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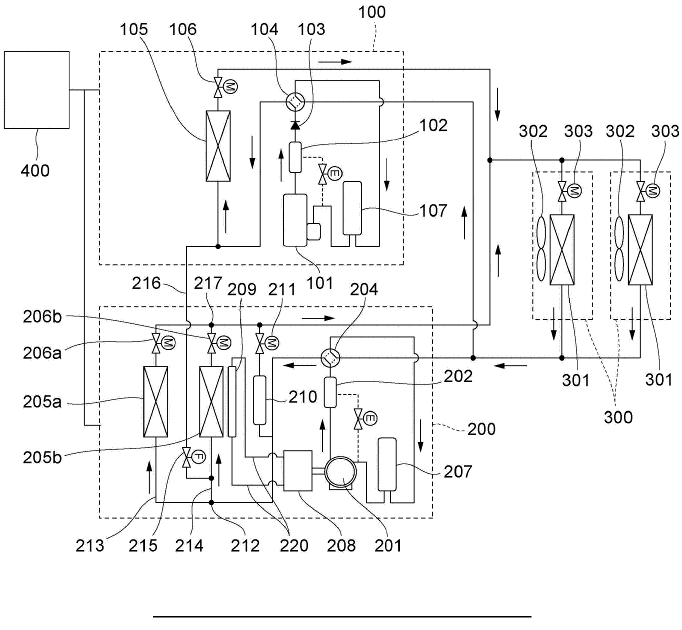
(54) **AIR CONDITIONER**

(57) An outdoor heat exchanger (105), an electrically driven compressor (101), and an indoor heat exchanger (301) are present in a first passage. A non-electrically driven compressor (201) and a third heat exchanger (301) are present in a second passage. The second passage branches to a first branch pipe (213) and a second branch pipe (214) at a branch portion (212). An outdoor heat exchanger (205a) is present in the first branch pipe (213). An outdoor heat exchanger (205b) is present in the second branch pipe (214). The outdoor heat exchanger (205a), the non-electrically driven compressor (201), the outdoor heat exchanger (105), and the indoor heat exchanger (301) are present in a third passage. The third passage includes an outdoor heat-exchange connection pipe (216) that connects a point in the second branch pipe (214) with a point in the first passage. A controller (400) selects one of the first passage, the second passage, and the third passage.

FIG. 1



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Description

BACKGROUND

1. Technical Field

[0001] The present disclosure relates to an air conditioner that includes an electrically driven outdoor unit including a compressor that is driven by electric power and a non-electrically driven outdoor unit including a compressor that is driven by a non-electric driving source.

2. Description of the Related Art

[0002] Some existing air conditioners include a plurality of outdoor units, which are connected in parallel to an inter-unit pipe extending from an indoor unit, and control the number of outdoor units that are operated and the rotation speeds of compressors of the outdoor units. Examples of such air conditioners include a so-called "hybrid air conditioner" in which one of outdoor units includes a compressor that is driven by electric power and the other outdoor unit includes a compressor that is driven by a non-electric driving source so that electric power usage can be leveled out (see, for example, Japanese Unexamined Patent Application Publication No. 05-340624).

[0003] The hybrid air conditioner has advantages in that the basic electricity rate can be reduced and the energy risk can be diversified, compared with an air conditioner in which all compressors are driven by electric power. Based on such advantages, the following technology has been developed in order to maintain a high overall efficiency and to level out electric power usage: the rate of the operation of an electrically driven compressor to the operation of a non-electrically driven compressor is controlled in accordance with a combination of parameters, such as the load capacity of the non-electrically driven compressor, the load capacity of the electrically driven compressor, and the upper limit of electric power usage of the electrically driven compressor, (see, for example, Japanese Unexamined Patent Application Publication No. 2007-187342).

SUMMARY

[0004] When electricity demand is at a peak, for example, in a midsummer afternoon, the existing air conditioner stops the outdoor unit including a compressor that is driven by electric power and continues operating the outdoor unit including a compressor that is driven by a non-electric driving source. When electricity demand is not at a peak, the air conditioner continues operating all of the outdoor units. Thus, electric power usage can be levelled out.

[0005] However, with existing technologies, when the external air temperature is high, for example, in a midsummer afternoon, the outdoor unit including a compressor that is driven by a non-electric driving source, such as a gas engine, is operated alone.

[0006] If the outdoor unit that uses a gas engine as a driving source is operated alone, in particular, when the external air temperature is high, for example, in a midsummer afternoon, it is difficult for a radiator of the gas engine to release a sufficient amount of waste heat from the gas engine (hereinafter, simply referred to as "engine waste heat").

[0007] The reason for this is considered as follows. The radiator for releasing the engine waste heat transfers heat to comparatively-high-temperature air, which has been heated by a refrigerant in a refrigerant heat exchanger of the outdoor unit. Therefore, the radiator cannot release a sufficient amount of heat, and the temperature of cooling water of the gas engine increases. As a result, the rotation speed of the gas engine has to be reduced, and desired air-conditioning performance cannot be achieved.

[0008] One non-limiting and exemplary embodiment provides an air conditioner in which a radiator can release a sufficient amount of heat even in a midsummer afternoon and that can level out electric power usage while maintaining high air-conditioning performance.

[0009] In one general aspect, the techniques disclosed here feature an air conditioner including a pipe in which a refrigerant flows; a first heat exchanger; a first compressor that is driven by electric power; a first-second heat exchanger; a second-second heat exchanger; a second compressor that is driven by a non-electric driving source; a radiator that cools the non-electric driving source; a fan that blows air from the second-second heat exchanger toward the radiator; a third heat exchanger; a valve that is disposed in the pipe; and a controller that controls the valve to select one passage of the pipe, in which the refrigerant flows, from the group consisting of a first passage, a second passage, and a third passage. The first heat exchanger, the first compressor, and the third heat exchanger are present in the first passage. The second compressor and the third heat exchanger are present in the second passage. The second passage includes a first portion and a second portion, the second passage branching to a first branch passage and a second branch passage at the first portion, the first branch passage and the second branch passage being combined with each other at the second portion. The first-second heat exchanger is present in the first branch passage. The second-second heat exchanger is present in the second branch passage. The first-second heat exchanger, the second compressor, the first heat exchanger, and the third heat exchanger are present in the third passage. The third passage includes a connection passage that connects a point in the second branch passage with a point in the first passage.

[0010] Thus, when electricity demand is at a peak, for example, in a midsummer afternoon, the controller selects the third passage to allow a refrigerant discharged from the second compressor to flow through the connection passage and to cool the refrigerant in the first heat exchanger. Thus, heat exchange between the refrigerant and external air is not performed in the second-second heat exchanger; and external air, whose temperature has not been increased, flows into the radiator that is disposed downstream of the second-second heat exchanger in the airflow direction. As a result, the radiator can release a sufficient amount of heat from the cooling water.

