, in a vehicle where an engine efficiency is improved thereby reducing heat-generating amount of the engine, or in a hybrid vehicle, it is difficult to sufficiently heat air by using the engine coolant as the heat source.

[0021] To increase the temperature of the coolant as the heat source of the heating, a high-temperature hot water or a high-temperature fluid may be mixed with the coolant as the heat source of the heating. However, in this case, it is difficult to effectively use the heat quantity in the entire system.

[0022] In view of the above problems, it is an object of the present invention to provide a vehicle air conditioner which can effectively reduce consumed energy.

[0023] It is another object of the present invention to provide a vehicle air conditioner which can effectively perform heating operation while reducing consumed energy.

[0024] It is another object of the present application to provide an air conditioner including a heating heat exchanger provided with first and second heat exchanging portions, which can heat air to be blown into a vehicle compartment, by effectively using both a first fluid for cooling an internal combustion engine and a second fluid having a temperature higher than the first fluid.

[0025] According to an aspect of the present invention, an air conditioner for a vehicle provided with a driving unit for a vehicle traveling, includes: first and second heating heat exchangers disposed to heat air to be blown into a vehicle compartment by using a cooling fluid for cooling the driving unit as a heat source; a heater disposed to heat the cooling fluid flowing to the second heating heat exchanger in the first and second heating heat exchangers; and a controller for controlling a temperature of air to be blown into the vehicle compartment. The controller outputs an operation request signal to the driving unit when a temperature of the cooling fluid is lower than a predetermined temperature. Furthermore, the second heating heat exchanger are arranged downstream of the first heating heat exchanger in an air flow to heat air after passing through the first heating heat exchanger, and the first and second heating heat exchangers are arranged in parallel with respect to a flow direction of the cooling fluid. In the vehicle air conditioner, the controller controls a flow amount of the cooling fluid flowing into the second heating heat exchanger to be smaller than a flow amount of the cooling fluid flowing into the first heating heat exchanger when the heater heats the cooling fluid flowing to the second heating heat exchanger.

[0026] Accordingly, the temperature of the cooling fluid flowing into the second heating heat exchanger can be effectively increased by the heater, it is unnecessary to increase the temperature of the cooling fluid more than a necessary temperature required for the heating of air, by operation of the driving unit. Thus, it is possible to set a predetermined temperature, which is a basic temperature for determining whether an operation request signal is output to the driving unit, to be lower. Thus, operation frequency of the driving unit can be reduced, thereby reducing energy consumed in the driving unit. Furthermore, because only the cooling fluid flowing toward the second heating heat exchanger is heated between the first and second heating heat exchangers, the consumed energy consumed for heating the cooling fluid can be reduced. In addition, in the vehicle air conditioner, because the controller controls a flow amount of the cooling fluid flowing into the second heating heat exchanger to be smaller than a flow amount of the cooling fluid flowing into the first heating heat exchanger when the heater heats the cooling fluid flowing to the second heating heat exchanger, a ratio of heat radiation from the cooling fluid in the second heat exchanger to the heat quantity due to the heater in the cooling fluid can be effectively increased. As a result, it can restrict the heat quantity without being heat-exchanged with air in the second heating heat exchanger from being radiated from the surface of the driving unit, thereby effectively using the heat quantity due to the heating of the heater.

[0027] For example, the first and second heating heat exchangers may be configured such that a flow resistance of the cooling fluid flowing in the second heating heat exchanger is higher than a flow resistance of the cooling fluid flowing in the first heating heat exchanger.

[0028] Furthermore, a flow adjustment unit may be provided to reduce the flow amount of the cooling fluid flowing into the second heating heat exchanger when the heater is turned on to heat the cooling fluid flowing into the second heating heat exchanger, as compared with that when the heater is turned off.

[0029] Alternatively/Further, the air conditioner may be provided with a sensible heat exchanger that is configured to move heat from the cooling fluid downstream of the second heating heat exchanger to the cooling fluid upstream of the heater.

[0030] The driving unit may include an electrical motor for a vehicle traveling, and the heater may be an electrical heater which uses a high-voltage electrical source for supplying electrical power to the electrical motor, as an electrical source. Alternatively, the heater may be a heat generator, which is mounted to the vehicle separately from the driving unit, and generates heat when being operated. For example, the heat generator is an inverter which converts an electrical current supplied to the electrical motor.

[0031] According to another aspect of the present invention, an air conditioner for a vehicle provided with a driving unit for a vehicle traveling, includes: a heating heat exchanger disposed to heat air to be blown into a vehicle compartment by using a cooling fluid for cooling the driving unit as a heat source; a controller for controlling a temperature of air to be blown into the vehicle compartment, the controller outputs an operation request signal to the driving unit when a temperature of the cooling fluid is lower than a predetermined temperature; a heat absorbing portion configured to absorb heat from the cooling fluid; a heat radiating portion configured to radiate heat to the cooling fluid; and a pump portion configured to pump heat from the heat absorbing portion to the heat radiation portion. Generally, the cooling fluid has a temperature higher than outside air in winter. Thus, it is compared with a case where the pump portion pumps heat from outside air, heat radiation amount to the cooling fluid (heat source) can be increased, thereby reducing consumed energy in the pump portion.

[0032] For example, the pump portion is a Peltier element that includes a heat, absorbing surface thermally connected to the heat absorbing portion, and a heat radiating surface thermally connected to the heat radiating portion. In this case, the Peltier element absorbs heat from the heat absorbing surface and radiates heat from the heat radiating surface when direct current is applied to the Peltier element.

[0033] The heating heat exchanger may be a heat exchanger in which the cooling fluid flowing therein is heat exchanged with air passing therethrough so as to heat air. In this case, the heat absorbing portion is disposed downstream of the heating heat exchanger in a flow direction of the cooling fluid, to absorb heat from the cooling fluid flowing out of the heating heat exchanger, and the heat radiation portion is disposed upstream of the heating heat exchanger in the flow direction of the cooling fluid, to radiate heat to the cooling fluid flowing into the heating heat exchanger. Furthermore, the heating heat exchanger may include a first heater core for heating air, and a second heater core disposed to heat air after passing through the first heater core. In this case, the heat absorbing portion is disposed downstream of the second heater core in the flow direction of the cooling fluid to absorb heat from the cooling fluid flowing out of the second heater core, and the heat radiating portion is disposed upstream of the second heater core in the flow direction of the cooling fluid to radiate heat to the cooling fluid flowing into the second heater core. Here, the first and second heater cores may be arranged in parallel with respect to the flow, direction of the cooling fluid, or may be arranged in series in the flow direction of the cooling fluid.

[0034] Furthermore, a heat exchanger may be disposed to perform heat exchange between the cooling fluid before flowing into the heat radiating portion, and the cooling fluid before flowing into the heat absorbing portion at a position downstream of the second heater core in the flow direction of the cooling fluid.

[0035] A first bypass passage may be provided such that a part of the cooling fluid before flowing into the heat radiating portion is introduced into the heat absorbing portion without performing heat exchange with air in the second heater core, via the first bypass passage. Furthermore/Alternatively, a second bypass passage may be provided such that a part of the cooling fluid upstream of the heat radiating portion is introduced to the driving unit while bypassing the heat radiating portion and the heat absorbing portion, via the second bypass passage.

[0036] In the air conditioner, a first fluid circuit, in which the cooling fluid of the driving unit is circulated, may be independently provided from a second fluid circuit in which a fluid heated by the cooling fluid is circulated to flow into the heating heat exchanger.

[0037] According to another aspect of the present invention, an air conditioner for a vehicle with an internal combustion engine includes a heating heat exchanger configured to heat air to be blown into a vehicle compartment, by using a first fluid for cooling the internal combustion engine and a second fluid having a temperature higher than the first fluid, as a heat source. Furthermore, the heating heat exchanger includes a first heat exchanging portion in which the first fluid or a mixture of the first fluid and the second fluid flows, and a second heat exchanging portion in which a fluid that is mainly the second fluid and has a temperature higher than a fluid flowing into the first heat exchanging portion flows. In addition, the first heat exchanging portion and the second heat exchanging portion are integrated to form a space therebetween. Thus, air can be heated in the first heat exchanging portion by using a low temperature fluid at least including the first fluid for cooling the internal combustion engine as the heat source, and air can be heated in the second heat exchanging portion by using a high temperature fluid that is mainly the second fluid as the heat source. Accordingly, as compared with a case where air is heated by using the mixture of the first fluid and the second fluid as a heat source, the heat quantity of the second fluid can be effectively used, and thereby the temperature of air after being heated in the second heat exchanging portion can be improved.

[0038] For example, the second heat exchanging portion may be arranged downstream of the first heat exchanging portion in an air flow direction. Furthermore/Alternatively, the first heat exchanging portion and the second heat exchanging portion may be arranged in parallel with respect to an air flow direction.

[0039] The first heat exchanging portion may have a heat exchanging area in which air is heat exchanged with the fluid, and the heat exchanging area of the first heat exchanging portion may be larger than the heat exchanging area of the second heat exchanging portion.

[0040] Alternatively/Furthermore, the first heat exchanging portion and the second heat exchanging portion may be arranged such that a flowing amount of the fluid flowing in the first heat exchanging portion is larger than that flowing in the second heat exchanging portion. Furthermore, the first heat exchanging portion and the second heat exchanging portion may be configured to have respective fluid passages that are independent from each other.

[0041] The air conditioner may be provided with an air conditioning case in which the first heat exchanging portion and the second heat exchanging portion are disposed. In this case, the air conditioning case may be provided with a first air outlet from which air only having passed through the first heat exchanging portion is blown toward an inner surface of a windshield of the vehicle, and a second air outlet from which air having passed through the second heat exchanging portion is blown toward a passenger in the vehicle compartment.

[0042] In the air conditioner, the first fluid may be a cooling fluid for cooling a cylinder head of the internal combustion engine, and the second fluid may be a cooling fluid for cooling a cylinder block of the internal combustion engine. Alternatively, the first fluid may be a cooling fluid for cooling the internal combustion engine, and the second fluid may be a cooling fluid for cooling a heat generation member that is an equipment mounted to the vehicle and is different from the internal combustion engine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] Other objects, features and advantages of the present invention will become more apparent from the following description made with reference to the accompanying drawings, in which like parts are designated by like reference numbers and in which:

[0044] FIG. **1** is a schematic diagram showing an air conditioner for a vehicle according to a first embodiment of the invention;

[0045] FIG. **2** is a block diagram showing an electric controller of the air conditioner for a vehicle in FIG. **1**;

[0046] FIG. **3** is a flowchart showing a control performed by the electric controller of the air conditioner, shown in FIG. **2**;

[0047] FIG. **4** is a flowchart showing a detail control at step S4 of FIG. **3**;

[0048] FIG. **5** is a schematic diagram showing an air conditioner for a vehicle according to a second embodiment of the invention;

[0049] FIG. **6** is a schematic diagram showing an air conditioner for a vehicle according to a third embodiment of the invention;

[0050] FIG. **7** is a schematic diagram showing an air conditioner for a vehicle according to a fourth embodiment of the invention;

[0051] FIG. **8** is a schematic diagram showing an air conditioner for a vehicle according to a fifth embodiment of the invention;

[0052] FIG. **9** is a schematic diagram showing an air conditioner for a vehicle according to a sixth embodiment of the invention;

[0053] FIG. **10** is a schematic diagram showing an air conditioner for a vehicle according to a seventh embodiment of the invention;

[0054] FIG. **11** is a schematic diagram showing an air conditioner for a vehicle according to an eighth embodiment of the invention;

[0055] FIG. **12** is a schematic diagram showing an air conditioner for a vehicle according to a ninth embodiment of the invention;

[0056] FIG. **13** is a schematic diagram showing an air conditioner for a vehicle according to a tenth embodiment of the invention;

[0057] FIG. **14** is a schematic diagram showing an air conditioner for a vehicle according to an eleventh embodiment of the invention;

[0058] FIG. **15** is a schematic diagram showing an air conditioner for a vehicle according to a twelfth embodiment of the invention;

[0059] FIG. **16** is a block diagram showing an electric controller of the air conditioner for a vehicle in the twelfth embodiment;

[0060] FIG. **17** is a flowchart for determining ON/OFF operation of an electrical heater, according to the twelfth embodiment of the invention;

[0061] FIG. **18** is a schematic diagram showing an air conditioner for a vehicle according to a thirteenth embodiment of the invention;

[0062] FIG. **19** is a schematic diagram showing an air conditioner for a vehicle according to a fourteenth embodiment of the invention;

[0063] FIG. **20** is a perspective view showing first and second heater cores according to a fifteenth embodiment of the invention;

[0064] FIG. **21** is a schematic diagram showing an air conditioner for a vehicle according to a sixteenth embodiment of the invention;

[0065] FIG. **22** is a side view showing a heating heat exchanger according to the sixteenth embodiment;

[0066] FIG. **23** is a front view showing the heating heat exchanger according to the sixteenth embodiment;

[0067] FIG. **24** is a graph showing a temperature variation in air passing through the first and second heater cores of the heating heat exchanger according to a sixteenth embodiment of the invention;

[0068] FIGS. **25**A, **25**B and **25**C are graphs showing a heat loss of coolant from an engine surface, an average temperature of a combustion chamber of the engine and an actual fuel consumption rate, according to the sixteenth embodiment and a comparison example (second comparison example);

[0069] FIG. **26** is a side view showing a heating heat exchanger according to a seventeenth embodiment of the invention;

[0070] FIG. **27** is a side view showing a heating heat exchanger according to an eighteenth embodiment of the invention;

[0071] FIG. **28** is a side view showing a heating heat exchanger according to a nineteenth embodiment of the invention;

[0072] FIG. **29** is a front view showing a heating heat exchanger according to the nineteenth embodiment;

[0073] FIG. **30** is a side view showing a heating heat exchanger according to a twentieth embodiment of the invention;

[0074] FIG. **31** is a front view showing a heating heat exchanger according to the twentieth embodiment;

[0075] FIG. **32** is a side view showing a heating heat exchanger according to a twenty-first embodiment of the invention; and

[0076] FIG. **33** is a schematic diagram showing an air conditioner for a vehicle according to a twenty-second embodiment of the invention.

EMBODIMENTS

[0077] Embodiments for carrying out the present invention will be described hereafter referring to drawings. In the embodiments, a part that corresponds to a matter described in a preceding embodiment may be assigned with the same reference numeral, and redundant explanation for the part may be omitted. When only a part of a configuration is described in an embodiment, another preceding embodiment may be applied to the other parts of the configuration. The parts may be combined even if it is not explicitly described that the parts can be combined. The embodiments may be partially combined even if it is not explicitly described that the embodiments can be combined, provided there is no harm in the combination.

First Embodiment

[0078] A first embodiment of the present invention will be described with reference to FIGS. **1** to **4**.

[0079] FIG. **1** is a schematic diagram showing an air conditioner **1** for a vehicle according to the present embodiment of the invention, and FIG. **2** is a block diagram showing an electric controller of the air conditioner for a vehicle in the present embodiment. In the present embodiment, the air conditioner **1** for a vehicle of the invention is mounted to a so-called hybrid car which obtains a driving force for a vehicle traveling from an internal combustion engine (engine) EG and an electric motor for traveling. Thus, the engine EG is an example of a driving device for obtaining a driving force for a vehicle running in the invention.

[0080] In the hybrid vehicle of the embodiment, the engine EG is operated or stopped in accordance with a traveling load of the vehicle. Thus, the hybrid vehicle can be switched to a traveling state in which the vehicle is traveled by using driving force from both of the engine EG and the electrical motor for traveling, or a traveling state (i.e., EV traveling state) in which the vehicle is traveled only by using the electrical motor for traveling while the engine is stopped. Thus, in the hybrid vehicle, fuel consumption can be improved as compared with a vehicle driven by only the engine EG.

[0081] The air conditioner **1** for a vehicle is provided with an interior air conditioning unit **10** shown in FIG. **1**, and an air conditioning controller **60** (A/C ECU) shown in FIG. **2**.

[0082] The interior air conditioning unit **10** is located inside of an instrument panel (i.e., dash panel) positioned at the frontmost portion in the vehicle compartment. The interior air-conditioning unit **10** includes an air conditioning casing **11** forming an outer shell and defining an air passage. In the air conditioning casing **11**, a blower **12**, an evaporator **13**, a first heater core **14**, a second heater core **15** and the like are disposed.

[0083] The casing **11** defines the air passage through which air flows into the vehicle compartment. The casing **11** is made of a resin (e.g., polypropylene) having a suitable elasticity and being superior in the strength. An inside/outside air switching box **20** is located in the casing **11** at the most upstream side to selectively introduce inside air or/and outside air into the casing **11**.

[0084] More specifically, the inside/outside air switching box **20** is provided with an inside air introduction port **21** for introducing inside air into the casing **11**, and an outside air introduction port **22** for introducing outside air into the casing **11**. An inside/outside air switching door **23** is disposed in the inside/outside air switching box **20** to continuously adjust open areas of the inside air introduction port **21** and the outside air introduction port **22**. Therefore, the inside/outside air switching door **23** can adjust a ratio between a flow amount of inside air (i.e., air inside the vehicle compartment) introduced from the inside air introduction port **21** and a flow amount of outside air (i.e., air outside the vehicle compartment). The inside/outside air switching door **23** is driven by an electrical actuator **71**, and operation of the electrical actuator **71** is controlled by a control signal output from the air conditioning controller **60**.

[0085] The blower **12** is disposed in the casing **31** at a downstream air side of the inside/outside air switching box **20**, to blow air drawn via the inside/outside air switching box **20** toward the interior of the vehicle compartment. The blower **12** is an electrical blower having a centrifugal multi-blade fan (e.g., sirocco fan) **12***a* and an electrical motor **12***b*, for example. In this case, the centrifugal multi-blade fan **12***a* is driven by the electrical motor **12***b*, and the rotational speed (air blowing amount) of the electrical motor **12***b* is controlled by a control voltage output from the air conditioning controller **60**.

[0086] The evaporator **13** is disposed in the casing **11** at a downstream air side of the blower **12** to cross all the air passage area in the casing **11**. The evaporator **13** is a cooling heat exchanger in which refrigerant passing therein is heat-exchanged with air blown by the blower **12** to cool the blown air. The evaporator **12** is one component in a refrigerant cycle. The refrigerant cycle includes, for example, a compressor, a condenser, a gas-liquid separator and an expansion valve, in addition to the evaporator **13**, which are generally known.

