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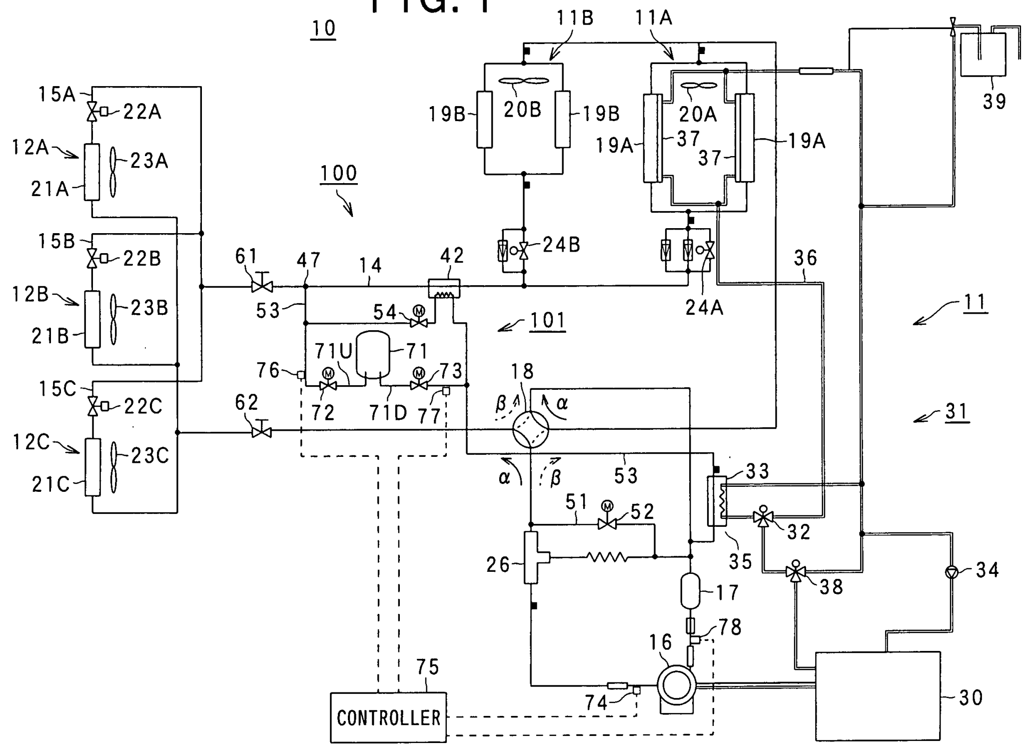
(54) **Air conditioner**

(57) An air conditioner (1) having a refrigerant circuit including a compressor (16), a four-way valve (18), outdoor heat exchangers (19, 19A, 19B) and indoor heat exchangers (21A, 21B, 21C) which are successively connected to one another through a refrigerant pipe (14) including a receiver tank (71) connected to the outdoor heat exchangers in parallel, and a refrigerant bypass circuit (101) for making a part of refrigerant to the suction side of the compressor through the receiver tank while bypassing the outdoor heat exchangers under heating operation.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an air conditioner, and particularly to a technique of keeping refrigerant pressure under heating operation to an optimum state.

2. Description of the Related Art

[0002] Energy-saving air conditioners have been hitherto required, and there has been known an air conditioner in which liquid refrigerant circulated and condensed in a refrigerating cycle is super-cooled to saturation temperature or less so that no residual gas is contained in refrigerant and then the refrigerant concerned is circulated to an evaporator, whereby the coefficient of performance (COP) of the refrigerating cycle of the air conditioner is enhanced (for example, see JP-A-6-281270).

[0003] Some air conditioners of this type use air heat exchangers for performing heat-exchange with air to super-cool liquid refrigerant. However, the air heat exchanger needs a very large heat transfer area and it is inefficient. Therefore, there has been proposed an air conditioner in which a part of liquid refrigerant being circulated is branched from the main flow of the liquid refrigerant , evaporated and then heat-exchanged with refrigerant before the branch, whereby the liquid refrigerant before the branch is super-cooled and thus the refrigerant circulation amount to the evaporator is reduced, thereby reducing the pressure loss of the refrigerant by the refrigerant pipe.

[0004] In the air conditioner, required refrigerant capacity is different between heating operation and cooling operation even in the same air conditioner, and the required refrigerant amount under heating operation may be smaller than that under cooling operation.

[0005] Therefore, in order to absorb extra refrigerant under heating operation, the air conditioner is provided with a receiver for stocking the extra refrigerant in a refrigerant pipe passage through which an indoor heat exchanger and an outdoor heat exchanger are connected to each other.

[0006] From the viewpoint of execution of an efficient air-conditioning operation, it is required to set the refrigerant amount in accordance with the operation state of the air conditioner. When the receiver tank is provided in the refrigerant pipe passage at all times, there is an advantage that a proper refrigerant amount can be maintained and thus excessive increase of the refrigerant pressure with respect to the optimum refrigerant pressure corresponding to the air-conditioning load can be avoided, however, there is a disadvantage that it is difficult to keep the pressure at the discharge side of the compressor high and thus the efficiency is lowered particularly under heating operation.