[0011] As a result, because a sufficient amount of heat can be released from the cooling water, the temperature of the cooling water of the non-electric driving source can be maintained at an appropriate temperature, even when the operation of the second compressor is continued.

[0012] With the air conditioner according to the present disclosure, because the controller selects the third passage when electricity demand is at a peak, for example, in a midsummer afternoon, decrease of the rotation speed of the non-electric driving source due to increase in the temperature of the cooling water can be avoided and desired air-conditioning performance can be achieved.

[0013] Additional benefits and advantages of the disclosed embodiments will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained by the various embodiments and features of the specification and drawings, which need not all be provided in order to obtain one or more of such benefits and/or advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 illustrates the structure of an air conditioner according to an embodiment of the present disclosure and the flow of a refrigerant during a cooling operation;

Fig. 2 illustrates the structure of the air conditioner and the flow of the refrigerant during a heating operation; and

Fig. 3 illustrates the structure of the air conditioner and the flow of the refrigerant during a cooling operation that is performed when, for example, electricity demand is at a peak.

DETAILED DESCRIPTION

[0015] According to a first disclosure, an air conditioner includes a pipe in which a refrigerant flows; a first heat exchanger; a first compressor that is driven by electric power; a first-second heat exchanger; a second-second heat exchanger; a second compressor that is driven by a non-electric driving source; a radiator that cools the non-electric driving source; a fan that blows air from the second-second heat exchanger toward the radiator; a third heat exchanger; a valve that is disposed in the pipe; and a controller that controls the valve to select one passage of the pipe, in which the refrigerant flows, from the group consisting of a first passage, a second passage, and a third passage. The first heat exchanger, the first compressor, and the third heat exchanger are present in the first passage. The second compressor and the third heat exchanger are present in the second passage. The second passage includes a first portion and a second portion, the second passage branching to a first branch passage and a second branch passage at the first portion, the first branch passage and the second branch passage being combined with each other at the second portion. The first-second heat exchanger is present in the first branch passage. The second-second heat exchanger is present in the second branch passage. The first-second heat exchanger, the second compressor, the first heat exchanger, and the third heat exchanger are present in the third passage. The third passage includes a connection passage that connects a point in the second branch passage with a point in the first passage.

[0016] In other words, the valve is disposed in the pipe and regulates the flow rate of the refrigerant flowing in the pipe. The connection passage connects a point in the first passage with a point in the second branch passage that is positioned between the first portion and the second-second heat exchanger.

[0017] When electricity demand is at a peak, for example, in a midsummer afternoon, the compressor that is driven by electric power is stopped and the non-electrically driven outdoor unit including the compressor that is driven by the non-electric driving source is operated to continue an air-conditioning operation while suppressing electric power usage.

[0018] With the present disclosure, when the controller selects the third passage, the refrigerant discharged from the second compressor can flow through the connection passage and can be cooled by the first heat exchanger. Thus, heat exchange between the refrigerant and external air is not performed in the second-second heat exchanger, so that external air, whose temperature has not been increased, flows into the radiator that is disposed downstream of the second-second heat exchanger in the airflow direction. Accordingly, the radiator can release a sufficient amount of heat from the cooling water.

[0019] As a result, because a sufficient amount of heat can be released from the cooling water, the temperature of the cooling water of the non-electric driving source can be maintained at an appropriate temperature even when the operation of the second compressor is continued. Therefore, decrease of the rotation speed of the non-electric driving source due to increase in the temperature of the cooling water can be avoided, and desired air-conditioning performance can be achieved.

[0020] According to a second disclosure, in the air conditioner according to the first disclosure, the valve includes a first valve that is positioned in the connection passage, and the controller opens the first valve to select the third passage.

[0021] In this case, when the controller opens the first valve, which is positioned in the connection passage, to select the third passage, the refrigerant that is discharged from the second compressor can flow through the connection passage and can be cooled by the first heat exchanger.

[0022] As a result, heat exchange between the refrigerant and external air is not performed in the second-second heat exchanger, so that external air, whose temperature has not been increased, flows into the radiator that is disposed downstream of the second-second heat exchanger in the airflow direction. Therefore, the radiator can release a sufficient amount of heat from the cooling water of the non-electric driving source.

[0023] According to a third disclosure, in the air conditioner according to the first or second disclosure, the valve includes a second valve that regulates a flow rate of the refrigerant flowing in the second-second heat exchanger, and the controller closes the second valve to select the third passage. In other words, the second valve is positioned between the second portion and the second-second heat exchanger in the second branch passage.

[0024] In this case, when the controller closes the second valve to select the third passage, the refrigerant that is discharged from the second compressor does not flow to the second-second heat exchanger.

[0025] As a result, heat exchange between the refrigerant and external air is not performed in the second-second heat exchanger, and external air, whose temperature has not been increased, flows into the radiator that is disposed downstream of the second-second heat exchanger in the airflow direction. Accordingly, the radiator can release a sufficient amount of heat from the cooling water of the non-electric driving source.

[0026] According to a fourth disclosure, in the air conditioner according to any one the first to third disclosures, the first heat exchanger and the first compressor constitute an electrically driven outdoor unit; the first-second heat exchanger, the second-second heat exchanger, and the second compressor constitute a non-electrically driven outdoor unit; and the third heat exchanger constitutes an indoor unit.

[0027] In this case, the electrically driven outdoor unit and the non-electrically driven outdoor unit, which are disposed outdoors, and the indoor unit, which is disposed indoors, constitute the air conditioner.

[0028] According to a fifth disclosure, in the air conditioner according to any one the first to fourth disclosures, the controller selects the third passage when the first compressor is stopped and the second compressor is operated.

[0029] When electricity demand is at a peak, for example, in a midsummer afternoon, the first compressor is stopped and the second compressor is operated. When electricity demand is at a peak, the controller can select the third passage to reduce the inlet air temperature of the radiator that is disposed downstream of the second-second heat exchanger in the airflow direction. Therefore, the radiator can release a sufficient amount of heat from the cooling water of the non-electric driving source.

[0030] Hereinafter, an embodiment according to the present disclosure will be described with reference to the drawings. Note that the embodiment does not limit the present disclosure.

Embodiment

[0031] Fig. 1 illustrates the structure of an air conditioner according to an embodiment of the present disclosure and the flow of a refrigerant during a cooling operation. Fig. 2 illustrates the structure of the air conditioner and the flow of the refrigerant during a heating operation. Fig. 3 illustrates the structure of the air conditioner and the flow of the refrigerant when, for example, electricity demand is at a peak.

[0032] The air conditioner according to the present embodiment includes two outdoor units and two indoor units, which are connected to each other.

[0033] The air conditioner includes an electrically driven outdoor unit 100, and a non-electrically driven outdoor unit 200.

[0034] The electrically driven outdoor unit 100 and the non-electrically driven outdoor unit 200 are connected in parallel to unit pipes extending from indoor units 300.