[0087] At a downstream air side of the evaporator **13**, the air passage of the casing **31** is provided with a first air passage **16** through which air after passing through the evaporator **13** flows, a second air passage **17** used as a cool air bypass passage through which air after passing through the evaporator **13** flows while bypassing the first and second heater core **14**, **15**, and a mixing space **18** in which air from the first air passage **16** and air from the second air passage **17** are mixed.

[0088] In the first air passage **16**, the first and second heater cores **14** and **15** are arranged, so that air dehumidified and cooled by the evaporator **13** flows through the first and second heater cores **14** and **15** in this order through the first air passage **16**. The first heater core **14** is a first heating heat exchanger configured to perform heat exchange between engine coolant (hot water) heated by heat of the vehicle engine EG and air after passing through the evaporator **13**. Thus, the first heat core **14** heats air after passing through the evaporator **13** in the first air passage **16**. The second heater core **15** is a second heating heat exchanger configured to perform heat exchange between engine coolant (hot water) and air after passing through the first heater core **14**. Thus, the second heat core **15** further heats air after passing through the first heater core **14** in the first air passage **16**. For example, the engine coolant is water, or a water solution including addition component.

[0089] Specifically, a coolant circuit **30** is provided, so that coolant is circulated between the first and second heater cores **14**, **15** and the engine EG via the coolant circuit **30**. The coolant circuit **30** is provided with a coolant passage **31** adapted to the first and second heater cores **14**, **15**, and a coolant passage **32** adapted to a radiator **41**. The coolant passages **31**, **32** are connected to the engine EG in parallel with respect to a flow of the coolant from the engine EG.

[0090] The coolant passage **31** for the first and second heater cores **14**, **15** is provided with a branch point **31***a*, a join point **31***b*, and first and second coolant passages **33**, **34**. The coolant flowing out of the engine EG is branched at the branch portion **31***a* into the first coolant passage **33** and the second coolant passage **34**, and is joined at the join point **31***b*: The first heater core **14** is located in the first coolant passage **33** so that the coolant flowing into the first coolant passage **33** flows through the first heater core **14**. The second heater core **15** is located in the second coolant passage **34** so that the coolant flowing into the second coolant passage **34** flows through the second heater core **15**. The coolant having passed through the first and second heater cores **14**, **15** respectively is joined at the join point **31***b*, and returns to the engine EG. Thus, the first and second heater cores **14**, **15** are arranged in parallel with respect to the flow of the engine coolant.

[0091] As shown in FIG. **1**, a heat-absorption side heat exchanger **51** is located in the second coolant passage **34** at a downstream side of the second heater core **15** in the coolant flow, and a heat-radiation side heat exchanger **52** is located in the second coolant passage **34** at an upstream side of the second heater core **15** in the coolant flow. A Peltier element **53** is disposed outside of the second coolant passage **34**, at a position between the heat-absorption side heat exchanger **51** and the heat-radiation side heat exchanger **52**.

[0092] The heat-absorption side heat exchanger **51** is a heat exchanger for absorbing heat from the coolant, and the heat-radiation side heat exchanger **52** is a heat exchanger for radiating heat to the coolant. The heat-absorption side heat exchanger **51** and the heat-radiation side heat exchanger **52** are configured such that the flow direction of the coolant flowing through the heat-absorption side heat exchanger **51** is opposite to the flow direction of the coolant flowing through the heat-radiation side heat exchanger **52**. That is, the coolant reversely flows through the heat-absorption side heat exchanger **51** and the heat-radiation side heat exchanger **52**.

[0093] The Peltier element **53** is provided with a heat absorbing surface thermally connected to the heat-absorption side heat exchanger **51**, and a heat radiating surface thermally connected to the heat-radiation side heat exchanger **52**. When electrical current is applied to the Peltier element **53**, heat is absorbed via the heat absorbing surface, and heat is radiated via the heat radiating surface. Thus, the Peltier element **53** is a heat pump system for pumping heat from the heat absorbing surface of the Peltier element **53** to the heat radiating surface of the Peltier element **53**. The pumped heat quantity is adjusted by adjusting the electrical current applied to the Peltier element **53**.

[0094] Because the heat-absorption side heat exchanger **51** and the heat-radiation side heat exchanger **52** are thermally connected respectively to the heat absorbing surface and the heat radiating surface of the Peltier element **53**, heat is transmitted therebetween. Thus, when the direct current flows the Peltier element **53**, the Peltier element **53** absorbs heat from the coolant at a coolant outlet side of the second heater core **15** via the heat-absorption side heat exchanger **51**, and radiates heat to the coolant at a coolant inlet side of the second heater core **15** via the heat-radiation side heat exchanger **52**. The operation of the Peltier element **53** is controlled based on the control current output from the air conditioning controller **60**. Specifically, an electrical power turning on/off operation of the Peltier element **53** and an electrical current to be applied to the Peltier element **53** in the electrical power turning-on operation are controlled based on the control signal output from the air conditioning controller **60**.

[0095] A thermostat **42** is located in the coolant circuit **30** at a coolant inlet side of the engine EG in the coolant circuit **30**. A flow amount of the coolant flowing into the coolant passage **31** for the first and second heater cores **14**, **15** and a flow amount of the coolant flowing into the coolant passage **32** for the radiator **41** are adjusted by the thermostat **42**. An electrical water pump **43** is disposed in the coolant circuit **30** so that the coolant circulates in the coolant circuit **30**. The operation of the water pump **43** can be controlled such that the water pump **43** is operated even when the engine EG is stopped. The water pump **43** may be operated by the power from the engine EG. In this case, the water pump **43** is also stopped when the engine EG stops.

[0096] A first coolant temperature sensor **65** is located at a coolant outlet side of the engine EG, to detect the temperature of the coolant flowing out of the engine EG. A second coolant temperature sensor **66** is located between the heat-radiation side heat exchanger **52** and the second heater core **15** in the coolant circuit **30**, to detect the temperature of the coolant flowing into the second core **15**.

[0097] On the other hand, cool air having passed through the evaporator **13** flows into the mixing space **18** through the second air passage **17** used as the cool air bypass passage while bypassing the first and second heater cores **14** and **15**. Thus, the temperature of air (i.e., conditioned air) mixed in the mixing space **18** is changed by adjusting a ratio between a flow amount of air passing through the first air passage **16** and a flow amount of air passing through the second air passage **17**.

[0098] In the present embodiment, an air mix door **19** is located on a downstream air side of the evaporator **13** at an upstream air side of the first air passage **16** and the second air passage **17**, and is configured to continuously change a ratio between a flow amount of air passing through the first air passage **16** and a flow amount of air passing through the second air passage **17**.

[0099] The air mix door **19** is used as a temperature adjusting unit that adjusts the air temperature in the mixing space **18** so as to adjust the temperature of conditioned air to be blown into the vehicle compartment. The air mix door **19** is driven by an electrical actuator **72**, and operation of the electrical actuator **72** for the air mix door **19** is controlled by a control signal output from the air conditioning controller **60**.

[0100] Furthermore, at the most downstream air side, the casing **11** is provided with plural opening portions **24**, **25**, **26** from which conditioned air of the mixing space **18** is blown into the vehicle compartment that is a space to be air-conditioned. For example, the plural opening portions **24**, **25**, **26** include a defroster opening portion **24**, a face opening portion **25** and a foot opening portion **26**.

[0101] A defroster duct (not shown) is connected to the defroster opening portion **24**, such that conditioned air is blown toward an inner surface of a front windshield of the vehicle from a defroster air outlet provided at a downstream end of the defroster duct. A face duct (not shown) is connected to the face opening portion **25**, such that conditioned air is blown toward an upper side of a passenger in the vehicle compartment from a face air outlet provided at a downstream end of the face duct. A foot duct (not shown) is connected to the foot opening portion **26**, such that conditioned air is blown toward a lower side of a passenger in the vehicle compartment from a foot air outlet provided at a downstream end of the foot duct.

[0102] Air outlet mode doors for selectively switching an air outlet mode are provided in the casing **11**. The air outlet mode doors include a defroster door **24** for opening and closing the defroster opening portion **24**, a face door **25***a* for opening and closing the face opening portion **25**, and a foot door **26***a* for opening and closing the foot opening portion **26**. The outlet mode doors **24***a*, **25***a*, **26***a* are driven by an electrical actuator **73**, and operation of the electrical actuator **73** for the outlet mode doors **24***a*, **25***a*, **26***a* is controlled by a control signal output from the air conditioning controller **60**.

[0103] Next, an electrical control portion of the present embodiment will be described with reference to FIG. **2**. The air conditioning controller **60** is configured by a very-known microcomputer including CPU, ROM, RAM, etc., and a circumference circuit of the microcomputer. The air conditioning controller **60** performs various calculations and processes based on control programs stored in the ROM, and performs control operation of various equipments connected to output of the air conditioning controller **60**. For example, operation of the blower **12**, the electrical actuators **71**, **72**, **73** and the Peltier element **53** is controlled by the air conditioning controller **60**.

[0104] Air conditioning sensor group is connected to an input side of the air conditioning controller **60**. For example, the air conditioning sensor group includes an inside air sensor **61** configured to detect an inside air temperature Tr of the vehicle compartment, an outside air sensor **62** configured to detect an outside air temperature Tam, a solar radiation sensor **63** configured to detect a solar radiation Ts entering into the vehicle compartment, an evaporator temperature sensor **64** configured to detect an air temperature TE blown from the evaporator **13**, the first and second coolant temperature sensors **65**, **66** for detecting the coolant temperature TW of the engine EG. The air temperature TE blown from the evaporator **13** corresponds to a refrigerant evaporation temperature in the evaporator **13**.

[0105] An operation panel **70** is located near the instrument panel at the front portion of the vehicle compartment. The operation panel **70** is connected to the input side of the air conditioning controller **60**, such that operation signals of various air-conditioning operation switches provided in the operation panel **70** are input to the air conditioning controller **60**. The air-conditioning operation switches provided in the operation panel **70** include, for example, an operation switch (not shown) of the air conditioner **1**, an air-conditioning switch **70***a* for selectively turning on or off of the compressor thereby turning on or off of the air conditioning operation of the air conditioner **1**, an automatic switch **70***b* for setting or releasing an automatic control of the air conditioner **1**, an operation mode selecting switch (not shown) for selecting an operation mode, a suction mode selecting switch (not shown) for selectively switching an air suction mode, an air outlet mode selecting switch (not shown) for selectively switching an air outlet mode, an air amount setting switch (not shown) for setting an air blowing amount of the blower **12**, a temperature setting switch **70***c* for setting a temperature of the vehicle compartment, an economic switch **70***d* for outputting an economy priority mode in which the refrigerant cycle is operated with a priority of the power saving.

[0106] The air conditioning controller **60** is electrically connected to an engine controller **80** which controls operation of the engine EG. The air conditioning controller **60** and the engine controller **80** are configured to be capable of electrically communicating with each other. Based on detection signals or/and operation signals inputted from one of the engine controller **80** and the air conditioning controller **60**, operation of various equipments connected to the other one of the engine controller **80** and the air conditioning controller **60** can be controlled. For example, when the air conditioning controller **60** outputs an operation request signal to the engine controller **80**, the engine controller **80** causes the engine EG to be operated.

[0107] Next, the operation of the present embodiment with the above configuration will be described with reference to FIG. **3**. FIG. **3** is a flowchart showing a basic control process performed by the air conditioning controller **60** in the first embodiment. The respective steps in FIG. **3** correspond to respective function portions provided in the air conditioning controller **60**.

[0108] First, at step S**1**, initialization of a flag, a timer, a control variable, and an initial position setting of a stepping motor in respective electrical motors, and the like are performed.

[0109] At step S**2**, operation signals of the operation panel **70** and signals regarding the circumstances of the vehicle used for the air conditioning control, that is, detection signals from the above group of sensors **61** to **66** are read, and then the operation proceeds to step S**3**. Specifically, the operation signals include a vehicle interior setting temperature Tset set by the temperature setting switch **70***c*, a selection signal of the air outlet mode, a selection signal of the air suction mode, a setting signal of the amount of air blown by the blower **12**, and the like.

[0110] At step S**3**, a target outlet air temperature TAO of blown air into the vehicle compartment is calculated. The target outlet air temperature TAO of blown air into the vehicle compartment is calculated based on the vehicle interior setting temperature Tset and the vehicle environment condition such as the inside air temperature, by using the following formula F1.

$$TAO=Kset\times Tset-Kr\times Tr-Kam\times Tam-Ks\times Ts+C \qquad (F1)$$

[0111] where Tset is a vehicle interior setting temperature set by the temperature setting switch **70***c*, Tr is an inside air temperature detected by the inside air sensor **61**, Tam is an outside air temperature detected by the outside air sensor **62**, and Ts is an amount of solar radiation detected by the solar radiation sensor **63**. The Kset, Kr, Kam, and Ks are control gains, and C is a constant for correction.

[0112] Next, at step S**4**, control target values of the various equipments connected to the output side of the air conditioning controller **60** are determined. For example, the air blowing amount (blower level) of the blower **12**, the air suction mode, the air outlet mode, the open degree of the air mix door **19**, the engine operation request signal and ON/OFF operation of the Peltier element **53** and the like are determined. The air blowing amount and the air outlet mode and the like are determined based on the target outlet air temperature TAO calculated at S**3**. Furthermore, the air conditioning controller **60** determines whether the engine operation request signal is output or not based on the engine coolant temperature TW. For example, when the engine coolant temperature TW detected by the first coolant temperature sensor **65** is lower than a predetermined temperature TW**1**, the air conditioning controller **60** outputs the engine operation request signal to the engine EG. Next, the ON/OFF operation determination of the Peltier element **53** will be described.

[0113] Then, at step S**5**, control signals are output from the air conditioning controller **60** to various air-conditioning control equipments or the engine controller **80**, such that the control target values determined at step S**4** of FIG. **3** can be obtained.

[0114] Thus, the blower **12** is operated to have a predetermined air blowing amount, the air outlet mode doors are positioned to set a desired air outlet mode, and the engine EG is operated in accordance with the engine operation request signal output from the air conditioning controller **60**, for example.

[0115] Next, at step S**6**, it is determined whether a control period elapses. When it is determined that the control period τ elapses at step S**6**, the control program returns to step S**2**.

[0116] Next, the control process of step S**4** for determining the ON/OFF operation of the Peltier element **53** will be described in detail. FIG. **4** is a flowchart for determining ON/OFF operation of the Peltier element **53**, according to the present embodiment.

[0117] At step S**11**, a temperature TWD of air blown from the second heater core **15** is calculated. The air temperature TWD is a heated temperature of air heated by the engine coolant at least at the second heater core **15**. The air temperature TWD can be calculated by the coolant temperature detected by the second coolant temperature sensor **66**, the air temperature TE after passing through the evaporator **13** and the heat exchange capacity of the heater core **15** and the like. Generally, the air temperature TWD blown out of the second heater core **15** is approximately equal to the coolant temperature detected by the second coolant temperature sensor **66**.

[0118] Next, at step S**12**, the air temperature TWD blown from the second heater core **15** is compared with the target outlet air temperature TAO. When the air temperature TWD is lower than the target outlet air temperature TAO at step S**12**, the Peltier element **53** is turned on at step S**13**. When the air temperature TWD is not lower than the target outlet air temperature TAO at step S**12**, the Peltier element **53** is turned off at step S**14**.

[0119] For example, when a long time elapses after the engine EG stops, the coolant temperature may become lower, and thereby the air temperature TWD may become lower than the target outlet air temperature TAO. In this case, in the present embodiment, electrical power is supplied to the Peltier element **53**, such that heat is absorbed from the coolant after passing through the second heater core **15**, and heat is radiated to the coolant flowing toward the second heater core **15**. Thus, the temperature of the coolant flowing into the second heater core **15** is increased to a temperature required for the heating of the vehicle compartment. In this case, it is prefer to set the air mix door **19** at the maximum heating position, by the air conditioning controller **60**.

[0120] When the engine EG is operated or an elapsed time after the stop of the engine EG is shorter, the coolant temperature is sufficiently high. In this case, if the air temperature TWD is equal to or higher than the target outlet air temperature TAO, it is unnecessary to heat the engine coolant by using the operation of the Peltier element **53**. In this case, the Peltier element **53** is not turned on by the air conditioning controller **60**, and the position (open degree) of the air mix degree **19** is controlled by the air conditioning controller **60**, thereby adjusting the temperature of conditioned air to be blown into the vehicle compartment.

[0121] The operation effects of the first embodiment will be described.

[0122] (1) According to the present embodiment, when the air temperature TWD from the second heater core **15** is lower than the target outlet air temperature TAO, the temperature of the coolant flowing into the second heater core **15** is increased by the operation of the Peltier element **53**, instead of the operation of the engine EG. Thus, the operation frequency of the engine EG can be reduced, thereby improving the fuel consumption efficiency of the engine EG, as compared with an air conditioner without having the Peltier element **53**.

[0123] Because the temperature of the engine coolant is increased by the operation of the Peltier element **53**, it is possible to delay the temperature decrease of the engine coolant immediately after the stop of the engine EG, and thereby a time, for which the engine coolant temperature TW detected by the first coolant temperature sensor **65** becomes equal to or higher than the engine-operation required temperature, can be made longer. Accordingly, in the present embodiment, as compared with a case where the Peltier element **53** is not provided, the operation frequency of the engine EG can be effectively reduced.

[0124] (2) Generally, the temperature of the engine coolant flowing into the second heater core **15** is preferably equal to or higher than a necessary temperature required for the heating, e.g., 60° C. On the other hand, the temperature of the coolant flowing into the interior of the engine EG is preferably equal to or higher than a lower limit temperature for effectively heating the respective parts of the engine EG. Here, the lower limit temperature is 40° C., for example.

[0125] Thus, in a conventional vehicle air conditioner without having the Peltier element **53**, the engine-operation required temperature is set at a temperature around 60° C. in order to keep the coolant temperature equal to or higher than 60° C.