[0035] The electrically driven outdoor unit 100 includes an electrically driven compressor 101, which is an example of a first compressor that is driven by electric power. An oil separator 102 is disposed in a discharge pipe of the electrically driven compressor 101. The oil separator 102 separates oil from a refrigerant gas discharged from the electrically driven compressor 101. The oil that is separated by the oil separator 102 is returned to a suction pipe of the electrically driven compressor 101.

[0036] A check valve 103 is disposed on the discharge side of the oil separator 102. A four-way valve 104 is disposed on the downstream side of the check valve 103. The check valve 103, which is disposed in a refrigerant pipe between the oil separator 102 and the four-way valve 104, prevents the refrigerant from flowing backward from the four-way valve 104 toward the discharge side of the electrically driven compressor 101. The four-way valve 104 is set in a state shown by solid lines during a cooling operation and in a state shown by broken lines during a heating operation to reverse the flow of the refrigerant.

[0037] An outdoor heat exchanger 105, which is an example of a first heat exchanger, is disposed between the four-way valve 104 and the indoor units 300. The outdoor heat exchanger 105 releases heat of the refrigerant to the outside in a cooling operation and absorbs heat of external air in a heating operation by using an outdoor fan (not shown).

[0038] A decompressor 106, which regulates the pressure and the flow rate of the refrigerant, is disposed between the outdoor heat exchanger 105 and the indoor units 300. An accumulator 107 is disposed on the suction side of the electrically driven compressor 101. A gas refrigerant is supplied from the accumulator 107 to the electrically driven compressor 101.

[0039] The non-electrically driven outdoor unit 200 includes a non-electrically driven compressor 201, which is an example of a second compressor that is driven by a non-electric driving source.

[0040] An oil separator 202 is disposed in a discharge pipe of the non-electrically driven compressor 201. An outdoor heat exchanger 205a, which is an example of a first-second heat exchanger, and an outdoor heat exchanger 205b, which is an example of a second-second heat exchanger, are disposed in parallel on the discharge side of the oil separator 202 via a four-way valve 204.

[0041] Decompressors 206a and 206b are disposed between the indoor units 300 and the outdoor heat exchangers 205a and 205b. The decompressor 206b functions as a second valve. An accumulator 207 is disposed on the suction side of the non-electrically driven compressor 201.

[0042] Descriptions of the oil separator 202, the four-way valve 204, the outdoor heat exchangers 205a and 205b, the decompressors 206a and 206b, and the accumulator 207 will be omitted, because they function in the same as those of the electrically driven outdoor unit 100.

[0043] The non-electrically driven outdoor unit 200 includes a gas engine 208, which is an example of a non-electric driving source. A belt is looped over a pulley (not shown) of the non-electrically driven compressor 201 and a pulley (not shown) of the gas engine 208, and the gas engine 208 drives the non-electrically driven compressor 201.

[0044] A radiator 209 is disposed downstream of the outdoor heat exchanger 205b in the airflow direction. The gas engine 208 and the radiator 209 are connected to each other through cooling water pipes 220, in which cooling water circulates. An outdoor fan (not shown) blows air, which has passed through the outdoor heat exchanger 205b, through the radiator 209 to release heat from the cooling water flowing in the cooling water pipes 220. The cooling water, which has been cooled, is supplied to the gas engine 208 to cool the gas engine 208.

[0045] A waste-heat-recovery heat exchanger 210 and a waste-heat-recovery decompressor 211 are disposed near the radiator 209. The waste-heat-recovery heat exchanger 210 is connected to the refrigerant pipe so as to be in parallel with the outdoor heat exchangers 205a and 205b. The waste-heat-recovery heat exchanger 210 is structured so that the refrigerant can absorb heat also from the engine cooling water during a heating operation.

[0046] A branch portion 212, which is an example of a first portion at which the discharge pipe branches, is disposed on the discharge side of the non-electrically driven compressor 201 of the non-electrically driven outdoor unit 200. The branch portion 212 branches to a first branch pipe 213, which constitutes a first branch passage, and a second branch pipe 214, which constitutes a second branch passage. The first branch pipe 213 and the second branch pipe 214 are combined with each other at a combining portion 217, which is an example of a second portion.

[0047] The first branch pipe 213 and the second branch pipe 214 are respectively connected to the outdoor heat exchangers 205a and 205b.

[0048] The second branch pipe 214 and a discharge pipe of the electrically driven outdoor unit 100 are connected to each other through an outdoor heat-exchange connection pipe 216, which constitutes a connection passage. An on-off valve 215, which is an example of a first valve, is disposed on a part of the outdoor heat-exchange connection pipe 216.

[0049] Each of the indoor units 300 includes an indoor heat exchanger 301, which is an example of a third heat exchanger; an indoor blower fan 302; and an indoor decompressor 303, which expands the refrigerant.

[0050] In the present embodiment, a first passage is constituted by a passage including the electrically driven compressor 101 and the outdoor heat exchanger 105 of the electrically driven outdoor unit 100 and the indoor heat exchangers 301 of the indoor units 300.

[0051] A second passage is constituted by a passage including the non-electrically driven compressor 201 and the outdoor heat exchangers 205a and 205b of the non-electrically driven outdoor unit 200 and the indoor heat exchangers 301 of the indoor units 300.

[0052] A third passage is constituted by a passage including the non-electrically driven compressor 201, the outdoor heat exchanger 205a, and the indoor heat exchangers 301; and a passage including the non-electrically driven compressor 201, the outdoor heat-exchange connection pipe 216, the outdoor heat exchanger 105, and the indoor heat exchangers 301.

[0053] The air conditioner includes a controller 400. The controller 400 controls the compressors 101 and 201; the decompressors 106, 206a, 206b, and 211; the on-off valve 215; the fans of the outdoor heat exchangers 105, 205a, and 205b; the indoor blower fan 302; and the like.

[0054] In the present embodiment, upon receiving instruction to reduce electric power usage when, for example, electricity demand is at a peak, the controller 400 stops the electrically driven compressor 101 of the electrically driven outdoor unit 100 and operates only the non-electrically driven outdoor unit 200 to continue an air-conditioning operation. Moreover, the controller 400 opens the on-off valve 215, which is disposed in the outdoor heat-exchange connection pipe 216, and closes the decompressor 206b.

[0055] The controller 400 may be any device having a control function. The controller 400 includes a processor (not shown) and a storage unit (not shown) that stores a control program. Examples of the processor include an MPU and a CPU. Examples of the storage unit include a memory. The controller 400 may be constituted by a single control circuit that performs intensive control or a plurality of control circuits that cooperatively perform distributed control.

[0056] Referring to Figs. 1 to 3, operations of the electrically driven outdoor unit 100, the non-electrically driven outdoor unit 200, and the indoor units 300 will be described.