[0126] In contrast, according to the present embodiment, when the temperature of the engine coolant becomes lower than 60° C. while the engine EG stops, the Peltier element **53** is operated so that the temperature of the engine coolant is increased. Thus, it is possible to set the engine-operation required temperature to be lower than 60° C. For example, the engine-operation required temperature is set at a temperature about 40° C.

[0127] In the present embodiment, the engine-operation request temperature can be set at a temperature at which the necessary heating of the vehicle compartment cannot be maintained even when the Peltier element **53** is operated, or the engine-operation request temperature can be set at a temperature at which the engine EG cannot be effectively operated.

[0128] (3) In the present embodiment, the Peltier element **53** absorbs heat from the coolant of the engine EG, which is a subject to be heat-absorbed.

[0129] The subject to be heat-absorbed in the Peltier element **53** may be an outside air, instead of the coolant of the engine EG. However, when the Peltier element **53** absorbs heat from the outside air, a heat pump capacity required in the Peltier element **53** becomes larger as the outside air temperature becomes lower, and thereby the consumed electrical power of the Peltier element **53** becomes larger.

[0130] In contrast, according to the present embodiment, the Peltier element **53** absorbs heat from the engine coolant that has a temperature generally higher than the temperature of the outside air in the winter. Thus, it is possible to increase the heat radiation amount radiated from the Peltier element **53** to the coolant. As a result, the consumed power of the Peltier element **53**, consumed for increasing the temperature of the coolant to a desired temperature, can be reduced.

[0131] According to the present embodiment, when the coolant temperature TW detected by the first coolant temperature sensor **65** is lower than the required temperature (40° C.) of the engine operation, the engine operation request signal is output to the engine EG: Thus, the coolant temperature can be kept at a temperature equal to or higher than the required temperature, and thereby the coolant temperature always becomes higher than the outside air temperature.

[0132] (4) when the Peltier element **53** is not provided, the coolant flowing out of the second heater core **15** flows simply into the engine EG. In this case, the heat quantity without heat-exchanged with air in the second heater core **15** is radiated from the surface of the engine EG.

[0133] In contrast, according to the present embodiment, because the heat is pumped from the coolant flowing out of the second heater core **15** by the Peltier element **53**, the heat quantity without being heat exchanged with air in the second heater core **15** can be further used for the heating of the vehicle compartment. Thus, the heat quantity of the engine coolant can be effectively used.

Second Embodiment

[0134] A second embodiment of the invention will be described with reference to FIG. **5**. FIG. **5** is a schematic diagram showing an air conditioner **1** for a vehicle according to the second embodiment of the invention.

[0135] In a coolant circuit **30** of the second embodiment, a second coolant passage **34** for the second heater core **15** is made different from that of the first embodiment. As shown in FIG. **5**, a first bypass passage **35** is provided, such that a part of coolant flowing into the second coolant passage **34** from the branch point **31***a* is directly introduced into the heat-absorption side heat exchanger **51** through the first bypass passage **35**, without passing through the heat-radiation side heat exchanger **52**. Furthermore, a first flow adjustment valve **36** is disposed to adjust a flow amount of the coolant flowing through the first bypass passage **35**.

[0136] Specially, one end of the first bypass passage **35** is connected to an upstream side of the heat-radiation side heat exchanger **52** in the coolant flow, and the other end of the first bypass passage **35** is connected to a position of the second coolant passage **34** between a coolant outlet of the second heater core **15** and a coolant inlet of the heat-absorption side heat exchanger **51**. Therefore, the coolant flowing through the first bypass passage **35** bypasses the heat-radiation side heat exchanger **52** and the second heater core **15**, and flows into the heat-absorption side heat exchanger **51**, without radiating heat at the heat-radiation side heat exchanger **52** and without performing heat exchange with air at the second heater core **15**.

[0137] In the example of FIG. **5**, the first flow adjustment valve **36** is located at a branch portion of the first bypass passage **35** branched from the coolant passage flowing through the heat radiation-side heat exchanger **52**. Therefore, the flow adjustment valve **36** can easily adjust a flow amount of the coolant flowing into the heat-radiation side heat exchanger **52** and a flow amount of the coolant flowing through the first bypass passage **35**. However, the first flow adjustment valve **36** may be disposed at any position in the first bypass passage **35**, without being limited to the branch portion of the first bypass passage **35**. For example, the first flow adjustment valve **36** may be located at a joint portion at which the downstream end of the first bypass passage **35** is joined to a coolant passage from the second heater core **15**.

[0138] In the present embodiment, the air conditioning controller **60** controls the first flow adjustment valve **36**, such that a part of the coolant flows into the first bypass passage **35** when the Peltier element **53** is turned on, and the flow amount of the coolant flowing through the first bypass passage **35** becomes zero when the Peltier element **53** is turned off.

[0139] According to the present embodiment, when the Peltier element **53** is turned on so that electrical current is applied to the Peltier element **53**, a part of the coolant before flowing to the heat-radiation side heat exchanger **52** is introduced into the inlet side of the heat-absorption side heat exchanger **51**. Therefore, the temperature of the coolant flowing into the heat-radiation side heat exchanger **52** can be approached to the temperature of the coolant flowing into the heat-absorption side heat exchanger **51**. Generally, the heat radiation amount of the Peltier element **53** becomes larger, as a temperature difference between the heat absorbing surface and the heat radiating surface of the Peltier element **53** is smaller. Thus, according to the present embodiment, because the first bypass passage **35** is provided, the heat radiation amount radiated to the coolant in the heat-radiation side heat exchanger **52** can be made larger, and thereby the temperature increase of the coolant flowing into the second heater core **15** can be made larger.

[0140] According to the present embodiment, when the Peltier element **53** is turned on so that the electrical current is applied to the Peltier element **53**, the air conditioning controller **60** controls the first flow adjustment valve **36**, so as to adjust the flow amount of the coolant flowing through the first bypass passage **35** in accordance with the heating capacity required in the second heater core **15**.

[0141] For example, when an air amount blown from an air outlet into the vehicle compartment is small, the heating capacity required in the second heater core **15** is generally small. In this case, the flow amount of the coolant flowing through the first bypass passage **35** can be made larger than the flow amount of the coolant flowing through the heat-radiation side heat exchanger **52**. Thus, the flow amount of the coolant flowing into the second heater core **15** can be reduced, and thereby the temperature increase in the coolant due to the heat radiation of the heat-radiation side heat exchanger **52** can be increased.

[0142] Furthermore, when the air amount blown from the air outlet into the vehicle compartment is large, the heating capacity required in the second heater core **15** is generally large. In this case, the flow amount of the coolant flowing through the first bypass passage **35** can be made smaller than the flow amount of the coolant flowing through the heat-radiation side heat exchanger **52**. In this case, the flow amount of the coolant flowing through the heat-radiation side heat exchanger **52** can be made larger, and thereby the heating capacity of the second heater core **15** can be increased.

[0143] In the above-described second embodiment, the first flow adjustment valve **36** is used to adjust the flow amount flowing through the first bypass passage **35**. However, a flow switching valve may be used instead of the first flow adjustment valve **36**, to switch the flow amount flowing through the first bypass passage **35** between zero and a predetermined amount larger than zero. In the above-described second embodiment, the other parts of the air conditioner **1** may be similar to those of the above-described first embodiment.

Third Embodiment

[0144] A third embodiment of the invention will be described with reference to FIG. **6**. FIG. **6** is a schematic diagram showing an air conditioner **1** for a vehicle according to the third embodiment of the invention.

[0145] In the vehicle air conditioner **1** of the present embodiment, a foot passage **27** is provided through which warm air flowing out of the second heater core **15** is introduced only to the foot opening portion **26**. A partition wall **11***a* is disposed in the casing **11** to partition a space of the casing **11** at a downstream air side of the second heater core **15** into the foot passage **27** on a side of the foot opening portion **26** and an air passage on a side of the opening portions **24**, **25**. The foot passage **27** is formed by the partition wall **11***a* in the casing **11**.

[0146] A communication opening portion **28** is provided in the partition wall **11***a* at a position immediately downstream of the second heater core **15**, and an opening/closing door **28***a* is disposed at the position immediately after the second heater core **15** to open and close the communication opening portion **28**. When the opening/closing door **28***a* opens the communication opening portion **28**, the warm air flowing out of the second heater core **15** can be introduced to any the defroster opening portion **24**, the face opening portion **25** and the foot opening portion **26**. In contrast, when the opening/closing door **28***a* closes the communication opening portion **28**, the warm air flowing out of the second heater core **15** is only introduced to the foot opening portion **26**.

[0147] Furthermore, the size of the first heater core **14** is made larger than the size of the second heater core **15**. Specifically, the sectional area of the first heater core **14** is made larger than the sectional area of the second heater core **15**, so that a part of warm air flowing out of the first heater core **14** flows to the defroster opening portion **24** and the face opening portion **25** without passing through the second heater core **15**, when the opening/closing door **28***a* closes the communication opening portion **28**.

[0148] In the present embodiment, when the Peltier element **53** is turned on, the air conditioning controller **60** causes the opening/closing door **28***a* to close the communication opening portion **28**. Thus, in a foot mode in which the conditioned air is blown, from the foot air outlet and side face air outlets, the communication opening portion **28** is closed by the opening/closing door **28***a*, so that air heated by the first and second heater cores **14**, **15** is blown to the lower side of a passenger from the foot air outlet, and air heated by the first heater core **14** is mixed with cool air flowing through the second air passage **17** and is blown into the vehicle compartment from the side face air outlets. Thus, air conditioning with "cool-head and warm-foot" can be performed, thereby improving comfortable feeling given to a passenger in the vehicle compartment. In the above-described third embodiment, the other parts of the air conditioner **1** may be similar to those of the above-described first embodiment.

Fourth Embodiment

[0149] A fourth embodiment of the invention will be described with reference to FIG. **7**. FIG. **7** is a schematic diagram showing an air conditioner **1** for a vehicle according to the fourth embodiment of the invention.

[0150] In the above-described first to third embodiments, the coolant circuit **30** is provided such that the coolant flows to the first and second heater cores **14**, **15** in parallel with respect to the flow of the coolant. However, in the fourth embodiment, the coolant circuit **30** is provided such that the coolant flows to the first and second heater cores **14**, **15** in series with respect to the flow of the coolant. That is, in the fourth embodiment, the first and second heater cores **14**, **15** are arranged in series with respect to the flow of the coolant.

[0151] Specifically, the coolant circuit **30** is provided with a single coolant passage **31** for both the first and second heater cores **14**, **15**, such that the coolant flowing out of the coolant outlet of the engine EG flows through the first heater core **14** and the second heater core **15** in this order, and returns to the coolant inlet of the engine EG. Thus, the first heater core **14** is arranged upstream of the coolant flow, and the second heater core **15** is arranged downstream of the coolant flow, in the coolant circuit **30**.

[0152] The heat-absorption side heat exchanger **51** is located downstream of the second heater core **15** in the coolant flow, and the heat-radiation side heat exchanger **52** is located downstream of the first heater core **14** in the coolant flow and upstream of the second heater core **15** in the coolant flow.

[0153] In the present embodiment, heat can be absorbed by the Peltier element **53** via the heat-absorption side heat exchanger **51** from the coolant after performing heat exchange with air in the second heater core **15**, and heat can be radiated by the Peltier element **53** via the heat-radiation side heat exchanger **52** to the coolant flowing to the second heater core **15**. Therefore, the Peltier effect can be obtained similarly to the above described first embodiment.

[0154] In the present embodiment, because the coolant after performing heat exchange with air in the first heater core **14** flows into the heat-radiation side heat exchanger **52**, the heating capacity of the second heater core **15** is generally lower than the heating capacity of the first heater core **14**. However, heat can be radiated by the Peltier element **53** via the heat-radiation side heat exchanger **52**, the heating capacity of the second heater core **15** can be assisted by the Peltier element **53**. In the above-described fourth embodiment, the other parts of the air conditioner **1** may be similar to those of the above-described first embodiment.

Fifth Embodiment

[0155] A fifth embodiment of the invention will be described with reference to FIG. **8**. FIG. **8** is a schematic diagram showing an air conditioner **1** for a vehicle according to the fifth embodiment of the invention.

[0156] In the air conditioner **1** according to any one of the above-described first to fourth embodiments, two heater cores such as the first and second heater cores **14**, are disposed. In the air conditioner **1** for a vehicle, a single heater core **14** is disposed to heat air to be blown into the vehicle compartment.

[0157] In the vehicle air conditioner **1**, a coolant circuit **30** of the engine EG is provided such that the coolant is circulated between the heater core **14** and the engine EG. In the present embodiment, the coolant circuit **30** is provided with a coolant passage **31** for the heater core **14** and a coolant passage **32** for the radiator **41**.

[0158] In the present embodiment, the heat-absorption side heat exchanger **51** is disposed in the coolant passage **31** at a downstream side of the heater core **14** in the coolant flow, and the heat-radiation side heat exchanger **52** is disposed in the coolant passage **31** at an upstream side of the heater core **14** in the coolant flow.

[0159] In the present embodiment, heat can be absorbed by the Peltier element **53** via the heat-absorption side heat exchanger **51** from the coolant after performing heat exchange with air in the heater core **14**, and heat can be radiated by the Peltier element **53** via the heat-radiation side heat exchanger **52** to the coolant flowing to the second heater core **14**. Therefore, the Peltier effect can be obtained similarly to the above described first embodiment. In the above-described fifth embodiment, the other parts of the air conditioner **1** may be similar to those of the above-described first embodiment.

Sixth Embodiment

[0160] A sixth embodiment of the invention will be described with reference to FIG. **9**. FIG. **9** is a schematic diagram showing an air conditioner **1** for a vehicle according to the sixth embodiment of the invention. In the sixth embodiment, the features of the second embodiment described above are combined with the air conditioner **1** of the above-described sixth embodiment.

[0161] In the coolant circuit **30** of the sixth embodiment, as shown in FIG. **9**, a first bypass passage **35** is provided, such that a part of coolant flowing through the coolant passage **31** is introduced into the heat-absorption side heat exchanger **51** through the first bypass passage **35**, without passing through the heat-radiation side heat exchanger **52**. Furthermore, a first flow adjustment valve **36** is disposed to adjust a flow amount of the coolant flowing through the first bypass passage **35**. Specially, one end of the first bypass passage **35** is connected to an upstream side of the heat-radiation side heat exchanger **52** in the coolant flow, and the other end of the first bypass passage **35** is connected to a position of the coolant passage **31** between a coolant outlet of the heater core **14** and a coolant inlet of the heat-absorption side heat exchanger **51**. Therefore, the coolant flowing through the first bypass passage **35** bypasses the heat-radiation side heat exchanger **52** and the heater core **14**, and flows into the heat-absorption side heat exchanger **51**, without radiating heat at the heat-radiation side heat exchanger **52** and without performing heat exchange with air at the heater core **14**. In the example of FIG. **9**, the first flow adjustment valve **36** is located at a branch portion of the first bypass passage **35** branched from the coolant passage **31**. Therefore, the flow adjustment valve **36** can easily adjust a flow amount of the coolant flowing into the heat-radiation side heat exchanger **52** and a flow amount of the coolant flowing through the first bypass passage **35**.

[0162] However, the first flow adjustment valve **36** may be disposed at any position in the first bypass passage **35**, without being limited to the branch portion of the first bypass passage **35**. The flow adjustment valve **36** is controlled by the air conditioning controller **60**, similarly to the second embodiment. Thus, in the present embodiment, the effects described in the second embodiment can be obtained. In the above-described sixth embodiment, the other parts of the air conditioner **1** may be similar to those of the above-described fifth embodiment shown in FIG. **8**.

Seventh Embodiment

[0163] A seventh embodiment of the invention will be described with reference to FIG. **10**. FIG. **10** is a schematic diagram showing an air conditioner **1** for a vehicle according to the seventh embodiment of the invention.

[0164] In the seventh embodiment, the single heater core **14** is disposed in the casing **11** to heat air to be blown into the vehicle compartment, as in the above-described fifth embodiment of FIG. **8**. In the seventh embodiment, a heat exchanger **37** is disposed, with respect to the coolant circuit **30** of the above-described fifth embodiment shown in FIG. **8**. In the seventh embodiment, the heat exchanger **37** is disposed to perform heat exchange between the coolant before flowing into the heat-radiation side heat exchanger **52** and the coolant before flowing into the heat-absorption side heat exchanger **51**.

[0165] The heat exchanger **37** has therein a first passage through which the coolant upstream of the heat-radiation side heat exchanger **52** flows, and a second passage through which the coolant downstream of the heater core **14** flows, so as to perform heat exchange between the coolant passing through the first passage and the coolant passing through the second passage in the heat exchanger **37**. Therefore, the coolant flowing out of the heater core **14** is heated by performing heat exchange with the coolant flowing out of the engine EG, and then flows through the heat-absorption side heat exchanger **51**.

[0166] Thus, the temperature of the coolant flowing into the heat-radiation side heat exchanger **52** can be approached to the temperature of the coolant flowing into the heat-absorption side heat exchanger **51**. Generally, the heat radiation amount of the Peltier element **53** becomes larger, as a temperature difference between the heat absorbing surface and the heat radiating surface of the Peltier element **53** is smaller. Thus, according to the present embodiment, because the heat exchanger **37** is provided, the heat radiation amount radiated to the coolant in the heat-radiation side heat exchanger **52** can be made larger, and thereby the temperature increase of the coolant flowing into the heater core **14** can be made larger. In the above-described seventh embodiment, the other parts of the air conditioner **1** may be similar to those of the above-described fifth embodiment shown in FIG. **8**.

Eighth Embodiment

[0167] An eighth embodiment of the present invention will be described with reference to FIG. **11**. FIG. **11** is a schematic diagram showing an air conditioner **1** for a vehicle according to the eighth embodiment of the invention.

[0168] In a coolant circuit **30** of the eighth embodiment, as shown in FIG. **11**, a second bypass passage **38** is provided, such that a part of coolant flowing through the coolant passage **31** is introduced into the coolant inlet of the engine EG, without passing through the heat-radiation side heat exchanger **52**. Furthermore, a second flow adjustment valve **39** is disposed to adjust a flow amount of the coolant flowing through the second bypass passage **38**.

[0169] Specially, one end of the second bypass passage **38** is connected to a coolant upstream side of the heat-radiation side heat exchanger **52** at a downstream side of the coolant outlet of the engine EG, and the other end of the second bypass passage **38** is connected to a coolant downstream side of the heat-absorption side heat exchanger **51** at an upstream side of the coolant inlet of the engine EG. Therefore, coolant flowing through the second bypass passage **38** bypasses the heat-radiation side heat exchanger **52**, the heater core **14** and the heat-absorption side heat exchanger **51**, and directly returns to the engine EG.

[0170] In the example of FIG. **11**, the second flow adjustment valve **39** is located at a branch portion of the second bypass passage **38** branched from the coolant passage flowing through the heat radiation-side heat exchanger **52**. Therefore, the flow adjustment valve **39** can easily adjust a flow amount of the coolant flowing into the heat-radiation side heat exchanger **52** and a flow amount of the coolant flowing through the second bypass passage **38**. However, the second flow adjustment valve **39** may be disposed at any position in the second bypass passage **38**, without being limited to the branch portion of the second bypass passage **38**.

[0171] In the present embodiment, the air conditioning controller **60** controls the second flow adjustment valve **39**, such that a part of the coolant flows into the second bypass passage **38** when the Peltier element **53** is turned on, and the flow amount of the coolant flowing through the second bypass passage **38** becomes zero when the Peltier element **53** is turned off.

[0172] Because heat is absorbed from the coolant by the Peltier element **53**, the temperature of the coolant flowing out of the heat-absorption side heat exchanger **51** becomes lower, and thereby a temperature difference between the coolant flowing into the coolant inlet of the engine EG and the coolant outlet of the engine EG may become larger. If the temperature difference between the coolant inlet and the coolant outlet of the engine EG is large, a heat stress may be caused in the engine EG, and the engine EG may be damaged.

[0173] According to the present embodiment, when the Peltier element **53** is turned on, a part of the coolant upstream of the heat-radiation side heat exchanger **52** is introduced to the coolant inlet side of the engine EG via the second bypass passage **38**. Thus, the temperature difference between the coolant flowing into the coolant inlet of the engine EG and the coolant flowing out of the coolant outlet of the engine EG can be reduced, thereby preventing a heat stress of the engine EG.

[0174] When the second bypass passage **38** is provided, the flow amount of the coolant flowing through the second coolant passage **38** may be made larger than the flow amount of the coolant flowing toward the heat-radiation side heat exchanger **52**. In this case, the temperature difference between the coolant flowing into the coolant inlet of the engine EG and the coolant flowing out of the coolant outlet of the engine EG can be reduced.

[0175] In the above-described second embodiment, the second flow adjustment valve **39** is used to adjust the flow amount of the coolant flowing through the second bypass passage **38**. However, a flow switching valve may be used instead of the second flow adjustment valve **38**, to switch the flow amount flowing through the second bypass passage **38** between zero and a predetermined amount larger than zero. In the above-described eighth embodiment, the other parts of the air conditioner **1** may be similar to those of the above-described fifth embodiment shown in FIG. **8**.

Ninth Embodiment

[0176] A ninth embodiment of the present invention will be described with reference to FIG. **12**. FIG. **12** is a schematic diagram showing an air conditioner **1** for a vehicle according to the eighth embodiment of the invention.

[0177] In a coolant circuit **30** of the ninth embodiment, as shown in FIG. **12**, a third bypass passage **54** and a third flow adjustment valve **55** are provided, as compared with the coolant circuit **30** of the above-described fifth embodiment shown in FIG. **8**. The third bypass passage **55** is provided such that a part of coolant flowing through the coolant passage **31** is introduced into the heat-absorption side heat exchanger **51**, without passing through the heat-radiation side heat exchanger **52** and the heater core **14**. Furthermore, the third flow adjustment valve **55** is disposed to adjust a flow amount of the coolant flowing through the third bypass passage **54**.

[0178] The coolant passage **31** for the heater core **14** is provided such that the coolant flowing out of the coolant outlet of the engine EG flows toward the heater core **14**, and the coolant flowing out of the heater core **14** flows toward the coolant inlet of the engine EG. In the example of FIG. **12**, the third flow adjustment valve **55** is located at a branch portion of the third bypass passage **54** branched from the coolant passage **31** flowing through the heat radiation-side heat exchanger **52**.

[0179] Furthermore, the heat-absorption side heat exchanger **51** is disposed in the third bypass passage **54** so that the coolant flowing into the third bypass passage **54** flows through the heat-absorption side heat exchanger **51**. Therefore, the heat-absorption side heat exchanger **51** absorbs heat from the coolant flowing out of the coolant outlet of the engine EG, and thereby the coolant after performing heat exchange with air in the heater core **14** does not flow into the heat-absorption side heat exchanger **51**.

[0180] The heat-radiation side heat exchanger **52** is located downstream of the third flow adjustment valve **55** in the coolant passage **31**, and upstream of the heater core **14** in the coolant flow.

[0181] In the present embodiment, the air conditioning controller **60** controls the third flow adjustment valve **55**, such that the coolant flows into both the heat-absorption side heat exchanger **51** and the heat-radiation side heat exchanger **52** when the Peltier element **53** is turned on. Furthermore, the third flow adjustment valve **55** is controlled by the air conditioning controller **60** to close the third bypass passage **54** so that the coolant flows only toward the heater core **14** when the Peltier element **53** is turned off.

[0182] According to the present embodiment, when the Peltier element **53** is turned on, the coolant flowing out of the coolant outlet of the engine EG flows to both the heat-absorption side heat exchanger **51** and the heat-radiation side heat exchanger **52**, and thereby the heat absorbing surface and the heat radiating surface of the Peltier element **53** have the same temperature. Thus, according to the present embodiment, the heat radiation amount of the Peltier element **53** can be effectively increased. In the above-described ninth embodiment, the other parts of the air conditioner **1** may be similar to those of the above-described fifth embodiment shown in FIG. **8**.

Tenth Embodiment

[0183] A tenth embodiment of the present invention will be described with reference to FIG. **13**. FIG. **13** is a schematic diagram showing an air conditioner **1** for a vehicle according to the tenth embodiment of the invention.

[0184] In the tenth embodiment, as shown in FIG. **13**, a water circuit **90** is separately provided from a coolant circuit **30** for the engine EG.

[0185] The coolant circuit **30** is a closed circuit through which coolant of the engine EG is circulated between the engine EG, the heat-absorption side heat exchanger **51** and the radiator **41**. The coolant flowing out of the engine EG flows through the heat-radiation side heat exchanger **51** via a coolant passage **31**, and flows through the radiator **41** via a coolant passage **32**.

[0186] The water circuit **90** is a circuit independently provided from the coolant circuit **30**, and is provided to heat the air passing through the heater core **14** by using a hot water (fluid) as a heat source. In the present embodiment, water is circulated as an example of the fluid circulating in the water circuit **90**. A water pump **92** is located in a water, passage **91** of the water circuit **90** such that hot water heated by the Peltier element **53** via the heat-radiation side heat exchanger **52** circulates in the water passage **91** of the water circuit **90**.

[0187] In the present embodiment, the heat-absorption side heat exchanger **51** is disposed in the coolant circuit **30** to absorb heat from the coolant of the engine EG. In contrast, the heat-radiation side heat exchanger **52** is located in the water circuit **90** so that heat is radiated to the water in the water passage **91** of the water circuit **90**. Thus, when the Peltier element **53** is turned on, the Peltier element **53** absorbs heat from the coolant of the engine EG via the heat-absorption side heat exchanger **51**, and radiates heat to the water in the water circuit **90** via the heat-radiation side heat exchanger **52**. Therefore, water flowing through the heat-radiation side heat exchanger **52** is heated, and the heated water flows into the heater core **14**. Thus, in the present embodiment, air is heated in the heater core **14** by indirectly using the coolant of the engine EG as a heat source.

[0188] A first temperature sensor **65** is disposed in the coolant passage **31** of the coolant circuit **30** to detect the temperature of the coolant flowing out of the coolant outlet of the engine EG, and a second temperature sensor **66** is disposed in the coolant passage **91** of the water circuit **90** to detect the temperature of the water flowing into the heater core **14**.

[0189] When the coolant temperature detected by the first temperature sensor **65** is lower than a required coolant temperature TW**1**, the air conditioning controller **60** outputs an engine operation request signal to the engine EG. For example, in the present embodiment, the required coolant temperature TW**1** is set at a lower limit temperature (e.g., 40° C.) in which the engine EG can be effectively operated. Thus, in the present embodiment, the temperature of the coolant can be maintained to be equal to or higher than the lower limit temperature (e.g., 40° C.) in which the engine EG can be effectively operated.

[0190] On the other hand, in the water circuit **90**, the air conditioning controller **60** controls the turning on/off operation of the Peltier element **53** such that the water temperature detected by the second temperature sensor **66** becomes equal to or higher than a temperature (e.g., 60° C.) that is higher than the lower limit temperature (e.g., 40° C.) of the engine EG.

[0191] According to the present embodiment, the heat is pumped from the coolant of the engine. EG to the water flowing into the heater core **14**, so that the temperature of water flowing into the heater core **14** becomes higher than a necessary heating temperature. Thus, it is unnecessary to set the temperature of the coolant of the engine EG to be kept at a temperature equal to or higher than the necessary heating temperature. Thus, in the present embodiment, because the engine-operation required temperature can be set lower, the operation frequency of the engine EG can be reduced, and thereby the fuel consumption efficiency of the engine EG can be improved.

[0192] In the present embodiment, the Peltier element **53** absorbs heat from the coolant of the engine EG, which is a subject to be heat-absorbed. Therefore, the above effect (3) described in the first embodiment can be obtained.

[0193] Because the water circuit **90** is formed separately from the engine coolant circuit **30**, it can prevent heat of the water circuit **90**, without being heat-exchanged with air in the heater core **14**, from being radiated at the engine.

[0194] Thus, in the present embodiment, hot water is circuited in the closed water circuit **90**, and thereby all the heat pumped at the Peltier element **53** can be used for the heating of air in the heater core **14**.

[0195] In the present embodiment, the single heater core **14** is provided in the casing **11** to heat air. However, in the present embodiment, two heater cores may be located similarly to the first and second heater cores of the above-described first embodiment. For example, a first heater core is located in the casing **11** at an upstream air side, and a second heater core is located in the casing **11** at a downstream air side of the first core. In this case, the coolant of the engine EG may be supplied to the first heater core, and water of the water circuit **90** shown in FIG. **13** may flow to the second heater core as in the heater core **14** of FIG. **13**.

[0196] In this case, in the coolant circuit **30**, a coolant passage for supplying the coolant to the first heater core and a coolant passage for the heat-absorption side heat exchanger **51** may be arranged in parallel with respect the flow of the coolant. Thus, it is possible to increase the temperature of the coolant to be supplied to both the first heater core and the heat-absorption side heat exchanger **51**. In the above-described tenth embodiment, the other parts of the air conditioner **1** may be similar to those of the above-described first embodiment.

Eleventh Embodiment

[0197] An eleventh embodiment of the invention will be described with reference to FIG. **14**. FIG. **14** is a schematic diagram showing an air conditioner **1** for a vehicle according to the eleventh embodiment of the invention. In the eleventh embodiment, a heat pump cycle **100** is used as a heat pump device.

[0198] Specifically, in a vehicle air conditioner **1** of the present embodiment, a heat pump cycle **100** is used instead of the Peltier element **53**, as compared with the vehicle air conditioner **1** shown in FIG. **8**.

[0199] The heat pump cycle **100** includes a compressor **101**, a radiator **102**, an expansion valve **103**, a heat absorbing, unit **104**, a gas-liquid separator **105** and a refrigerant pipe **106**. The compressor **101** is adapted to compress refrigerant and to discharge the compressed refrigerant. The radiator **102** is disposed to cool and radiate the high-pressure refrigerant discharged from the compressor **101**.

[0200] The expansion valve **103** is disposed to decompress and expand the high-pressure refrigerant flowing out of the radiator **102**. The heat absorbing unit **104** is disposed so that the low pressure refrigerant decompressed by the expansion valve **103** absorbs heat in the heat absorbing unit **104**. Furthermore, the gas-liquid separator **105** is disposed to separate the low-pressure refrigerant from the heat absorbing unit **104** into gas refrigerant and the liquid refrigerant, and to supply the separated gas refrigerant to a refrigerant suction side of the compressor **101**.

[0201] As shown in FIG. **14**, a heat-absorption side heat exchanger **51** is disposed in the coolant passage **31** at a coolant downstream side of the heater core **14** to absorb heat from the coolant, and a heat-radiation side heat exchanger **52** is disposed in the content passage **31** at a coolant upstream side of the heater core **14** to radiate heat to the coolant.

[0202] The heat absorbing unit **104** is thermally connected to the heat-absorption side heat exchanger **51**, so that the refrigerant in the heat absorbing unit **104** absorbs heat from the coolant of the engine EG via the heat-absorption side heat exchanger **51**. The heat radiator **102** is thermally connected to the heat-radiation side heat exchanger **52**, so that the refrigerant in the heat radiator **102** radiates heat to the coolant of the engine EG via the heat-radiation side heat exchanger **52**.

[0203] In the present embodiment, heat can be absorbed by the heat pump cycle **100** via the heat-absorption side heat exchanger **51** from the coolant after performing heat exchange with air in the heater core **14**, and heat can be radiated by the heat pump cycle **100** via the heat-radiation side heat exchanger **52** to the coolant flowing to the heater core **14**. Therefore, the effects described in the above first embodiment can be obtained.

[0204] The heat pump cycle **100** may be considered to absorb heat from air, in order to heat the coolant by using the absorbed heat.

[0205] However, when the heat pump cycle **100** absorbs heat from the outside air, a heat pump capacity required in the heat pump cycle **100** may become larger as the outside air temperature becomes lower, and thereby the consumed power of the heat pump cycle **100** may become larger.

[0206] In contrast, according to the present embodiment, the heat pump cycle **100** absorbs heat from the engine coolant that is generally higher than the temperature of the outside air in the winter. Thus, it is possible to increase the heat radiation amount radiated from the heat pump cycle **100** to the coolant. As a result, the consumed power of the heat pump cycle **100**, consumed for increasing the temperature of the coolant to a desired temperature, can be reduced.

[0207] Furthermore, in the present embodiment, because heat is absorbed from the coolant having a heat transmission efficiency higher than air, the size of the heat-absorption side heat exchanger **51** can be effectively reduced.

[0208] In the present embodiment, the heat pump cycle **100** is used instead of the Peltier element **53** in the vehicle air conditioner **1** of the fifth embodiment. However, in the vehicle air conditioner **1** according to any one of the first to fourth embodiments and the sixth to tenth embodiments, the heat pump cycle **100** similarly to the eleventh embodiment may be used instead of the Peltier element **53**.

[0209] In the above-described eleventh embodiment, the other parts of the air conditioner **1** may be similar to those of the above-described fifth embodiment.

Twelfth Embodiment

[0210] A twelfth embodiment of the invention will be described with reference to FIGS. **15-17**. FIG. **15** is a schematic diagram showing an air conditioner **1** for a vehicle according to the twelfth embodiment of the invention. In the above-described first embodiment, the Peltier element **53** is provided in the second coolant passage **34**. However, in the twelfth embodiment, the element structure of the second coolant passage **34** is changed as compared with the first embodiment shown in FIG. **1**.

[0211] A water heating electrical heater **111** is disposed in the second coolant passage **34** at an upstream side of the second heater core **15** in a flow direction of the coolant in the second coolant passage **34**. A flow adjustment valve **112** is disposed at a downstream side of the second heater core **15** in the flow direction of the coolant in the second coolant passage **34**. Furthermore, a sensible heat exchanger **113** is disposed in the coolant passage **34** to perform heat exchange between coolants within the second coolant passage **34**.

[0212] The water heating electrical heater **111** is adapted to heat the coolant before flowing into the second heater core **15** in the second coolant passage **34**. For example, the water heating electrical heater **111** is an electrical heater which generates heat when an electrical power is applied thereto from a high-voltage electrical source such as a high-voltage battery or a high-voltage capacitor mounted to the vehicle. In this case, the high-voltage battery may be also used for supplying electrical power to an electrical motor for a vehicle traveling. The water heating electrical heater **111** is controlled by the air conditioning controller **60** to be turned on at a predetermined condition.

[0213] The flow adjustment valve **112** is configured such that its passage sectional area is changeable. Therefore, the flow adjustment valve **112** can adjust a flow amount of the coolant flowing through the second coolant passage **34**. As the flow adjustment valve **112**, an electrical valve or an electromagnetic valve may be used. In the present embodiment, the operation (e.g., open degree) of the flow adjustment valve **112** is controlled by the air conditioning controller **60** so that the flow amount of the coolant flowing through the second coolant passage **34** can be adjusted.

[0214] The sensible heat exchanger **113** is disposed in the second coolant passage **34**, such that the coolant upstream of the water heating electrical heater **111** is heat exchanged with the coolant, downstream of the second heater core **15**, thereby performing a heat transmission from the coolant after flowing out of the second heater core **15** to the coolant before flowing into the water heating electrical heater **111**. As the sensible heat exchanger **113**, a generally-known heat exchanging structure may be used.

[0215] For example, a heat pipe structure or a double pipe structure may be used as the heat exchanging structure of the sensible heat exchanger **113**. In the present embodiment, the sensible heat exchanger **113** is a countercurrent-type heat exchanger in which the fluid (e.g., the coolant) flows reversely in the flow direction.

[0216] A bypass passage **114**, through which the coolant flows while bypassing the sensible heat exchanger **113** at a downstream side of the second heater core **15**, is provided in the second Coolant passage **34**, and a flow switching valve **115** is disposed to switch a coolant path between the bypass passage **114** and a path of the sensible heat exchanger **113**.

[0217] Specifically, one end of the bypass passage **114** is connected to a position between the flow adjustment valve **112** and the sensible heat exchanger **113**, and the other end of the bypass passage **114** is connected to a position between the sensible heat exchanger **113** and the join point **31***b*. In the present embodiment shown in FIG. **15**, the flow switching valve **115** is located at an upstream end portion of the bypass passage **114** in the coolant flow. However, the flow switching valve **115** may be located at a downstream end portion of the bypass passage **114** in the coolant flow.