[0057] As illustrated in Fig. 1, during a cooling operation, the four-way valve 104 of the electrically driven outdoor unit 100 is set so as to allow a refrigerant to flow along the solid lines, and the refrigerant flows as indicated by solid-line arrows.

[0058] A high-temperature high-pressure refrigerant, which has been compressed by the electrically driven compressor 101, flows into the oil separator 102. The oil separator 102 separates oil from the refrigerant, and the refrigerant passes through the check valve 103 and the four-way valve 104 and flows into the outdoor heat exchanger 105. The gas refrigerant exchanges heat with external air in the outdoor heat exchanger 105 to release heat and condenses into a high-pressure liquid refrigerant. The high-pressure liquid refrigerant passes through the decompressor 106, is combined with a refrigerant in the non-electrically driven outdoor unit 200 in the inter-unit pipe, and is supplied to the indoor units 300.

[0059] The four-way valve 204 of the non-electrically driven outdoor unit 200 is set so as to allow a refrigerant to flow along the solid lines. A high-temperature high-pressure refrigerant, which has been compressed by the non-electrically driven compressor 201, flows into the oil separator 202. The oil separator 202 separates oil from the refrigerant, and the refrigerant passes through the four-way valve 204 and flows into the outdoor heat exchangers 205a and 205b.

[0060] The gas refrigerant exchanges heat with external air in the outdoor heat exchangers 205a and 205b to release heat and condenses into a high-pressure liquid refrigerant. The high-pressure liquid refrigerant flows through the decompressors 206a and 206b, is combined with a refrigerant in the electrically driven outdoor unit 100 in the inter-unit pipe, and is supplied to the indoor units 300.

[0061] The non-electrically driven compressor 201 of the non-electrically driven outdoor unit 200 is driven by the gas engine 208, and the gas engine 208 generates waste heat. To release the waste heat, engine cooling water, which is cooled by the radiator 209, is circulated in the gas engine 208, and the engine cooling water flows through the cooling water pipes 220 and releases heat in the radiator 209.

[0062] The high-pressure liquid refrigerant, which has entered the indoor units 300, is decompressed by the indoor decompressors 303 to become a gas-liquid two-phase refrigerant and flows into the indoor heat exchangers 301. In the indoor heat exchangers 301, the gas-liquid two-phase refrigerant absorbs heat by exchanging heat with air in a space to be air-conditioned, evaporates to become a gas refrigerant, and flows out of the indoor units 300.

[0063] The gas refrigerant, which has flowed out of the indoor units 300, returns to the electrically driven outdoor unit 100 and the non-electrically driven outdoor unit 200.

[0064] A part of the gas refrigerant that has flowed into the electrically driven outdoor unit 100 passes through the four-way valve 104 and the accumulator 107 and returns to the electrically driven compressor 101. Another part of the gas refrigerant that has flowed into the non-electrically driven outdoor unit 200 passes through the four-way valve 204 and the accumulator 207 and returns to the non-electrically driven compressor 201.

[0065] During a cooling operation, the electrically driven compressor 101 and the non-electrically driven compressor 201 are operated, for example, as follows.

[0066] If the cooling load is smaller than the cooling capacity of the non-electrically driven compressor 201 when it is operated at the lowest operation frequency (the minimum cooling capacity of the non-electrically driven compressor 201), the controller 400 operates only the electrically driven compressor 101. This is because, in such a case, the air conditioner would perform an intermittent operation if only the non-electrically driven compressor 201 were operated.

[0067] If the cooling load is larger than the minimum cooling capacity of the non-electrically driven compressor 201 and is smaller than the cooling capacity when both of the non-electrically driven compressor 201 and the electrically driven compressor 101 are operated at the lowest operation frequencies (the minimum cooling capacity when both of the compressors 101 and 201 are operated), the controller 400 selects and operates one of the non-electrically driven compressor 201 and the electrically driven compressor 101 whose operation cost or energy consumption, for example, is lower than the other.

[0068] If the cooling load is larger than the minimum cooling capacity when both of the compressors 101 and 201 are operated, the controller 400 operates both of the non-electrically driven compressor 201 and the electrically driven compressor 101 so as to minimize, for example, the operation cost or the energy consumption.

[0069] In this case, the operation frequencies of the non-electrically driven compressor 201 and the electrically driven compressor 101 for minimizing the operation cost or the energy consumption are determined by using the relationship between the operation frequency and the operation cost or the energy consumption of each of the compressors.

[0070] In practice, the ratio of a cooling load to be handled by the non-electrically driven compressor 201 to the entire cooling load is about $\pm 15\%$ of the ratio of the cooling capacity when only the non-electrically driven compressor 201 is operated at the highest operation frequency to the maximum cooling capacity when both of the compressors 101 and 201 are operated at the highest operation frequencies (the maximum cooling capacity when both of the compressors 101 and 201 are operated).

[0071] As illustrated in Fig. 2, during a heating operation, the four-way valve 104 of the electrically driven outdoor unit 100 is set so as to allow a refrigerant to flow along the broken lines, and the refrigerant flows as indicated by broken-line arrows.

[0072] A high-temperature high-pressure refrigerant, which has been compressed by the electrically driven compressor 101, flows into the oil separator 102. The oil separator 102 separates oil from the refrigerant, and the refrigerant passes through the check valve 103 and the four-way valve 104 and flows out of the electrically driven outdoor unit 100. The refrigerant is combined with a refrigerant in the non-electrically driven outdoor unit 200 in the inter-unit pipe, and is supplied to the indoor units 300.

[0073] The four-way valve 204 of the non-electrically driven outdoor unit 200 is set so as to allow a refrigerant to flow along the dotted lines. A high-temperature high-pressure refrigerant, which has been compressed by the non-electrically driven compressor 201, flows into the oil separator 202. The oil separator 202 separates oil from the refrigerant, and the refrigerant passes through the four-way valve 204 and flows out of the non-electrically driven outdoor unit 200. Then, the refrigerant is combined with a refrigerant in the electrically driven outdoor unit 100 in the inter-unit pipe, and is supplied to the indoor units 300.

[0074] The high-pressure liquid refrigerant, which has entered the indoor units 300, flows into the indoor heat exchangers 301. In the indoor heat exchangers 301, the high-temperature high-pressure gas refrigerant releases heat by exchanging heat with air in a space to be air-conditioned, condenses to become a high-pressure liquid refrigerant, passes through the indoor decompressors 303, and flows out of the indoor units 300.

[0075] The high-pressure liquid refrigerant, which has flowed out of the indoor units 300, returns to the electrically driven outdoor unit 100 and the non-electrically driven outdoor unit 200.

[0076] The high-pressure liquid refrigerant, which has flowed into the electrically driven outdoor unit 100, is decompressed by the decompressor 106 to become a gas-liquid two-phase refrigerant, and flows into the outdoor heat exchanger 105. The gas-liquid two-phase refrigerant exchanges heat with external air in the outdoor heat exchanger 105 and evaporates, passes through the four-way valve 104 and the accumulator 107, and returns to the electrically driven compressor 101.