[0218] FIG. **16** is a schematic diagram showing an electrical control portion of the air conditioner **1** for a vehicle according to the twelfth embodiment of the invention. As shown in FIG. **16**, the air conditioning controller **60** controls operation of the water heating electrical heater **111**, the flow adjustment valve **112** and the flow switching valve **115**, which are located at the output side of the air conditioning controller **60**. The air conditioning controller **60** controls ON/OFF operation of the water heating electrical heater **111**, the open degree of the flow adjustment valve **112** and the operation of the flow switching valve **115**.

[0219] FIG. **17** is a flowchart for determining ON/OFF operation of the water heating electrical heater **111**, according to the present embodiment. First, at step S**21**, an air temperature TA**1** blown into the vehicle compartment from an air outlet is calculated based on the temperature TW**1** of the coolant flowing into the first heater core **14** and the temperature TW**2** of the coolant flowing into the second heater core **15**. The temperature TW**2** of the coolant flowing into the second heater core **15** can be detected by the second coolant sensor **66**, and the temperature TW**1** of the coolant flowing into the first heater core **14** can be detected by the first coolant sensor **65**.

[0220] Next, at step S**22**, the air temperature TA**1** calculated based on the coolant temperature at step S**21** is compared with the target outlet air temperature TAO. When the air temperature TA**1** is lower than the target outlet air temperature TAO at step S**22**, the water heating electrical heater **111** is turned on at step S**23**. In contrast, when the air temperature TA**1** is not lower than the target outlet air temperature TAO at step S**22**, the water heating electrical heater **111** is turned off at step S**24**.

[0221] The open degree of the flow adjustment valve **112** is controlled such that the flow amount of the coolant is reduced while the water heating electrical heater **111** is turned on, as compared with the flow amount of the coolant while the water heating electrical heater is turned off. For example, when the water heating electrical heater **111** is not energized (OFF state), the open degree of the flow adjustment valve **112** is set at a first open degree such that the flow amount of the coolant flowing through the first heater core **14** is equal to the flow amount of the coolant flowing through the second heater core **15**. When the water heating electrical heater **111** is energized (ON state), the open degree of the flow adjustment valve **112** is set at a second open degree such that the flow amount of the coolant flowing through the second heater core **15** is smaller than the flow amount of the coolant flowing through the first heater core **14**.

[0222] Furthermore, the operation of the flow switching valve **115** is controlled, such that the coolant flows through the sensible heat exchanger **113** without flowing through the bypass passage **114** when the water heating electrical heater **111** is turned on, and the coolant only flows through the bypass passage **114** without flowing through the sensible heat exchanger **113** when the water heating electrical heater **111** is turned off.

[0223] For example, when a long time elapses after the engine EG stops, the coolant temperature may become lower, and thereby the air temperature TA**1** may become lower than the target outlet air temperature TAO. That is, in this case, the coolant temperature may become lower than a necessary temperature required in the heating of the vehicle compartment.

[0224] Thus, when the coolant temperature is lower than the necessary temperature required in the heating of the vehicle compartment, the air conditioning controller **60** causes the water heating electrical heater **111** to be turned on so as to heat the coolant, and causes the flow adjustment valve **112** to be set at the second open degree so that the flow amount of the coolant flowing through the second heater core **15** is made smaller. Furthermore, in this case, the air conditioning controller **60** controls the flow switching valve **115** so that all the coolant after flowing out of the second heater core **15** flows into the sensible heat exchanger **113**. Therefore, heat can be transferred from the coolant after flowing out of the second heater core **15** to the coolant before flowing into the water heating electrical heater **111**. In this case, it is prefer to set the air mix door **19** at the maximum heating position, by the air conditioning controller **60**.

[0225] Thus, the temperature of the coolant flowing in the second coolant passage **34** for the second heater core **15** can be controlled as follows. For example, in a case where the target temperature of air immediately after passing through the second heater core **15** is 50° C., if the coolant temperature immediately after flowing out of the engine EG is 40° C., the temperature of the coolant after passing through the sensible heat exchanger **113** is increased to 45° C. from 40° C. at the upstream side of the water-heating heat exchanger **113**, and the temperature of the coolant after passing through the water heating electrical heater **111** is increased to 70° C. Because the coolant radiates heat to air in the second heater core **15**, the temperature of the coolant at the coolant outlet of the second heater core **15** becomes 46° C., and is further reduced to 41° C. after passing through the sensible heat exchanger **113** at the downstream coolant side of the flow adjustment valve **112**.

[0226] As described above, the temperature of the coolant flowing into the second heater core **15** can be increased without operating the engine EG, and thereby a desired heating can be performed without operating the engine EG.

[0227] When the engine EG is operated or when an elapsed time after the stop of the engine EG is short, the coolant temperature is sufficiently high. In this case, if the air temperature TA**1** is equal to or higher than the target outlet air temperature TAO, it is unnecessary to heat the engine coolant by using the operation of the water heating electrical heater **111**. In this case, the water heating electrical heater **111** is not turned on by the air conditioning controller **60**, and the opening of the flow adjustment valve **112** is set at the first open degree so that the flow amount of the coolant flowing through the second heater core **15** is made larger. Furthermore, the flow switching valve **115** is controlled so that the coolant flowing out of the second heater core **15** flows through the bypass passage **114** without flowing through the sensible heat exchanger **113**. In this case, the position (open degree) of the air mix degree **19** is controlled by the air conditioning controller **60**, thereby adjusting the temperature of conditioned air to be blown into the vehicle compartment.

[0228] The operation effects of the present embodiment will be described.

[0229] (1) According to the present embodiment, when the coolant temperature is lower than the necessary temperature required for the heating of the vehicle compartment, the temperature of the coolant flowing into the second heater core **15** is increased by the operation of the water heating electrical heater **111**, instead of the operation of the engine EG. Thus, the operation frequency of the engine EG can be reduced, thereby improving the fuel consumption efficiency of the engine EG, as compared with an air conditioner without having the water heating electrical heater **111**.

[0230] Generally, the temperature of the engine coolant flowing into the second heater core **15** is preferably equal to or higher than the necessary temperature required for the heating, e.g., 60° C. On the other hand, the temperature of the coolant flowing into the interior of the engine EG is preferably equal to or higher than a lower limit temperature for effectively heating the respective parts of the engine EG. Here, the lower limit temperature is 40° C., for example.

[0231] Thus, in a conventional vehicle air conditioner without having the water heating electrical heater **111** and the sensible heat exchanger **113**, the engine-operation required temperature is set at a temperature around 60° C. in order to keep the coolant temperature equal to or higher than 60° C.

[0232] In contrast, according to the present embodiment, when the temperature of the engine coolant becomes lower than 60° C. while the engine EG stops, the engine. EG is not operated, but the water heating electrical heater **111** is operated so that the temperature of the engine coolant is increased. Thus, in the present embodiment, it is possible to set the engine-operation required temperature to be lower than 60° C. For example, the engine-operation required temperature can be set at a temperature about 40° C. Thus, in the present embodiment, the engine operation required temperature can be set lower, and thereby the operation frequency of the engine EG can be reduced, and thereby the fuel consumption efficiency of the engine EG can be improved.

[0233] (2) In the present embodiment, the first heater core **14** and the second heater core **15** are arranged in parallel with respect to the flow of the coolant, and the heat radiation portion of the sensitive heat exchanger **113** and the water heating electrical heater **111** are arranged upstream of the second heater core **15** in the coolant flow. When the heat source for the heating of the vehicle compartment is insufficient, only the coolant flowing into the second heater core **15** is heated by the operation of the water heating electrical heater **111**, thereby effectively reducing the consumed power of the water heating electrical heater **111**.

[0234] Furthermore, the second heater core **15** is disposed to heat air after passing through the first heater core **14**. Therefore, the air, after being heated by a low-temperature coolant in the first heater core **14**, can be further heated by a high-temperature coolant heated by the water heating electrical heater **111**, and thereby the heat quantity can be effectively increased for the heating of air.

[0235] (3) Furthermore, in the present embodiment, when the water heating electrical heater **111** is turned on, the flow amount of the coolant flowing through the second heater core **12** is made smaller than that when the water heating electrical heater **111** is turned off. Furthermore, when the water heating electrical heater **111** is turned on, the flow switching valve **115** is controlled so that the coolant flowing out of the second heater core **15** flows through the sensible heat exchanger **113**.

[0236] However, in a case where the flow adjustment valve **112** and the sensible heat exchanger **113** are not provided, the heat quantity without being heat-exchanged with air in the second heater core **15** may be radiated from the surface of the engine EG, and the heated quantity of the water heating electrical heater **111** may be uselessly consumed.

[0237] For example, in a case where the flow amount of the coolant flowing through the first heater core **14** is the same as the flow amount of the coolant flowing through the second heater core **15**, if the target temperature of air immediately after passing through the second heater core **15** is 50° C., the temperature of the coolant at the coolant outlet of the second heater core **15** is about 53° C. Thus, among the heat quantity obtained by the operation of the water heating electrical heater **111**, only the heat quantity corresponding to the temperature difference of the coolant before and after heat exchange in the second heater core **15** is transferred to air, but the remaining heat quantity is uselessly radiated from the engine surface, for example.

[0238] In contrast, according to the present embodiment, the flow amount of the coolant flowing through the second heater core **15** is made smaller when the water heating electrical heater **111** is turned on, as compared with that when the water heating electrical heater **111** is turned off. Accordingly, as compared with a case where the flow amount of the coolant flowing to the second heater core **15** is larger, a ratio of the heat radiation amount from the coolant to air in the second heater core **15** can be increased with respect to the heat quantity due to the water heating electrical heater **111**. Thus, in the present embodiment, the temperature of the coolant at the coolant outlet of the second heater core **15** can be decreased because of the flow adjustment valve **112** and the sensible heat exchanger **113**. Generally, in a case where the heat radiation amount from the coolant to air is constant, the temperature difference of the coolant before and after the heat exchange becomes smaller as the flow amount of the coolant is larger, and the temperature difference of the coolant before and after the heat exchange becomes larger as the flow amount of the coolant is smaller.

[0239] Accordingly, in the present embodiment, it can restrict the heat quantity of the coolant, without being heat-exchanged with air in the second heater core **15**, from being radiated from the surface of the engine EG. As a result, the heat quantity obtained by the water heating electrical heater **111** can be effectively used.

[0240] Furthermore, heat is transferred from the coolant flowing out of the second heater core **15** to the coolant before flowing into the water heating electrical heater **111**. Therefore, in the present embodiment, it can further restrict the heat quantity of the coolant, without being heat-exchanged with air in the second heater core **15**, from being radiated from the surface of the engine EG. Because the temperature of the coolant flowing into the water heating electrical heater **111** is increased by the sensible heat exchanger **113**, consumed electrical power of the water heating electrical heater **111**, for heating the coolant to a necessary heating temperature, can be decreased by the temperature increase of the coolant due to the sensible heat exchanger **113**.

[0241] (4) In the present embodiment, the water heating electrical heater **111** can be operated by using a high-voltage electrical source for supplying an electrical power to an electrical motor for a vehicle traveling, as an electrical source.

[0242] In this case, the water heating electrical heater **111** can be located in an engine compartment of the vehicle, thereby preventing an electrical shock trouble even when a high-voltage electrical voltage is applied to the water heating electrical heater **111**. Therefore, it is unnecessary to use a DC-DC converter, thereby preventing an electrical loss due to the DC-DC converter. Furthermore, because the high-voltage electrical source is used, the weight of the electrical source can be reduced as compared with that in a case where a low-voltage electrical source is used.

[0243] In the present embodiment, at steps S**22**, S**23**, when the air temperature TA**1** calculated based on the coolant temperature at step S**21** is lower than the target outlet air temperature TAO, it is determined that the temperature of the coolant is lower than the necessary coolant temperature required for the heating. However, when the coolant temperature detected by the first coolant sensor **65** or the second coolant temperature sensor **66** is lower than a predetermined temperature, it may be determined that the temperature of the coolant is lower than the necessary coolant temperature required for the heating. As the predetermined temperature, the engine-operation request temperature may be used.

[0244] In the present embodiment, when the water heating electrical heater **111** is turned on, the open degree of the flow adjustment valve **112** is set at the second open degree that is smaller than the first open degree. However, the open degree of the flow adjustment valve **112** may be adjusted such that all the heat quantity supplied to the coolant by the operation of the water heating electrical heater **111** can be substantially radiated to air in the second heater core **15**.

[0245] In the above-described embodiment, the flow adjustment valve **112** is arranged in the second coolant passage **34** at a position downstream of the second heater core **15** in the flow direction of the second coolant. However, the flow adjustment valve **112** may be arranged in the second coolant passage **34** at a position upstream of the second heater core **15** in the flow direction of the second coolant.

[0246] In the above-described embodiment, when the water heating electrical heater **111** is turned off, the passage switching valve **115** is switched such that the coolant flows through the bypass passage **114**. However, when the temperature Ta of the coolant flowing out of the second heater core **15** is lower than the temperature Tb of the coolant flowing into the water heating electrical heater **111**, the flow switching valve **115** may be switched such that the coolant flows through the bypass passage **114**. That is, in a condition where heat transmission, from the coolant flowing out of the second heater core **15** to the coolant flowing into the water heating electrical heater **111**, cannot be performed, the flow switching valve **115** may be switched such that the coolant flows through the bypass passage **114** without flowing through the sensible heat exchanger **113**.

Thirteenth Embodiment

[0247] A thirteenth embodiment of the invention will be described with reference to FIG. **18**. FIG. **18** is a schematic diagram showing an air conditioner **1** for a vehicle according to the thirteenth embodiment of the invention. In the air conditioner **1** for a vehicle of the thirteenth embodiment, the sensible heat exchanger **113**, the bypass passage **114** and the flow switching valve **115** are omitted with respect to the vehicle air conditioner **1** of the above-described twelfth embodiment.

[0248] Even in the case where the sensible heat exchanger **113** is omitted, when the water heating electrical heater **111** is turned on, the flow amount of the coolant flowing through the second heater core **12** is made smaller than that when the water heating electrical heater **111** is turned off. Thus, the heat radiation from the surface of the engine EG can be effectively reduced. In the above-described thirteenth embodiment, the other parts may be similar to those of above-described twelfth embodiment.

Fourteenth Embodiment

[0249] A fourteenth embodiment of the invention will be described with reference to FIG. **19**. FIG. **19** is a schematic diagram showing an air conditioner **1** for a vehicle according to the fourteenth embodiment of the invention.

[0250] In the air conditioner **1** for a vehicle of the fourteenth embodiment, the water heating electrical heater **111**, the sensible heat exchanger **113**, the bypass passage **114** and the flow switching valve **115** are omitted, and an inverter **121** is used as a water heater instead of the water heating electrical heater **111**, with respect to the vehicle air conditioner **1** of the above-described twelfth embodiment.

[0251] In the present embodiment, a coolant system is configured such that the coolant flowing out of the engine EG passes through the inverter **121**, and the coolant system is switchable between a coolant passage flowing to the second heater core **15** and a inverter coolant circuit **120** that is a closed circuit.

[0252] In the inverter coolant circuit **120**, the inverter **121**, a water pump **122**, a radiator **123**, a first flow switching valve **124** and a second flow switching valve **125** are provided.

[0253] The inverter **121** is generally mounted to a hybrid vehicle to convert an electrical current, supplied from the electrical motor for a vehicle traveling, from the direct current to alternate current. The water pump **122** is disposed in the inverter coolant circuit **120** so that the coolant circulates in the inverter coolant circuit **120**. The radiator **123** is a heat exchanger configured to radiate heat from the coolant after passing through the inverter **121** to air.

[0254] Specifically, the first flow switching valve **124** and the second flow switching valve **125** are disposed to be switched between a first passage in which the coolant flowing out of the engine EG passes through the inverter **121** and then flows into the second heater core **15** as in the solid line arrows in FIG. **19**, and a second passage in which coolant circulates the inverter **121**, the water pump **122**, the radiator **123** and the inverter **121** in this order as in the chain line arrows in FIG. **19**.

[0255] When the coolant temperature detected by the first coolant temperature sensor **65** is lower than a predetermined temperature, the air conditioning controller **60** causes the water pump **122** of the inverter coolant circuit **120** to be stopped, and controls the first flow switching valve **124** and the second flow switching valve **125** so that the coolant flows to the second heater core **15** through the first passage. At this time, the inverter **121** is controlled by the air conditioning controller **60** via an inverter controller, so that the converting efficiency of the inverter **121** is reduced thereby increasing the heat generating amount of the inverter **121**.

[0256] Thus, when the temperature of the coolant is lower than the necessary temperature required for the heating of the vehicle compartment, the heat generation amount of the inverter **121** is increased, so that the inverter **121** can be used as a water heater.

[0257] Even when the converting efficiency of the inverter **121** is reduced, the electrical power supplied to the electrical motor for a vehicle traveling is not affected, and is hardly affected to the vehicle traveling. Thus, even when the heat generation amount of the inverter **121** is increased, the inverter **121** is cooled by the engine coolant, and the inverter element of the inverter **121** can be effectively operated.

[0258] In contrast, when the coolant temperature detected by the first coolant temperature sensor **65**, located at the coolant outlet side of the engine EG, is higher than the predetermined temperature, the first flow switching valve **124** and the second flow switching valve **125** are controlled so that the coolant flows in the inverter coolant circuit **120** as in the second passage. In this case, the inverter **121** is controlled so that the converting efficiency of the inverter **121** is increased.

[0259] Thus, when the temperature of the coolant is lower than the necessary temperature required for the heating of the vehicle compartment, the coolant is circulated in the inverter coolant circuit **120**, so that the inverter **121** can be cooled by the coolant. In this case, the coolant only flows through the first heater core **14** without flowing through the second heater core **15**, so that air is heated by the first heater core **14**.

[0260] In the present embodiment, the inverter **121** is used as the coolant heater. However, a heat generator mounted to the vehicle, using the exhaust heat of the vehicle other than the engine EG, may be used as the heat generator. For example, a motor generator mounted to a hybrid vehicle or an electrical vehicle, or a fuel cell of a hybrid vehicle provided with an engine EG and the fuel cell may be used as the heat generator. Furthermore, the coolant may be heated by using exhaust gas of the engine EG as the heat source.

Fifteenth Embodiment

[0261] A fifteenth embodiment of the invention will be described with reference to FIG. **20**. FIG. **20** is a perspective view showing an integrated heat exchanger of first and second heater cores **14**, **15** according to a fifteenth embodiment of the invention.

[0262] In the fifteenth embodiment; the first and second heater cores **14**, **15** of the thirteenth embodiment are integrated, but the flow adjustment valve **112** of the thirteenth embodiment is removed such that the flow resistance of the coolant in the second heater core **15** is higher than the flow resistance of the coolant in the first heater core **14**.

[0263] The integrated heat exchanger shown in FIG. **20** includes an inlet-side first header tank **131**, an inlet-side second header tank **132**, an outlet-side header tank **133**, a plurality of first tubes **134** extending between the inlet-side first header tank **131** and the outlet-side header tank **133** to communicate with the inlet-side first header tank **131** and the outlet-side header tank **133**, and a plurality of second tubes **135** extending between the inlet-side second header tank **132** and the outlet-side header tank **133** to communicate with the inlet-side second header tank **132** and the outlet-side header tank **133**.

[0264] The inlet-side first header tank **131** extends in a tube stacking direction of the first tubes **134**, so that the coolant flowing into the inlet-side first header tank **131** from a coolant inlet **131*a*** is distributed into the first tubes **134**. Similarly, the inlet-side second header tank **132** extends in a tube stacking direction of the second tubes **135**, so that the coolant flowing into the inlet-side second header tank **132** from a coolant inlet **132*a*** is distributed into the second tubes **135**. The outlet-side header tank **133** is provided commonly for the first and second tubes **134**, **135**, so that the coolant having passed through the first and second tubes **134**, **135** is collected in the outlet-side header tank **133**.

[0265] The first heater core **14** is configured by the inlet-side first header tank **131**, the first tubes **134** and the outlet-side header tank **133**. The second heater core **15** is configured by the inlet-side second header tank **132**, the second tubes **135** and the outlet-side header tank **133**.

[0266] The second heater core **15** is configured, such that a sectional area of the coolant passage formed in the second tube **135** is smaller than a sectional area of the coolant passage formed in the first tube **134** of the first heater core **14**. Thus, the flow resistance of the coolant flowing through the second heater core **15** can be made larger than the flow resistance of the coolant flowing through the first heater core **14**. Alternatively/Furthermore, a passage sectional area of the second header tank **132** of the second heater core **15** on the coolant inlet side may be made smaller than a passage sectional area of the first header tank **131**, such that the flow resistance of the coolant flowing in the second heater core **15** may be larger than the flow resistance of the coolant flowing in the first heater core **14**.

[0267] Furthermore, in the present embodiment, a water heating electrical heater **111** is disposed in the second coolant passage **34** between the coolant inlet **132***a* of the second heater core **15** and the branch point **31***a* of the coolant passage **31** for the heater cores **14**, **15**. At the branch point **31***a*, the first coolant passage **33** and the second coolant passage **34** are branched from each other.

[0268] Because the common outlet-side header tank **133** is provided for the first heater core **14** and the second heater core **15**, the first heater core **14** and the second heater core **15** can be integrated by the outlet-side header tank **133**. Thus, the flow resistance of the coolant flowing through the second heater core **15** can be made larger than the flow resistance of the coolant flowing through the first heater core **14**, and thereby the flow amount of the coolant flowing through the second heater core **15** can be made always smaller than the flow amount of the coolant flowing through the first heater core **14**.

[0269] Thus, according to the present embodiment, the flow amount of the coolant flowing through the second heater core **15** is made smaller that the flow amount of the coolant flowing through the first heater core **14** when the water heating electrical heater **111** is turned on. Accordingly, as compared with a case where the flow amount of the coolant flowing to the second heater core **15** is equal to the flow amount of the coolant flowing through the first heater core **14**, a ratio of the heat radiation amount from the coolant to air in the second heater core **15** can be increased relatively with respect to the heat quantity due to the water heating electrical heater **111**.

[0270] Accordingly, in the present embodiment, it can restrict the heat quantity of the coolant without being heat-exchanged with air in the second heater core **15** from being radiated from the surface of the engine EG. As a result, the heat quantity obtained by the water heating electrical heater **111** can be effectively used.

[0271] In the present embodiment, the flow resistance of the coolant flowing in the second coolant passage **34** for the second heater core **15** may be set larger than the flow resistance of the coolant flowing in the first coolant passage **33** for the first heater core **14**. Even in this case, the flow resistance of the coolant flowing through the second heater core **15** can be made larger than the flow resistance of the coolant flowing through the first heater core **14**. For example, the passage sectional area of the second coolant passage **34** for the second heater core **15** may be set smaller than the passage sectional area of the first coolant passage for the first heater core **14**.

Sixteenth Embodiment

[0272] A sixteenth embodiment of the invention will be described with reference to FIGS. **21** to **25**C. FIG. **21** is a schematic diagram showing an air conditioner **201** for a vehicle according to the sixteenth embodiment of the invention. In the present embodiment, the air conditioner **201** for a vehicle of the invention is mounted to a so-called hybrid car which obtains a driving force for a vehicle traveling from an internal combustion engine (engine) EG and an electric motor for traveling.

[0273] A coolant system of the present embodiment is provided with a first coolant circuit **210** and a second coolant circuit **220**. The first coolant circuit **210** is a coolant circuit in which coolant after cooling a cylinder header **231** of an engine **230** flows. A first heater core **211**, a first water pump **212** and a first temperature sensor **213** are disposed in the first coolant circuit **210**. In contrast, the second coolant circuit **220** is a coolant circuit in which coolant after cooling a cylinder block **232** of the engine **230** flows. A second heater core **221**, a second water pump **222** and a second temperature sensor **223** are disposed in the second coolant circuit **220**. For example, the engine coolant is water, or a water solution including an addition component. The coolant for cooling the cylinder head **231** corresponds to a first fluid, and the coolant for cooling the cylinder block **232** corresponds to a second fluid. The second fluid may be the same fluid as the first fluid, or may be different from the first fluid.

[0274] In the engine **230**, the cylinder block **232** is a block body forming a cylinder bore (e.g., cylindrical hole) in which a piston reciprocates. In contrast, the cylinder head **231** is a block body configured to close an opening portion at a top dead-point side of the cylinder bore, and to define the consumption chamber.

[0275] A first coolant inlet **231***a* and a first coolant outlet **231***b* are provided in the engine **230** at a side of the cylinder head **231**. The cylinder head **231** has therein a coolant passage in which the coolant flows to cool the cylinder head **231**. The coolant flowing from the first coolant inlet **231***a* passes through the coolant passage within the cylinder head **231**, and then flows out of the first coolant outlet **231***b*.

[0276] Similarly, a second coolant inlet **232***a* and a second coolant outlet **232***b* are provided in the engine **230** at a side of the cylinder block **232**. The cylinder block **232** has therein a coolant passage in which the coolant flows to cool the cylinder block **232**. The coolant flowing from the second coolant inlet **232***a* passes through the coolant passage within the cylinder block **232**, and then flows out of the second coolant outlet **232***b*. In the present embodiment, the coolant flows through the coolant passage within the cylinder block **232**, without joining with the coolant flowing through the coolant passage within the cylinder head **231**.

[0277] Each of the first heater core **211** and the second heater core **221** is a heating heat exchanger, in which the coolant flowing out of the engine **230** is heat-exchanged with air to be blown into a vehicle compartment, thereby heating air to be blown into the vehicle compartment. In the present embodiment, the first heater core **211** and the second heater core **221** are integrated so as to form a single heating heat exchanger **202**. The first heater core **211** corresponds to a first heat exchanging portion of the heating heat exchanger **202**, and the second heater core **221** corresponds to a second heat exchanging portion of the heating heat exchanger **202**, in the present embodiment.

[0278] Furthermore, within the interior of the heating heat exchanger **202**, the coolant passage of the first heater core **211** is provided independently from the coolant passage of the second heater core **221**. A coolant inlet **211***a* of the first heater core **211** is connected to the first coolant outlet **231***b* of the cylinder head **231** via a coolant piping. On the other hand, a coolant inlet **221***a* of the second heater core **221** is connected to the second coolant outlet **231***b* of the cylinder block **232** via a coolant piping.

[0279] The heating heat exchanger **202** is accommodated in an air conditioning case defining an air passage through which air blown by a blower flows into the vehicle compartment. The blower may be accommodated in the air conditioning case. The heating heat exchanger **202** is disposed in the air conditioning case to form a bypass passage through which air bypasses the heating heat exchanger **202**. An air mix door is disposed in the air conditioning case to adjust a mix ratio between a flow amount of air passing through the bypass passage and a flow amount of air passing through the heating heat exchanger **202**.

[0280] FIGS. **22** and **23** are a side view and a front view showing the heating heat exchanger **202** of the present embodiment.

[0281] As shown in FIG. **22**, the second heater core **221** is located downstream of the first heater core **211** in an air flow of the heating heat exchanger **202**. In the heating heat exchanger **202**, the first heater core **211** and the second heater core **221** are connected with each other by a connection member **301**.

[0282] Specifically, as shown in FIGS. **22** and **23**, the first heater core **211** is provided with a first inlet-side tank **211***c* having the first coolant inlet **211***a*, a first outlet-side tank **211***d* having the first coolant outlet **211***b*, a plurality of flat tubes **211***e*, and corrugated heat-transmitting fins **211***f* each of which is bonded to outer surfaces of adjacent flat tubes **211***e*. One end of each flat tube **211***e* is connected to the first inlet-side tank **211***c* to communicate with the first inlet-side tank **211***c*, and the other end of each flat tube **211***e* is connected to the first outlet-side tank **211***d* to communicate with the first outlet-side tank **211***d*.

[0283] The flat tubes **211***e* and the heat-transmitting fins **211***f* are stacked in a stack direction to form a first heat exchanging portion **211***g*. The first heater core **211** is configured in one-way flow type in which the coolant flows through all the flat tubes **211***e* in one way from the first inlet-side tank **211***c* to the first outlet-side tank **211***d*. Thus, air passing through the first heat exchanging portion **211***g* is heat exchanged with the coolant flowing in the flat tubes **211***e*, to be heated by the coolant.

[0284] Similarly, the second heater core **221** is provided with a second inlet-side tank **221***c* having the second coolant inlet **221***a*, a second outlet-side tank **221***d* having the second coolant outlet **221***b*, a plurality of flat tubes **221***e*, and corrugated heat-transmitting fins **221***f* each of which is bonded to outer surfaces of adjacent flat tubes **221***e*. One end of each flat tube **221***e* is connected to the second inlet-side tank **221***c* to communicate with the second inlet-side tank **221***c*, and the other end of each flat tube **221***e* is connected to the second outlet-side tank **221***d* to communicate with the second outlet-side tank **221***d*.

[0285] The flat tubes **221***e* and the heat-transmitting fins **221***f* are stacked in a stack direction to form a second heat exchanging core portion **221***g*. The second heater core **221** is configured in one-way flow type in which the coolant flows through all the flat tubes **221***e* in one way from the second inlet-side tank **221***c* to the second outlet-side tank **221***d*. Thus, air passing through the second heat exchanging portion **221***g* is heat exchanged with the coolant flowing in the flat tubes **221***e*, to be heated by the coolant.

[0286] In the first and second heater cores **211**, **221**, the plural flat tubes **211***e*, **221***e* extend in one direction that is perpendicular to the air flow direction and the stacking direction. Furthermore, the flat tubes **211***e* of the first heater core **211** are arranged on one line in a stacking direction, and the flat tubes **221***e* of the second heater core **221** are arranged on another one line in a stacking direction in parallel with the one line of the flat tubes **211***e* at a downstream air side of the flat tubes **211***e*. For example, the flat surface of the flat tube **211***e* of the first heater core **211** may be parallel with the flat surface of the flat tube **221***e* of the second heater core **221**. Furthermore, the flat surface of the flat tube **211***e* in the first heater core **211** may be substantially on the same surface as the flat surface of a corresponding flat tube **221***e* in the second heater core **221**. The first inlet-side tank **211***c* and the first outlet-side tank **211***d* respectively extend in the tube arrangement direction (i.e., stacking direction) to respectively communicate with the one ends and the other ends of the flat tubes **211***e*. Similarly, the second inlet-side tank **221***c* and the second outlet-side tank **221***d* respectively extend in the tube arrangement direction (i.e., stacking direction) to respectively communicate with the one ends and the other ends of the flat tubes **221***e*.

[0287] In the example of FIGS. **22** and **23**, the inlet-side tanks **211***c*, **22***c* are arranged at an upper side of the flat tubes **211***e*, **221***e*, and the outlet-side tanks **211***d*, **221***d* are arranged at a lower side of the flat tubes **211***e*, **221***e* so that the flat tubes **211***e*, **221***e* extend in a top-bottom direction. Furthermore, the flat tubes **211***e*, **221***e* are arranged in parallel in a vehicle left-right direction in each of the first and second heater cores **211**, **221**. Thus, in the example of FIGS. **22** and **23**, coolant flows downwardly from the top to the bottom in each of the first heater core **211** and the second heater core **221**.

[0288] Furthermore, in the present embodiment, the passage cross section of the first heater core **211** on a surface perpendicular to the air flow direction has the same size as that of the second heater core **221**. Thus, all air having passed through the first heater core **211** passes through the second heater core **221**.

[0289] However, in the present embodiment, the dimension of the first heater core **211** is made larger than the dimension of the second heater core **221** in an air flow direction, so that the heat exchanging capacity of the first heater core **211** is made larger than that of the second heater core **221**. The dimensions of the flat tubes **211***e* and the heat transmitting fins **211***f* of the first heater core **211** in the air flow direction are made larger than the dimensions of the flat tubes **221***e* and the heat transmitting fins **221***f* of the second heater core **221** in the air flow direction. Therefore, the total heat exchanging area between air and the coolant can be made larger in the first heater core **211**, than that in the second heater core **221**.

[0290] The passage sectional area of each flat tube **211***e* of the first heater core **211** is made larger than the passage sectional area of each flat tube **221***e* of the second heater core **221**, and thereby the flow resistance of the coolant (fluid) flowing in the first heater core **211** is made lower than the flow resistance of the coolant (fluid) flowing in the second heater core **221**. Therefore, the flow amount of the coolant flowing in the first heater core **211** can be easily set larger than the flow amount of the coolant flowing in the second heater core **221**.

[0291] The connection member **301** is disposed to connect the first and second inlet-side tanks **211***c*, **221***c*, and to connect the first and second outlet-side tanks **211***d*, **221***d*. That is, the connection member **301** connects the first and second heater cores **211** and **221** with each other, at positions other than the heat-exchanging core portions **211***g*, **221***g*. Furthermore, in the present embodiment, the connection member **301** is adapted as a spacer for forming a space between the heat-exchanging core portions **211***g*, **221***g*.

[0292] Thus, the first heater core **211** and the second heater core **221** are connected to each other by the connection member **301** with a space between the heat-exchanging core portions **211***g*, **221***g* in the air flow direction. Therefore, it can prevent the coolant flowing in the first heater core **211** and the second heater core **221** from being directly heat-transmitted at the heat-exchanging core portions **211***g*, **221***g*. The connection member **301** may be made of the same material as the tanks **211***c*, **221***c*, **211***d*, **221***d*.

[0293] As shown in FIG. **21**, the first temperature sensor **213** is disposed in the first coolant circuit **210**, and the second temperature sensor **223** is disposed in the second coolant circuit **220**. More specifically, the first temperature sensor **213** is arranged between the first coolant outlet **231***b* of the engine **230** on the side of the cylinder head **231** and the coolant inlet **211***a* of the first heater core **211**, so as to detect the temperature of the coolant flowing out of the first coolant outlet **231***b* of the engine **230** on the side of the cylinder header **231**. On the other hand, the second temperature sensor **223** is arranged between the second coolant outlet **232***b* of the engine **230** on the side of the cylinder block **232** and the coolant inlet **221***a* of the second heater core **221**, so as to detect the temperature of the coolant flowing out of the second coolant outlet **232***b* of the engine **230** on the side of the cylinder block **232**.

[0294] The first water pump **212** and the second water pump **222** are disposed to circulate the coolant respectively in the first and second coolant circuits **210**, **220**, and to adjust the flow amount of the coolant flowing in each of the first and second coolant circuits **210**, **220**. The first water pump **212** is arranged in the first coolant circuit **210** between the coolant outlet **211***b* of the first heater core **211** and the first coolant inlet **231***a* of the cylinder head **231** of the engine **230**. The second water pump **222** is arranged in the second coolant circuit **220** between the coolant outlet **221***b* of the second heater core **221** and the second coolant inlet **232***a* of the cylinder block **232** of the engine **230**.

[0295] The first water pump **212** and the second water pump **222** are electrical pumps. The rotational speeds of the first water pump **212** and the second water pump **222** are controlled so as to control respectively the flow amounts of the coolant circulating in the first coolant circuit **210** and the second coolant circuit **220**. In the present embodiment, during a general operation of the engine **230**, the first water pump **212** and the second water pump **222** are controlled such that the flow amount of the coolant flowing in the coolant passage of the cylinder head **231** is larger than the flow amount of the coolant flowing in the coolant passage of the cylinder block **232**. Thus, it is possible to keep the temperature of the cylinder head **231** at a low temperature while improving knocking-resistance performance. At the same time, the temperature of the cylinder block **232** can be kept at a high temperature, thereby preventing a viscosity decrease of an engine oil and preventing a friction increase in the interior of the engine **230**.

[0296] In the first coolant circuit **210** of the present embodiment, the coolant flowing out of the first coolant outlet **231***b* of the cylinder head **231** of the engine **230** flows into the first heater core **211**, is heat-exchanged with air in the first heater core **211**, and then flows into the engine **230** from the first coolant inlet **231***a* on the side of the cylinder head **231**.

[0297] In the second coolant circuit **220** of the present embodiment, the coolant flowing out of the second coolant outlet **232***b* of the cylinder head **232** of the engine **230** flows into the second heater core **221**, is heat-exchanged with air in the second heater core **221**, and then flows into the engine **230** from the second coolant inlet **232***a* on the side of the cylinder block **232**.