[0077] A part of the high-pressure liquid refrigerant that has flowed into the non-electrically driven outdoor unit 200 is decompressed by the decompressors 206a and 206b to become a gas-liquid two-phase refrigerant, and flows into the outdoor heat exchangers 205a and 205b and the waste-heat-recovery heat exchanger 210. In the outdoor heat exchangers 205a and 205b, the gas-liquid two-phase refrigerant exchanges heat with external air. In the waste-heat-recovery heat exchanger 210, the gas-liquid two-phase refrigerant exchanges heat with high-temperature cooling water that has been used to cool the gas engine 208. Thus, the gas-liquid two-phase refrigerant absorbs heat and evaporates, passes through the four-way valve 204 and the accumulator 207, and returns to the non-electrically driven compressor 201.

[0078] During a heating operation, the non-electrically driven compressor 201 and the electrically driven compressor 101 are operated, for example, as follows.

[0079] If the heating load is smaller than the heating capacity of the non-electrically driven compressor 201 when it is operated at the lowest operation frequency (the minimum heating capacity of the non-electrically driven compressor 201), the controller 400 operates only the electrically driven compressor 101. This is because the air conditioner would perform an intermittent operation if only the non-electrically driven compressor 201 were operated.

[0080] If the heating load is larger than the minimum heating capacity of the non-electrically driven compressor 201 and is smaller than the heating capacity when both of the non-electrically driven compressor 201 and the electrically driven compressor 101 are operated at the lowest operation frequencies (the minimum heating capacity when both of the compressors 101 and 201 are operated), the controller 400 selects and operates one of the non-electrically driven compressor 201 and the electrically driven compressor 101 whose operation cost or energy consumption, for example, is lower than the other.

[0081] If the heating load is larger than the minimum heating capacity when both of the compressors 101 and 201 are operated, the controller 400 operates both of the non-electrically driven compressor 201 and the electrically driven compressor 101 so as to minimize, for example, the operation cost or the energy consumption.

[0082] In this case, the operation frequencies of the non-electrically driven compressor 201 and the electrically driven compressor 101 for minimizing the operation cost or the energy consumption are determined by using the relationship between the operation frequency and the operation cost or the energy consumption of each of the compressors.

[0083] In practice, the ratio of a heating load to be handled by the non-electrically driven compressor 201 to the entire heating load is about $\pm 15\%$ of the ratio of the heating capacity when only the non-electrically driven compressor 201 is operated at the highest operation frequency to the maximum heating capacity when both of the compressors 101 and 201 are operated at the highest operation frequencies (the maximum heating capacity when both of the compressors 101 and 201 are operated).

[0084] During a heating operation, the controller 400 monitors the occurrence of frosting of the outdoor heat exchangers 105, 205a, and 205b. If frosting is likely to occur, even if the operation frequencies of the electrically driven compressor 101 and the non-electrically driven compressor 201 have been set so as to minimize the operation cost or the energy consumption, the controller 400 increases the operation frequency of the non-electrically driven compressor 201 and decreases the operation frequency of the electrically driven compressor 101.

[0085] When the operation frequency of the non-electrically driven compressor 201 is increased, the amount of waste heat of the gas engine 208 increases and the amount of heat of cooling water supplied to the waste-heat-recovery heat exchanger 210 increases. That is, the waste-heat-recovery heat exchanger 210 can evaporate a larger amount of refrigerant; the amount of refrigerant that flows through the outdoor heat exchangers 105, 205a, and 205b can be reduced; and the probability of the occurrence of frosting can be reduced.

[0086] Next, an operation in which the electrically driven outdoor unit 100 is stopped and the non-electrically driven outdoor unit 200 is operated to continue a cooling operation will be performed. This operation is performed, for example, in a midsummer afternoon.

[0087] Upon receiving instruction to reduce electric power usage when, for example, electricity demand is at a peak, the controller 400 stops the electrically driven compressor 101 of the electrically driven outdoor unit 100 and operates only the non-electrically driven outdoor unit 200 to continue a cooling operation. Moreover, the controller 400 opens the on-off valve 215, which is disposed in the outdoor heat-exchange connection pipe 216, and closes the decompressor 206b.

[0088] When the controller 400 performs control in this way, as indicted by solid-line arrows in Fig. 3, a refrigerant discharged from the non-electrically driven compressor 201 of the non-electrically driven outdoor unit 200 branches at the branch portion 212. A part of the refrigerant flows to the first branch pipe 213 and is cooled by the outdoor heat exchanger 205a. Another part of the refrigerant flows to the second branch pipe 214, passes through the outdoor heat-exchange connection pipe 216, is combined at the combining portion 217, and is cooled by the outdoor heat exchanger 105 of the electrically driven outdoor unit 100.

[0089] In this case, because the decompressor 206b of the non-electrically driven outdoor unit 200 has been closed, the refrigerant does not flow to the outdoor heat exchanger 205b, which is positioned upstream of the radiator 209 in the airflow direction.

[0090] Because the electrically driven outdoor unit 100 includes the check valve 103, the refrigerant that has flowed into the electrically driven outdoor unit 100 through the outdoor heat-exchange connection pipe 216 does not flow to the electrically driven compressor 101 of the electrically driven outdoor unit 100 but flows into the outdoor heat exchanger 105.

[0091] Note that the controller 400 stops only the electrically driven compressor 101 of the electrically driven outdoor unit 100 and continues the operation of an outdoor fan (not shown) of the electrically driven outdoor unit 100.

[0092] Consequently, the refrigerant, which is discharged from the non-electrically driven compressor 201 of the non-electrically driven outdoor unit 200, releases heat in the outdoor heat exchanger 205a of the non-electrically driven outdoor unit 200 and the outdoor heat exchanger 105 of the electrically driven outdoor unit 100 and becomes a high-temperature high-pressure liquid refrigerant.

[0093] On the other hand, because the refrigerant does not flow to the outdoor heat exchanger 205b of the non-electrically driven outdoor unit 200, heat exchange between the refrigerant and external air is not performed in the outdoor heat exchanger 205b. Therefore, external air, whose temperature has not been increased, flows into the radiator 209, which is disposed downstream the outdoor heat exchanger 205b in the airflow direction.

[0094] That is, normally, a refrigerant that has been discharged from the non-electrically driven compressor 201 flows in parallel to the outdoor heat exchangers 205a and 205b of the non-electrically driven outdoor unit 200, in which the non-electrically driven compressor 201 is operating, and heat exchange is performed. However, in the present embodiment, the refrigerant does not flow to the outdoor heat exchanger 205b, which is positioned upstream of the radiator 209 in the airflow direction. As indicated by the solid-line arrows in Fig. 3, instead if flowing to the outdoor heat exchanger 205b, the refrigerant flows to the outdoor heat exchanger 105 of the electrically driven outdoor unit 100, in which the electrically driven compressor 101 has been stopped.