[0298] The first and second coolant circuits **210**, **220** are configured to communicate with a radiator (not shown), such that the coolant flowing out of the cylinder head **231** is radiated in the radiator and the coolant after heat radiation flows into the cylinder head **231**, and the coolant flowing out of the cylinder block **232** is radiated in the radiator and the coolant after heat radiation flows into the cylinder block **232**.

[0299] Next, operation of the air conditioner **201** according to the present embodiment will be described.

[0300] In the present embodiment, the first water pump **212** and the second water pump **222** are controlled by the controller such that the flow amount of the coolant flowing in the coolant passage of the cylinder head **231** is larger than the flow amount of the coolant flowing in the coolant passage of the cylinder block **232**.

[0301] Furthermore, in a heating operation of the vehicle compartment (i.e., a space to be heated), the blower is controlled by the controller to an air blowing amount that is determined in accordance with a target outlet air temperature TAO. The target outlet air temperature TAO is a target temperature of air to be blown into the vehicle compartment, and can be calculated based on a set temperature and an air-conditioning load relative to the environmental conditions. For example, the target outlet air temperature TAO can be calculated similarly to that of the above-described first embodiment.

[0302] FIG. **24** is a graph showing a temperature variation in air passing through the first and second heater cores **211**, **221** according to the sixteenth embodiment, and a comparison example.

[0303] In the first heater core **211**, the coolant after cooling the cylinder head **231** is heat-exchanged with air passing therethrough, thereby heating the air. The temperature of the coolant after cooling the cylinder head **231** may be lower than the lowest temperature required for the heating. However, the flow amount of the coolant flowing in the cylinder head **231** is relatively large, and thereby the coolant having a large heat quantity flows into the first heater core **211** from the cylinder head **231**. In the present embodiment, the flow amount of the coolant flowing in the first heater core **211** is made larger than the flow amount of the coolant flowing in the second heater core **221**, and the heat exchanging area of the first heater core **211** is made larger than the heat exchanging area of the second heater core **221**. Therefore, a large amount of heat quantity of the coolant after cooling the cylinder head **231** can be transferred to air in the first heater core **211**. Therefore, a large amount of heat quantity can be supplied from the large amount coolant after passing through the cylinder head **231** to air. As a result, the temperature of air A**1** after passing through the first heater core **211** can be approached to a coolant temperature Th**1** before flowing into the first heater core **211**. For example, the coolant temperature Th**1** is a coolant temperature at the coolant inlet **211***a* of the first heater core **211**, as shown in FIG. **24**.

[0304] In the second heater core **221**, the coolant after cooling the cylinder block **232** is heat-exchanged with air A**1** having passed through the first heater core **211**, thereby further heating the air A**1**. The coolant after cooling the cylinder block **232** has a high temperature higher than the temperature of the coolant after cooling the cylinder head **231**. Therefore, the air A**1** after passing through the first heater core **211** can be further heated by the second heater core **221**, and the temperature of air A**2** after passing through the second heater core **221** can be increased to a temperature higher than the temperature of air A**1**. As shown in FIG. **24**, the temperature of the air A**2** after passing through the second heater core **221** can be increased to a temperature near a coolant temperature Th**2** flowing into the coolant inlet **221***a* of the second heater core **221**.

[0305] In a comparison example 1 shown in FIG. **24**, coolant after cooling the cylinder head **231** and coolant after cooling the cylinder block **232** are joined in the interior of the engine, and the joined coolant flows into a single heater core from a single coolant outlet provided in the engine. In the comparison example 1, the flow amount of the coolant flowing in the cylinder head is made larger than the flow amount of the coolant flowing in the cylinder block. However, in the comparison example 1, the temperature of air cannot be sufficiently increased, as compared with the present embodiment.

[0306] In contrast, according to the present embodiment, the first and second coolant circuits **210**, **220** are independently provided as two separate coolant systems. Furthermore, the first water pump **212** and the second water pump **222** are controlled such that the flow amount of the coolant flowing in the coolant passage of the cylinder head **231** is larger than the flow amount of the coolant flowing in the coolant passage of the cylinder block **232**, in the general operation of the engine **230**. Therefore, in the general operation of the engine **230**, the cylinder head **231** can be effectively cooled. Thus, the temperature of the coolant after cooling the cylinder head **231** may be lower than the lowest temperature required for the heating, but the temperature of the coolant after cooling the cylinder block **232** can become higher than the lowest temperature required for the heating.

[0307] If the coolant after passing through the cylinder head **231** and the coolant after passing through the cylinder block **232** are completely mixed as in the comparison example 1 of FIG. **24**, the temperature of the mixed coolant may become lower than the lowest temperature required for the heating. In this case, the heat transmitting efficiency from the coolant to air becomes lower, and thereby the temperature of air cannot be sufficiently heated by using the mixed coolant as the heat source.

[0308] In the present embodiment, the first coolant outlet **231***b* and the second coolant outlet **232***b* are provided in the engine **230**, such that low temperature coolant after cooling the cylinder head **231** flows out of the first coolant outlet **231***b*, and high temperature coolant after cooling the cylinder block **232** flows out of the second coolant outlet **232***b*. Thus, the low temperature coolant flowing out of the first coolant outlet **231***b* flows into the first heater core **211**, and the high temperature coolant flowing out of the second coolant outlet **232***b* flows into the second heater core **221**, without mixing therebetween.

[0309] In the present embodiment, the air having passed through the first heater core **211** is heated by using the high temperature coolant flowing out of the second coolant outlet **232***b* as the heat source in the second heater core **221**. Thus, the temperature of air after being heated in the first heater core **211** can be effectively increased by the second heater core **221**, as compared with a case where the air is heated by only using the low temperature coolant flowing out of the first coolant outlet **231***b* or a case where the air is heated by using the mixture of the low temperature coolant and the high temperature coolant as the heat source.

[0310] In the present embodiment, after air is heated by the low temperature coolant as the heat source in the first heater core **211**, the heated air is further heated by the high temperature coolant as the heat source in the second heater core **221**, thereby effectively using both of heat quantities of the low temperature coolant and the high temperature coolant.

[0311] Thus, in the present embodiment, the energy transmission efficiency from the coolant to air in the entire first and second heater cores **211**, **221** can be effectively increased, as compared with a case where the air to be blown into the vehicle compartment is heated by using the mixture of the coolants flowing out of the first and second coolant outlets **231***b*, **232***b* as the heat source in a single heater core.

[0312] As a result, even when the air blowing amount of the blower is large, the air can be sufficiently heated to a high temperature, thereby effectively performing the heating of the passenger compartment.

[0313] Furthermore, in the present embodiment, the fuel consumption amount consumed in the vehicle air conditioner can be reduced as shown in FIGS. **25**A, **25**B and **25**C. FIGS. **25**A, **25**B and **25**C show heat loss of the coolant from the surface of the engine **230**, an average temperature in a combustion chamber of the engine **230** and an actual fuel combustion rate, in the sixteenth embodiment and a comparison example 2. In the comparison example 2, the flow amount of the coolant flowing to the cylinder head **231** is made the same as the flow amount of the coolant flowing to the cylinder block **232**, and the temperature of the coolant after cooling the cylinder head **231** is made equal to the temperature of the coolant after cooling the cylinder block **232**.

[0314] According to the present embodiment, the heating heat quantity can be made the same as the comparison example 2, while heat loss from the cylinder head **231** of the engine **230** can be reduced, as shown in FIG. **25**A.

[0315] Furthermore, in the present embodiment, the average temperature in the combustion chamber of the engine **230** can be reduced as compared with the comparison example 2, as shown in FIG. **25**B. Therefore, in the present embodiment, the fuel consumption rate can be reduced as compared with the comparison example 2, as shown in FIG. **25**C.

Seventeenth Embodiment

[0316] A seventeenth embodiment of the invention will be described with reference to FIG. **26**. FIG. **26** is a side view showing a heating heat exchanger **202** of the seventeenth embodiment. In the present embodiment, a common outlet-side tank is provided with respect to the heating heat exchanger **202** described in the sixteenth embodiment.

[0317] Specifically, in the heating heat exchanger **202** of the present embodiment, as shown in FIG. **26**, a common tank **202***d* is provided to connect a coolant outlet side of the first heat-exchanging core portion **211***g* of the first heater core **211** and a coolant outlet side of the second heat-exchanging core portion **221***g* of the second heater core **221**. Furthermore, the common tank **202***d* is provided, with a single coolant outlet **202***b*.

[0318] Thus, the low temperature coolant flowing from the coolant inlet **211***a* of the first heater core **211** and the high temperature coolant flowing from the coolant inlet **221***a* of the second heater core **221** are joined in the common tank **202***d*, and then the joined coolant flows out of the single coolant outlet **202***b*.

[0319] Therefore, the coolant after passing through the first heat-exchanging core portion **211***g* of the first heater core **211** and the coolant after passing through the second heat-exchanging core portion **221***g* are joined adjacent to the coolant outlet **202***b* of the heating heat exchanger **202**.

[0320] In the present embodiment, the coolant flowing out of the coolant outlet **202***b* of the common tank **202***d* is branched at a coolant branch portion, and then the branched coolants respectively flow into the first coolant inlet **231***a* and the second coolant inlet **232***a* of the engine **230**. In the present embodiment, the other parts may be similar to those of the above-described sixteenth embodiment.

Eighteenth Embodiment

[0321] An eighteenth embodiment of the invention will be described with reference to FIG. **27**. FIG. **27** is a side view showing a heating heat exchanger **202** of the eighteenth embodiment. In the present embodiment, as shown in FIG. **27**, a common tank **202***d* is provided to connect a coolant inlet side of the first heat-exchanging core portion **211***g* of the first heater core **211** and a coolant outlet side of the second heat-exchanging core portion **221***g* of the second heater core **221**. That is, a coolant inlet **202***a* of the first heater core **211** is provided in the common tank **202***d* used in common for the first and second heater cores **211**, **221**, and an outlet side tank **211***d* of the first heater core **211** is provided adjacent to the inlet side tank **221***c* of the second heater core **221**.

[0322] The coolant inlet **202***a* provided in the common tank **202***d* is connected to the first coolant outlet **231***b* of the cylinder head **231** of the engine **230** shown in FIG. **21** via piping.

[0323] Thus, the high temperature coolant having passed through the second heat-exchanging core portion **221***g* of the second heater core **221** is joined with low temperature coolant flowing from the first coolant outlet **231***b* of the engine **230** to the coolant inlet **202***a* in the common tank **202***d*. Then, the joined coolant flows through the first heat-exchanging core portion **211***g* of the first heater core **211** from the common tank **202***d*, and thereafter flows out of the coolant outlet **211***b* provided in the outlet side tank **211***d* of the first heater core **211**.

[0324] Accordingly, in the present embodiment, the high temperature coolant flows through the second heater core **221**, and the mixture of the low temperature coolant from the first coolant outlet **231***b* of the engine **230** and the high temperature coolant having passed through the second heater core **221** flows into the heat-exchanging core portion **211***g* of the first heater core **211**. Therefore, the temperature of the coolant flowing in the second heater core **221** can be made higher than the temperature of the coolant flowing in the heat-exchanging core portion **211***g* of the first heater core **211**, thereby effectively performing the heating of air to be blown into the vehicle compartment. In the present embodiment, the other parts may be similar to those of the above-described sixteenth embodiment.

Nineteenth Embodiment

[0325] A nineteenth embodiment of the invention will be described with reference to FIGS. **28** and **29**. FIGS. **28** and **29** are a side view and a front view showing a heating heat exchanger **202** disposed in an air conditioning case **203** of the present embodiment.

[0326] In the heating heat exchanger **202** of the present embodiment, the first heater core **211** and the second heater core **221** are arranged in parallel with respect to a flow direction of air passing through the air passage in the air conditioning case **203**. In the examples of FIGS. **28** and **29**, the first heater core **211** is arranged at an upper side in the air passage of the air conditioning case **203**, and the second heater core **221** is arranged at a lower side in the air passage of the air conditioning case **203**, in a top-bottom direction of the vehicle. A lower end portion of the first heater core **211** is connected to an upper end portion of the second heater core **221** by a connection member **301**, such that a space is formed between the first heater core **211** and the second heater core **221**.

[0327] A partition wall **203***a* is provided in the air conditioning case **203** at a position downstream of the heating heat exchanger **202**, so as to partition the air passage of the air conditioning case **203** into a first passage communicating with a defroster air outlet **204***a* (DEF) and a second passage communicating with a foot air outlet **204***b* (FOOT). In the present embodiment, conditioned air is blown toward an inner surface of a windshield of the vehicle through the defroster air outlet **204***a* that is adapted as a first air outlet, and conditioned air is blown toward a lower side of a passenger in the vehicle compartment through the foot air outlet **204***b* that is adapted as a second air outlet. The first passage communicating with the defroster air outlet **204***a* is positioned at an upper side, and the second passage communicating with the foot air outlet **204***b* is positioned at a lower side in the air conditioning case **203**, in the vehicle top-bottom direction. Thus, air B1 after passing through the first heater core **211** mainly flows to the first passage communicating with the defroster air outlet **204***a*, and air **82** after passing through the second heater core **221** mainly flows to the second passage communicating with the foot air outlet **204***b*.

[0328] Furthermore, in the present embodiment, the structure of the first heater core **211** and the structure of the second heater core **221** are respectively similar to those in the above-described sixteenth embodiment.

[0329] In the examples of FIGS. **28** and **29**, the thickness of the first heater core **211** in the air flow direction is the same as the thickness of the second heater core **221**, but the dimensions of the heat exchanging core portions **211***g* and **221***g* in the vehicle top-bottom direction are made to be different from each other. Specifically, the dimension of the flat tube **211***e* and the heat transmitting fin **211***f* extending in the vehicle top-bottom direction is made longer than the dimension of the flat tube **221***e* and the heat transmitting fin **221***f* extending in the vehicle top-bottom direction. Therefore, the heat exchanging area between air and the coolant can be made larger in the first heater core **211**, than that in the second heater core **221**.

[0330] Accordingly, the passage sectional area of each flat tube **211***e* of the first heater core **211** can be made larger than the passage sectional area of each flat tube **221***e* of the second heater core **221**, and thereby the flow resistance of the coolant (fluid) flowing in the first heater core **211** can be made lower than the flow resistance of the coolant (fluid) flowing in the second heater core **221**.

[0331] Thus, in the present embodiment, in a heating operation, the air to be blown to the defroster air outlet **204***a* can be heated by using a large amount coolant after cooling the cylinder head **231**, as the heat source. In contrast, in the heating operation, the air to be blown to the foot air outlet **204***a* can be heated by using the high temperature coolant after cooling the cylinder block **232**, as the heat source.

[0332] Accordingly, relatively low-temperature warm air can be blown toward the windshield from the defroster air outlet, and at the same time, relatively high-temperature warm air can be blown toward the passage from the foot air outlet. Therefore, it is possible to set a temperature difference between the temperature of air blown to the defroster air outlet and the temperature of air blown to the foot air outlet.

Twentieth Embodiment

[0333] A twentieth embodiment of the invention will be described with reference to FIGS. **30** and **31**. FIGS. **30** and **31** are a side view and a front view showing a heating heat exchanger **202** of the present embodiment. In the present embodiment, as shown in FIGS. **30** and **31**, a single coolant outlet is provided with respect to the heating heat exchanger **202** of the above-described nineteenth embodiment shown in FIGS. **28** and **29**.

[0334] Specifically, in the heating heat exchanger **202** of the present embodiment, communication portions **302**, **303** are provided to communicate the outlet side tank **211***d* of the first heater core **211** and the outlet side tank **221***d* of the second heater core **221** with each other, without providing a special coolant outlet in the outlet side tank **211***d* of the first heater core **211**.

[0335] Thus, in the present embodiment, the coolant after passing through the heat-exchanging core portion **211***g* of the first heater core **211** flows into the communication portions **302**, **303**, and is joined with the coolant after passing through the heat-exchanging core portion **221***g* of the second heater core **221** in the outlet side tank **221***d* of the second heater core **221**. Then, the joined coolant flows out of heating heat exchanger **202** from the coolant outlet **221***b* of the outlet side tank **221***d* of the second heater core **221**.

[0336] As described above, even in the heating heat exchanger **202** in which the first heater core **211** and the second heater core **221** are arranged in parallel with respect to the air flow direction, the coolant after passing through the first heat-exchanging core portion **211***g* of the first heat core **211** and the coolant after passing through the second heat-exchanging core portion **221***g* of the second heater core **221** can be joined at a portion adjacent to the coolant outlet **221***b* of the heating heat exchanger **202**.

Twenty-First Embodiment

[0337] A twenty-first embodiment of the invention will be described with reference to FIG. **32**. FIG. **32** is a side view showing a heating heat exchanger **202** of the twenty-first embodiment. The twenty-first embodiment corresponds to a combination of the above-described sixteenth embodiment and nineteenth embodiment. That is, the partition wall **203***a*, the defroster air outlet **204***a* and the foot air outlet **204***b* are provided similar to the nineteenth embodiment shown in FIG. **28**. Specifically, as shown in FIG. **32**, a first heater core **211** is disposed in the air conditioning case **203** to across all the air passage of the air conditioning case **203**, and a second heater core **221** is located in the air conditioning case **203** downstream of the first heater core **211** in the air flow direction to be opposite to a part of the downstream surface of the first heater core **211**. Thus, a part of air having passed through the first heater core **211** flows into the second heater core **221**, and the other part of air having passed through the first heater core **211** bypasses the second heater core **221**.

[0338] The dimension of the heat-exchanging core portion **221***g* of the second heater core **221** in the top-bottom direction is made shorter than the dimension of the heat-exchanging core portion **211***g* of the first heater core **211** in the top-bottom direction, and is arranged at the lower side in the air passage of the air conditioning case **203**.

[0339] Therefore, in the heating operation of the present embodiment, a relatively low-temperature air heated by only the first heater core **211** can be blown toward the defroster air outlet **204***a*, and relatively high-temperature air heated by both the first heater core **211** and the second heater core **221** can be blown toward the foot air outlet **204***b*. As a result, the temperature of air to be blown into the foot air outlet **204***b* can be more increased as compared with the nineteenth embodiment. In the present embodiment, other parts may be similar to those of the above-described sixteenth embodiment.