[0095] As a result, the inlet air temperature of the radiator 209, which is disposed downstream of the outdoor heat exchanger 205b of the non-electrically driven outdoor unit 200 in the airflow direction, is reduced as compared with a case where the refrigerant and air exchange heat in the outdoor heat exchanger 205b. Accordingly, the radiator 209 can release a sufficient amount of heat from the engine cooling water.

[0096] Because a sufficient amount of heat can be released from the engine cooling water, the temperature of the engine cooling water can be maintained at an appropriate temperature even when the operation of the non-electrically driven outdoor unit 200 is continued. Therefore, decrease of the rotation speed of the gas engine 208 due to increase in the temperature of the engine cooling water can be avoided, and desired air-conditioning performance can be achieved.

[0097] As described above, in the present embodiment, the air conditioner includes the outdoor heat exchanger 105 (first heat exchanger); the electrically driven compressor 101 (first compressor) that is driven by electric power; the outdoor heat exchanger 205a (first-second heat exchanger); the outdoor heat exchanger 205b (second-second heat exchanger); the non-electrically driven compressor 201 (second compressor) that is driven by a non-electric driving source; the radiator 209 that cools the non-electric driving source; a fan that blows air from the outdoor heat exchanger 205b toward the radiator 209; the indoor heat exchangers 301 (third heat exchanger); the on-off valve 215 (valve) that is disposed in the pipe; and the controller 400 that controls the on-off valve 215 to select one passage of the pipe, in which the refrigerant flows, from the group consisting of the first passage, the second passage, and the third passage. The outdoor heat exchanger 105, the electrically driven compressor 101, and the indoor heat exchangers 301 are present in the first passage. The non-electrically driven compressor 201 and the indoor heat exchangers 301 are present in the second passage. The second passage includes the branch portion 212 (first portion) and the combining portion 217 (second portion), the second passage branching to the first branch pipe 213 (first branch passage) and the second branch pipe 214 (second branch passage) at the branch portion 212, the first branch pipe 213 and the second branch pipe 214 being combined with each other at the combining portion 217. The outdoor heat exchanger 205a is present in the first branch pipe 213. The outdoor heat exchanger 205b is present in the second branch pipe 214. The outdoor heat exchanger 205a, the non-electrically driven compressor 201, the outdoor heat exchanger 105, and the indoor heat exchangers 301 are present in the third passage. The third passage includes the outdoor heat-exchange connection pipe 216 (connection passage) that connects a point in the second branch pipe 214 with a point in the first passage.

[0098] With such a structure, when the controller 400 selects the third passage, the refrigerant discharged from the non-electrically driven compressor 201 can be cooled by the outdoor heat exchanger 105 of the electrically driven outdoor unit 100. Thus, heat exchange between the refrigerant and external air is not performed in the outdoor heat exchanger 205b, so that external air, whose temperature has not been increased, flows into the radiator 209, which is disposed downstream of the outdoor heat exchanger 205b in the airflow direction. Accordingly, the radiator 209 can release a sufficient amount of heat from the engine cooling water.

[0099] As a result, because a sufficient amount of heat can be released from the engine cooling water, the temperature of the engine cooling water can be maintained at an appropriate temperature even when the operation of the non-electrically driven outdoor unit 200 is continued. Therefore, decrease of the rotation speed of the gas engine 208 due to increase in the temperature of the engine cooling water can be avoided, and desired air-conditioning performance can be achieved.

[0100] In the present embodiment, the on-off valve 215 (first valve) is disposed in the outdoor heat-exchange connection pipe 216, and the controller 400 opens the on-off valve 215 to select the third passage.

[0101] Thus, when the controller 400 opens the on-off valve 215, which is positioned in the outdoor heat-exchange connection pipe 216, to select the third passage, the refrigerant that is discharged from the non-electrically driven compressor 201 can flow through the outdoor heat-exchange connection pipe 216 and can be cooled by the outdoor heat exchanger 105 of the electrically driven outdoor unit 100.

[0102] As a result, heat exchange between the refrigerant and external air is not performed in the outdoor heat exchanger 205b, so that external air, whose temperature has not been increased, flows into the radiator 209, which is disposed downstream of the outdoor heat exchanger 205b in the airflow direction. Therefore, the radiator 209 can release a sufficient amount of heat from the engine cooling water.

[0103] In the present embodiment, the decompressor 206b (second valve) regulates the flow rate of the refrigerant flowing in the outdoor heat exchanger 205b, and the controller 400 closes the decompressor 206b to select the third passage.

[0104] Thus, when the controller 400 closes the decompressor 206b to select the third passage, the refrigerant that is discharged from the non-electrically driven compressor 201 does not flow to the outdoor heat exchanger 205b.

[0105] As a result, heat exchange between the refrigerant and external air is not performed in the outdoor heat exchanger 205b, and external air, whose temperature has not been increased, flows into the radiator 209, which is disposed downstream of the outdoor heat exchanger 205b in the airflow direction. Accordingly, the radiator 209 can release a sufficient amount of heat from the engine cooling water.

[0106] In the present embodiment, the outdoor heat exchanger 105 and the electrically driven compressor 101 constitute the electrically driven outdoor unit 100; the outdoor heat exchanger 205a, the outdoor heat exchanger 205b, and the non-electrically driven compressor 201 constitute the non-electrically driven outdoor unit 200; and the indoor heat exchangers 301 constitute of the indoor units 300.

[0107] Thus, the electrically driven outdoor unit 100 and the non-electrically driven outdoor unit 200, which are disposed outdoors, and the indoor units 300, which are disposed indoors, constitute the air conditioner.

[0108] In the present embodiment, the controller 400 selects the third passage when the electrically driven compressor 101 is stopped and only the non-electrically driven compressor 201 is operated.

[0109] Thus, when electricity demand is at a peak, for example, in a midsummer afternoon, the electrically driven compressor 101 is stopped and only the non-electrically driven compressor 201 is operated. Therefore, when electricity demand is at a peak, the controller 400 can select the third passage to reduce the inlet air temperature of the radiator 209, which is disposed downstream of the outdoor heat exchanger 205b in the airflow direction. Accordingly, the radiator 209 can release a sufficient amount of heat from the engine cooling water.

[0110] In the present embodiment, the radiator 209 is disposed downstream of the outdoor heat exchanger 205b of the non-electrically driven outdoor unit 200 in the airflow direction. The radiator 209 may be disposed downstream of both of the outdoor heat exchangers 205a and 205b in the airflow direction.

[0111] As described above, the air conditioner according to the present disclosure can be effectively used as an air conditioner that can perform a continuous operation while maintaining desired air-conditioning performance and leveling out electric power usage.

Claims

1. An air conditioner comprising:

a pipe in which a refrigerant flows;
a first heat exchanger (105);
a first compressor (101) that is driven by electric power;
a first-second heat exchanger (205a);
a second-second heat exchanger (205b);
a second compressor (201) that is driven by a non-electric driving source (208);
a radiator (209) that cools the non-electric driving source (208);
a fan that blows air from the second-second heat exchanger (205b) toward the radiator (209);
a third heat exchanger (301);
a valve that is disposed in the pipe; and
a controller (400) that controls the valve to select one passage of the pipe, in which the refrigerant flows, from the group consisting of a first passage, a second passage, and a third passage, wherein

the first heat exchanger (105), the first compressor (101), and the third heat exchanger (301) are present in the first passage,
the second compressor (201) and the third heat exchanger (301) are present in the second passage,
the second passage includes a first portion (212) and a second portion (217), the second passage branching to a first branch passage (213) and a second branch passage (214) at the first portion (212), the first branch passage (213) and the second branch passage (214) being combined with each other at the second portion (217),
the first-second heat exchanger (205a) is present in the first branch passage (213),
the second-second heat exchanger (205b) is present in the second branch passage (214),
the first-second heat exchanger (205a), the second compressor (201), the first heat exchanger (105), and the third heat exchanger (301) are present in the third passage, and
the third passage includes a connection passage (216) that connects a point in the second branch passage (214) with a point in the first passage.

2. The air conditioner according to claim 1, wherein
the valve includes a first valve (215) that is positioned in the connection passage (216), and
the controller (400) opens the first valve (215) to select the third passage.

3. The air conditioner according to claim 1 or 2, wherein
the valve includes a second valve (206b) that regulates a flow rate of the refrigerant flowing in the second-second heat exchanger (205b), and
the controller (400) closes the second valve (206b) to select the third passage.

4. The air conditioner according to any one of claims 1 to 3, wherein
the first heat exchanger (105) and the first compressor (101) constitute an electrically driven outdoor unit (100),
the first-second heat exchanger (205a), the second-second heat exchanger (205b), and the second compressor (201) constitute a non-electrically driven outdoor unit (200), and
the third heat exchanger (301) constitutes an indoor unit (300).

5. The air conditioner according to any one of claims 1 to 4, wherein
the controller (400) selects the third passage when the first compressor (101) is stopped and the second compressor (201) is operated.

FIG. 1

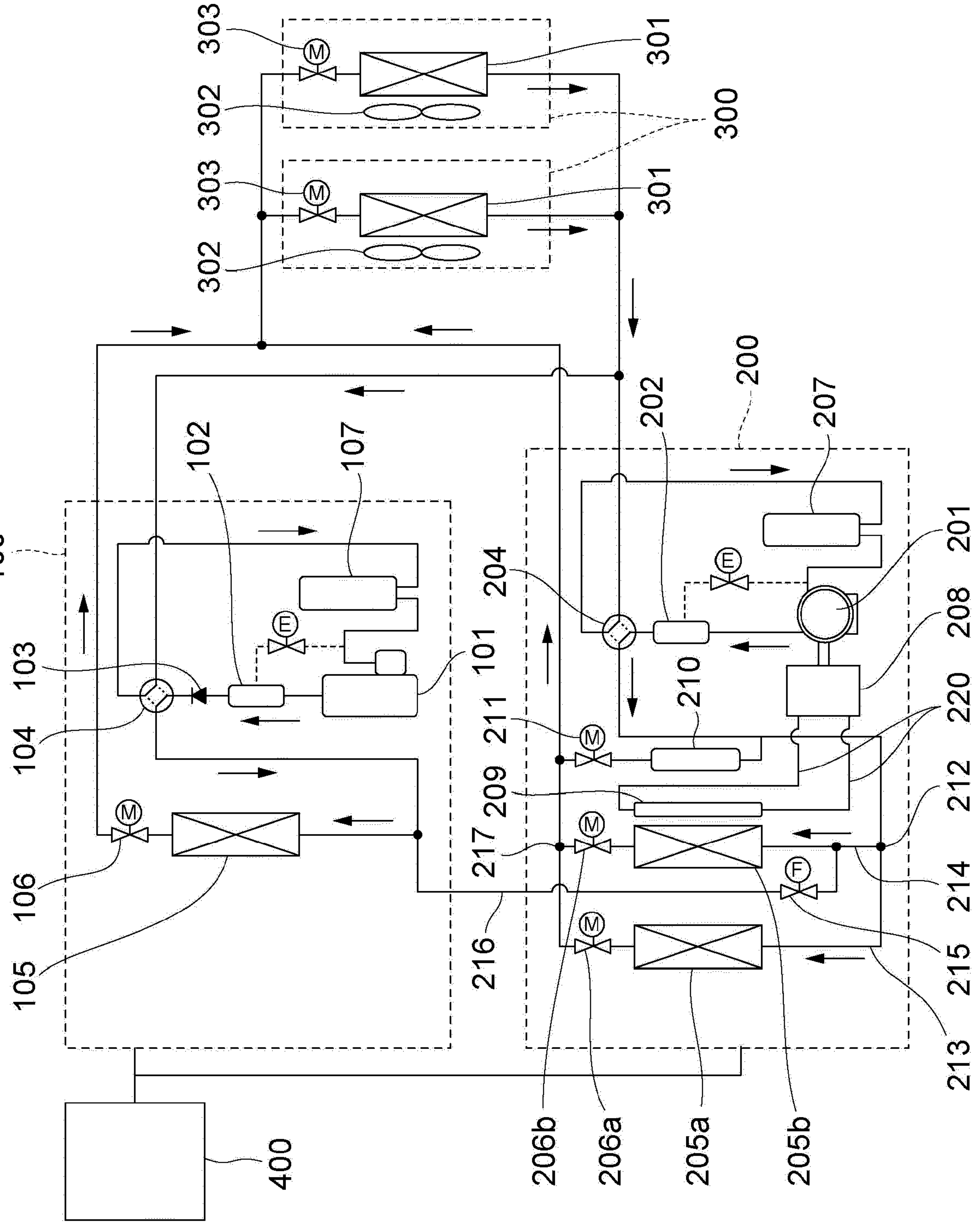
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FIG. 2