Twenty-Second Embodiment

[0340] A twenty-second embodiment of the invention will be described with reference to FIG. **33**. FIG. **33** is a schematic diagram showing an air conditioner for a vehicle according to the twenty-second embodiment of the invention. In the above-described sixteenth to twenty-first embodiments, the coolant after cooling the cylinder head **231** of the engine **230** is used as the low-temperature side coolant, and the coolant after cooling the cylinder block **232** of the engine **230** is used as the high-temperature side coolant. However, in the twenty-second embodiment, coolant of the engine **230** is used as the low temperature coolant, and coolant of an inverter **241** is used as the high temperature coolant. Thus; the coolant of the engine **230** corresponds to the first fluid, and the coolant of the inverter **241** corresponds to the second fluid.

[0341] As shown in FIG. **33**, a heating heat exchanger **202** of the present embodiment includes a first heater core **211** arranged at an upstream air side in an air conditioning case **203**, and a second heater core **221** arranged at a downstream air side of the first heater core **211** in the air conditioning case **203**, similarly to the above-described sixteenth embodiment.

[0342] The first heater core **211** is disposed in an engine coolant circuit so that the coolant after cooling the engine **230** flows into the first heater core **211**. Thus, a single coolant outlet is provided for the heating heat exchanger **202**, in the engine **230**.

[0343] On the other hand, the second heater core **221** is provided in an inverter coolant circuit **240**, so that the coolant in the inverter coolant circuit **240** flows into the second heater core **221**. The inverter coolant circuit **240**, in which the coolant for cooling the inverter **241** circulates, is a coolant circuit provided independently from the engine coolant circuit. The inverter coolant circuit **240** is provided with the inverter **241**, a water pump **242**, a radiator **243**, a thermostat **244**.

[0344] The inverter **241** is an electrical machine mounted to a hybrid vehicle, and is adapted to convert an electrical current supplied to an electrical motor for a vehicle traveling from the direct current to the alternate current. The water pump **242** is disposed in the inverter coolant circuit **240** so that the coolant circulates in the inverter coolant circuit **240**. The radiator **243** is a heat exchanger configured to radiate heat from the coolant after passing through the inverter **241** to air. The thermostat **244** is a flow opening/closing unit that opens or closes a coolant passage through which the coolant flows to the radiator **243**.

[0345] Generally, in the hybrid vehicle, the engine **230** may be stopped in accordance with a traveling load of the vehicle.

[0346] In the present embodiment, if a controller (not shown) determines that the temperature of the coolant flowing out of the engine **230** is lower than a necessary lowest temperature required for the heating in the beating operation and determines that the temperature of air after passing through the first heater core **211** cannot be sufficiently increased, a converting efficiency of the inverter **241** is decreased so that the inverter **241** is adapted as a heat generating member. Thus, the temperature of the coolant flowing into the second heater core **221** can be made higher than the temperature of the coolant flowing into the first heater core **211**, thereby further increasing the temperature of air to be blown toward the vehicle compartment. Furthermore, in a case where the temperature of the coolant of the inverter **241** is too increased, the coolant in the inverter coolant circuit is cooled by the radiator **243**, thereby preventing a trouble caused in the inverter **241**.

[0347] In the present embodiment, as the high temperature coolant, the coolant of the inverter **241** is used. However, coolant of a heat generator mounted to the vehicle to use the exhaust heat of the vehicle, other than the engine EG, may be used as the high temperature coolant. For example, coolant, for cooling an electrical machine such as a generator and a battery mounted on a hybrid vehicle or an electrical vehicle, may be used as the heat source for the heating of air to be blown into the vehicle compartment.

[0348] Furthermore, hot water of a hot water circuit heated by a heating unit other than the engine may flow into the second heater core **221**. As the heating unit, a water-heating electrical heater, a heat pump, an exhaust heat of an exhaust gas or the like may be used. In this case, it is prefer for the flow amount of the coolant flowing through the second heater core **221** to be smaller than the flow amount of the coolant flowing through the first heater core **211**. In the above-described twenty-second embodiment, the inverter coolant circuit is configured separately from the engine coolant circuit. However, the inverter coolant circuit may be configured to be connected to the engine coolant circuit, so that a part of the engine coolant circuit flows into the inverter coolant circuit.

Other Embodiments

[0349] Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications will become apparent to those skilled in the art.

[0350] (1) In the above-described embodiments, the air conditioner according to the invention is used for a hybrid car having an engine EG and an electrical motor for a vehicle traveling. However, the air conditioner according to the invention may be suitably used for an idling-stop vehicle or other kinds of vehicles such as a fuel cell vehicle or an electrical vehicle that has a vehicle driving source other than the engine EG.

[0351] For example, in the air conditioner for a fuel cell vehicle provided with a fuel cell and an electrical motor, air to be blown into the vehicle compartment is heated in a heating heat exchanger by using coolant of the fuel cell as a heat source.

[0352] (2) In the above-described sixteenth embodiment, the heat-exchanging core portion **211***g* of the first heater core **211** and the heat-exchanging core portion **221***g* of the second heater core **221** are spaced from each other in the air flow direction in the whole area of the heat-exchanging core portions **211***g*, **221***g*. However, the heat-exchanging core portion **211***g* of the first heater core **211** and the heat-exchanging core portion **221***g* of the second heater core **221** may be partially spaced from each other so that a part area can be connected therebetween. Even in this case, the heat transmission between the heat-exchanging core portion **211***g* of the first heater core **211** and the heat-exchanging core portion **221***g* of the second heater core **221** can be reduced as compared with a case where the all area are connected to each other.

[0353] (3) In the above-described sixteenth embodiment, the flow direction of the coolant in the first heater core **211** is made the same as that in the second heater core **221**, such that the coolant flows from the top side to the bottom side in the heat-exchanging core portions **211***g*, **221***g*. However, the flow direction of the coolant in the first heater core **211** can be made reversely to the flow direction of the coolant in the second heater core **221**.

[0354] (4) In the above-described nineteenth to twenty-first embodiment of the invention, the air after passing through the first heater core **211** mainly flows to the first passage communicating with the defroster air outlet **204***a*. However, the air after passing through the first heater core **211** may flow to the first passage communicating with a face air outlet through which air is blown toward an upper side of the vehicle compartment. Thus, relatively low-temperature air can be blown toward an upper side of the vehicle compartment or the windshield, while relatively high-temperature air can be blown toward a lower side of the vehicle compartment.

[0355] Alternatively, in a case where only a driver is seated on the driver's seat of the vehicle and no other passenger is on the seat other than the driver's seat of the vehicle, the relatively high-temperature air after passing through the second heater core **221** can be blown toward the driver of the vehicle compartment, and the relatively low-temperature air after passing through the first heater core **211** can be blown toward the seats other than the driver's seat in the vehicle compartment.

[0356] (5) In the above-described sixteenth to twenty-first embodiments, only the coolant for cooling the cylinder head **231** flows out of the first coolant outlet **231***b* of the engine **230**. However, a part of the coolant for cooling the cylinder block **232** may be mixed with the coolant for cooling the cylinder head **231**, and the mixed coolant may flows from the first coolant outlet **231***b* of the engine **230** to the first heater core **211**. That is, the coolant mainly cooling the cylinder head **231** in the engine **230** may flows out of the first coolant outlet **231***b* of the engine **230** to the first heater core **211**.

[0357] Similarly, in the above-described sixteenth to twenty-first embodiments, only the coolant for cooling the cylinder block **232** flows out of the second coolant outlet **232***b* of the engine **230**. However, a part of the coolant for cooling the cylinder head **231** may be mixed with the coolant for cooling the cylinder block **232**, and the mixed coolant may flows from the second coolant outlet **232***b* of the engine **230** to the second heater core **221**. Thus, the coolant mainly cooling the cylinder block **232** in the engine **230** may flows out of the second coolant outlet **232***b* of the engine **230** to the second heater core **221**, while the coolant mainly cooling the cylinder head **231** in the engine **230** may flows out of the first coolant outlet **231***b* of the engine **230** to the first heater core **211**. Even in this case, the temperature of the coolant flowing out of the second coolant outlet **232***b* in the engine **230** can be made higher than the temperature of the coolant flowing out of the first coolant outlet **231***b* in the engine **230**.

[0358] For example, a part of the coolant after cooling the cylinder head **231** may be mixed with the coolant after cooling the cylinder block **232** in the engine **230**, and the mixed coolant may flow out of the second coolant outlet **232** of the engine **230** to flow into the second heater core **221**. Even in this case, the temperature of the coolant flowing into the second heater core **221** can be increased more than the temperature of the coolant flowing into the first heater core **211**.

[0359] (6) In the above-described sixteenth embodiment, only the coolant flowing out of the second coolant outlet **232***b* of the engine **230** flows into the second heater core **221**. However, a part of the coolant flowing out of the first coolant outlet **231***b* may be mixed with the coolant after flowing out of the second coolant outlet **232***b*, and the mixed coolant may flow into the second heater core **221**.

[0360] Even in this case, the temperature of the coolant flowing into the second heater core **221** can be made higher than the temperature of the coolant flowing into the first heater core **211**, thereby effectively increasing the temperature of air to be blown toward the vehicle compartment.

[0361] (7) In the above-described sixteenth to the twenty-second embodiments, the flow amount of the coolant flowing through the first heater core **211** is made larger than the flow amount of the coolant flowing through the second heater core **221**. However, the flow amount of the coolant flowing through the first heater core **211** may be made equal to the flow amount of the coolant flowing through the second heater core **221**

[0362] For example, in the structure of the above-described sixteenth embodiment, a part of the low temperature coolant flowing out of the first coolant outlet **231***b* of the engine **230** may be joined with the high temperature coolant flowing out of the second coolant outlet **232***b*, such that the flow amount of the coolant flowing through the first heater core **211** is equal to the flow amount of the coolant flowing through the second heater core **221**.

[0363] (8) In the above-described sixteenth to twenty-first embodiments, the air conditioner of the present embodiment may be applied to a vehicle having an internal combustion engine; however, may be applied to a vehicle in which exhaust heat of an equipment other than the internal combustion engine is used as the heat source for the heating. For example, a heat generating member that generates heat when being operated may be used instead of the internal combustion engine.

[0364] (9) In the above-described embodiments, the coolant is used as a cooling fluid for cooling a heat generating member such as an engine mounted to a vehicle. However, as the cooling fluid, a cooling liquid other than water or a gas fluid may be used without being limited to the coolant.

[0365] (10) The above described embodiments may be suitably combined if there is no contradiction therebetween.

[0366] Such changes and modifications are to be understood as being within the scope of the present invention as defined by the appended claims.

What is claimed is:

1. An air conditioner for a vehicle provided with a driving unit for a vehicle traveling, the air conditioner comprising:

first and second heating heat exchangers disposed to heat air to be blown into a vehicle compartment by using a cooling fluid for cooling the driving unit as a heat source, the second heating heat exchanger being arranged downstream of the first heating heat exchanger in an air flow to heat air after passing through the first heating heat exchanger;

a heater disposed to heat the cooling fluid flowing to the second heating heat exchanger, in the first and second heating heat exchangers; and

a controller for controlling a temperature of air to be blown into the vehicle compartment, the controller outputs an operation request signal to the driving unit when a temperature of the cooling fluid is lower than a predetermined temperature, wherein

the first and second heating heat exchangers are arranged in parallel with respect to a flow direction of the cooling fluid, and

the controller controls a flow amount of the cooling fluid flowing into the second heating heat exchanger to be smaller than a flow amount of the cooling fluid flowing into the first heating heat exchanger when the heater heats the cooling fluid flowing to the second heating heat exchanger.

2. The air conditioner according to claim **1**, wherein the first and second heating heat exchangers are configured such that a flow resistance of the cooling fluid flowing in the second heating heat exchanger is higher than a flow resistance of the cooling fluid flowing in the first heating heat exchanger.

3. The air conditioner according to claim **1**, further comprising

a flow adjustment unit that is configured to reduce the flow amount of the cooling fluid flowing into the second heating heat exchanger when the heater is turned on to heat the cooling fluid flowing into the second heating heat exchanger, as compared with that when the heater is turned off.

4. The air conditioner according to claim **1**, further comprising

a sensible heat exchanger that is configured to move heat from the cooling fluid downstream of the second heating heat exchanger to the cooling fluid upstream of the heater.

5. The air conditioner according to claim **1**, wherein

the driving unit includes an electrical motor for a vehicle traveling, and

the heater is an electrical heater which uses a high-voltage electrical source for supplying electrical power to the electrical motor, as an electrical source.

6. The air conditioner according to claim **1**, wherein

the heater is a heat generator, which is mounted to the vehicle separately from the driving unit, and generates heat when being operated.

7. The air conditioner according to claim **6**, wherein the heat generator is an inverter which converts an electrical current supplied to the electrical motor.

8. An air conditioner for a vehicle provided with a driving unit for a vehicle traveling, the air conditioner comprising:
- a heating heat exchanger disposed to heat air to be blown into a vehicle compartment by using a cooling fluid for cooling the driving unit as a heat source;
- a controller for controlling a temperature of air to be blown into the vehicle compartment, the controller outputs an operation request signal to the driving unit when a temperature of the cooling fluid is lower than a predetermined temperature;
- a heat absorbing portion configured to absorb heat from the cooling fluid;
- a heat radiating portion configured to radiate heat to the cooling fluid; and
- a pump portion configured to pump heat from the heat absorbing portion to the heat radiation portion.

9. The air conditioner according to claim **8**, wherein
- the pump portion is a Peltier element that includes a heat absorbing surface thermally connected to the heat absorbing portion, and a heat radiating surface thermally connected to the heat radiating portion, and
- the Peltier element absorbs heat from the heat absorbing surface and radiates heat from the heat radiating surface when direct current is applied to the Peltier element.

10. The air conditioner according to claim **8**, wherein
- the heating heat exchanger is a heat exchanger in which the cooling fluid flowing therein is heat exchanged with air passing therethrough so as to heat air,
- the heat absorbing portion is disposed downstream of the heating heat exchanger in a flow direction of the cooling fluid, to absorb heat from the cooling fluid flowing out of the heating heat exchanger, and
- the heat radiation portion is disposed upstream of the heating heat exchanger in the flow direction of the cooling fluid, to radiate heat to the cooling fluid flowing into the heating heat exchanger.

11. The air conditioner according to claim **10**, wherein
- the heating heat exchanger includes a first, heater core for heating air, and a second heater core disposed to heat air after passing through the first heater core,
- the heat absorbing portion is disposed downstream of the second heater core in the flow direction of the cooling fluid to absorb heat from the cooling fluid flowing out of the second heater core, and
- the heat radiating portion is disposed upstream of the second heater core in the flow direction of the cooling fluid to radiate heat to the cooling fluid flowing into the second heater core.

12. The air conditioner according to claim **11**, wherein the first and second heater cores are arranged in parallel with respect to the flow direction of the cooling fluid.

13. The air conditioner according to claim **10**, further comprising
- a heat exchanger disposed to perform heat exchange between the cooling fluid before flowing into the heat radiating portion, and the cooling fluid before flowing into the heat absorbing portion at a position downstream of the second heater core in the flow direction of the cooling fluid.

14. The air conditioner according to claim **10**, further comprising
- a first bypass passage through which a part of the cooling fluid before flowing into the heat radiating portion is introduced into the heat absorbing portion without performing heat exchange with air in the second heater core.

15. The air conditioner according to claim **10**, further comprising
- a second bypass passage through which a part of the cooling fluid upstream of the heat radiating portion is introduced to the driving unit while bypassing the heat radiating portion and the heat absorbing portion.

16. The air conditioner according to claim **8**, further comprising:
- a first fluid circuit in which the cooling fluid of the driving unit is circulated; and
- a second fluid circuit independently provided from the first fluid circuit, in which a fluid heated by the cooling fluid is circulated to flow into the heating heat exchanger.

17. An air conditioner for a vehicle having an internal combustion engine, the air conditioner comprising
- a heating heat exchanger configured to heat air to be blown into a vehicle compartment, by using a first fluid for cooling the internal combustion engine and a second fluid having a temperature higher than the first fluid, as a heat source, wherein
- the heating heat exchanger includes a first heat exchanging portion in which the first fluid or a mixture of the first fluid and the second fluid flows, and a second heat exchanging portion in which a fluid that is mainly the second fluid and has a temperature higher than a fluid flowing into the first heat exchanging portion flows, and
- the first heat exchanging portion and the second heat exchanging portion are integrated to form a space therebetween.

18. The air conditioner according to claim **17**, wherein the second heat exchanging portion is arranged downstream of the first heat exchanging portion in an air flow direction.

19. The air conditioner according to claim **17**, wherein the first heat exchanging portion and the second heat exchanging portion are arranged in parallel with respect to an air flow direction.

20. The air conditioner according to claim **17**, wherein the first heat exchanging portion has a heat exchanging area in which air is heat exchanged with the fluid, and the heat exchanging area of the first heat exchanging portion is larger than the heat exchanging area of the second heat exchanging portion.

21. The air conditioner according to claim **17**, wherein the first heat exchanging portion and the second heat exchanging portion are arranged such that a flowing amount of the fluid flowing in the first heat exchanging portion is larger than that flowing in the second heat exchanging portion.

22. The air conditioner according to claim **17**, wherein the first heat exchanging portion and the second heat exchanging portion are configured to have respective fluid passages that are independent from each other.

23. The air conditioner according to claim **17**, further comprising
- an air conditioning case in which the first heat exchanging portion and the second heat exchanging portion are disposed,
- the air conditioning case has a first air outlet from which air only having passed through the first heat exchanging portion is blown toward an inner surface of a windshield of the vehicle, and a second air outlet from which air

having passed through the second heat exchanging portion is blown toward a passenger in the vehicle compartment.

24. The air conditioner according to claim **17**, wherein

the first fluid is a cooling fluid for cooling a cylinder head of the internal combustion engine, and

the second fluid is a cooling fluid for cooling a cylinder block of the internal combustion engine.

25. The air conditioner according to claim **17**, wherein

the first fluid is a cooling fluid for cooling the internal combustion engine, and

the second fluid is a cooling fluid for cooling a heat generation member that is an equipment mounted to the vehicle and is different from the internal combustion engine.

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