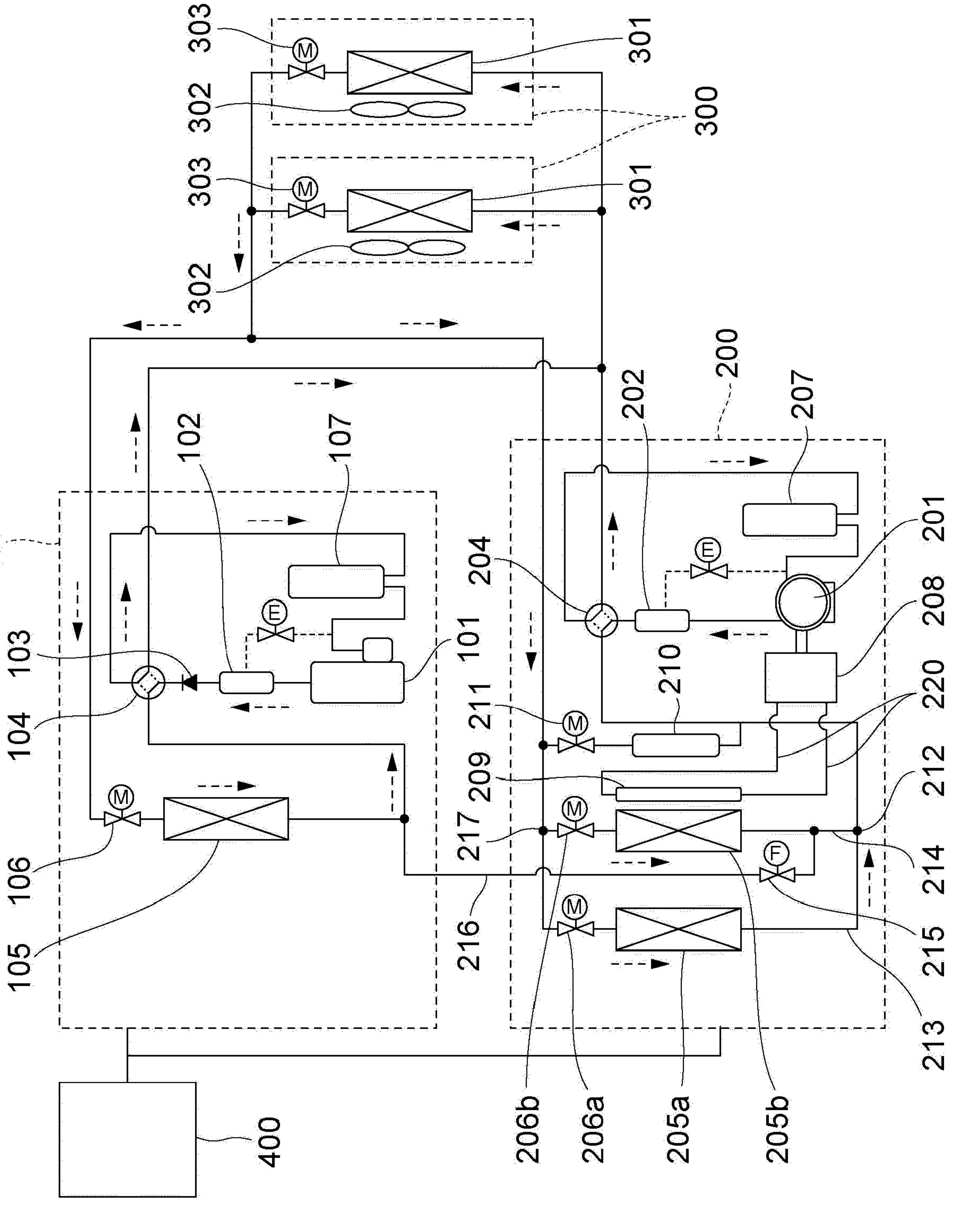

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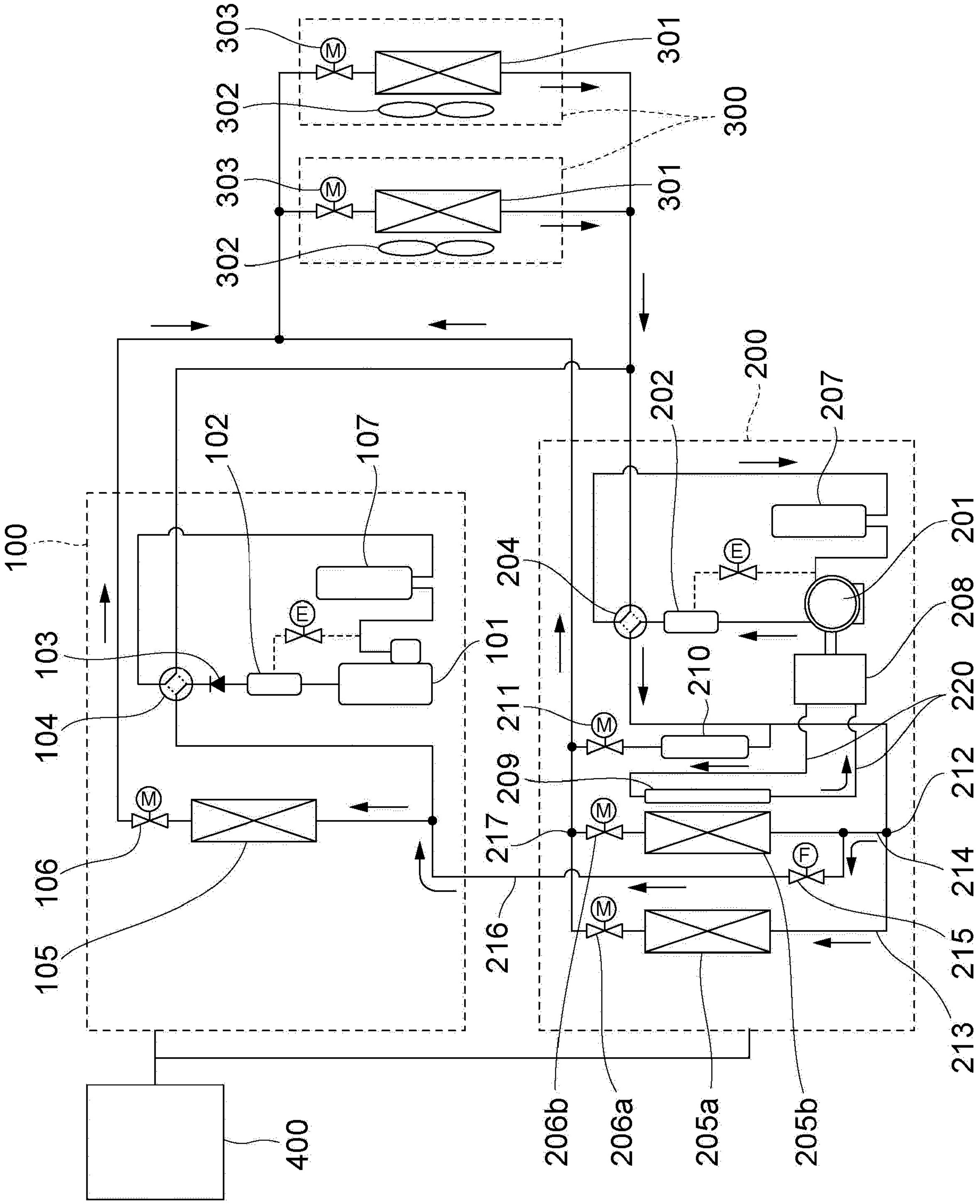
FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 16 20 2126

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