[0007] In order to avoid this problem, it may be considered that the receiver tank is separated from the refrigerant circuit so that the receiver tank is not used under cooling operation. However, in this case, the refrigerant remains in the receiver tank, and thus refrigerant may be not used effectively. Furthermore, the refrigerant pressure may be liable to be higher than the optimum pressure corresponding to the load.

SUMMARY OF THE INVENTION

[0008] Therefore, an object of the present invention is to provide an air conditioner in which refrigerant pressure can be kept to an optimum state in accordance with an operation state, particularly an operation state under heating operation.

[0009] In order to attain the above object, an air conditioner (1) having a refrigerant circuit including a compressor (16), a four-way valve (18), outdoor heat exchangers (19, 19A, 19B) and indoor heat exchangers (21A, 21B, 21C) which are successively connected to one another through a refrigerant pipe (14) is characterized by comprising: a receiver tank (71) connected to the outdoor heat exchangers in parallel; and a refrigerant bypass circuit (101) for making a part of refrigerant to the suction side of the compressor through the receiver tank while bypassing the outdoor heat exchangers under heating operation.

[0010] In the above air conditioner, the refrigerant bypass circuit may comprise a first valve (72) through which the refrigerant flows into the receiver tank, a second valve (73) through which the refrigerant flows out from the receiver tank, and a valve controller (75) for setting at least one of the first valve and the second valve to an open state under heating operation.

[0011] In the above air conditioner, the valve controller may set the first valve to an open state and set the second valve to a close state when refrigerant discharge pressure of the compressor is higher than a predetermined pressure range corresponding to a load under heating operation or cooling operation.

[0012] In the above air conditioner, the valve controller may set the first valve to a close state and set the second valve to an open state when the refrigerant discharge pressure of the compressor is lower than a predetermined pressure range under heating operation.

[0013] The above air conditioner may further comprise a liquid valve (54) connected to the refrigerant pipe (14) in parallel to the receiver tank, and an evaporator (42) that is connected to the receiver tank in series, evaporates the refrigerant flowing in the liquid valve or the receiver tank and makes the evaporated refrigerant flow to the suction side of the compressor.

[0014] In the above air conditioner, the valve controller may set the liquid valve to a close state and set the first valve and the second valve to an open state when the refrigerant discharge pressure of the compressor is in or higher than the predetermined pressure range under heating operation and also the refrigerant flow amount at the liquid valve is short.

[0015] In the above air conditioner, the first valve and the second valve are constructed as electromagnetic valves or electrically-operated valves.

[0016] According to the above air conditioner, the connection state of the receiver tank, that is, the operation state of the receiver tank is switched in accordance with the operation state of the refrigerant circuit, whereby a more proper refrigerant pressure status corresponding to a load or the operation state (operation condition) of the air conditioner can be maintained.

[0017] Furthermore, according to this invention, the air conditioner is equipped with the refrigerant bypass circuit for making a part of the refrigerant flow to the suction side of the compressor through the receiver tank under heating operation while bypassing the outdoor heat exchangers under heating operation. Therefore, the connection state of the receiver tank, that is, the operation state of the receiver tank is switched in accordance with the operation state of the refrigerant circuit by the refrigerant bypass circuit, whereby the more proper refrigerant pressure state corresponding to the load or the operation state (operation condition) of the air conditioner can be maintained, whereby the air-conditioning operation can be more efficiently performed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Fig. 1 is a diagram showing a refrigerant circuit showing an air conditioner according to an embodiment of the present invention;
Fig. 2 is a process flowchart under heating operation to change the operation mode of a receiver tank of the embodiment; and
Fig. 3 is a process flowchart under cooling operation to change the operation mode of the receiver tank of the embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0019] A preferred embodiment according to the present invention will be described hereunder with reference to the accompanying drawings.

[0020] Fig. 1 is a circuit diagram showing an air conditioner according to the present invention.

[0021] The air conditioner 10 is a gas heat pump type air conditioner, and has plural outdoor heat exchanger groups 11A and 11B which are connected in parallel, and plural (three in this embodiment) indoor units 12A, 12B and 12C.

[0022] A refrigerant pipe 14 connected to the outdoor heat exchanger groups 11A, 11B and respective indoor refrigerant pipes 15A, 15B, 15C connected to the indoor units 12A, 12B and 12C are joined to one another to constitute a part of a refrigerating cycle 100.

[0023] Each of the indoor units 12A, 12B and 12C is disposed in a room, and indoor heat exchangers 21A, 21B and 21C are connected to the indoor refrigerant pipes 15A, 15B and 15C. Indoor expansion valves 22A, 22B, 22C as pressure-reducing devices are disposed in the neighborhood of these indoor heat exchangers 21A, 21B, 21C so as to be connected to the indoor heat exchangers 21A, 21B, 21C. Furthermore, indoor fans 23A, 23B, 23C for blowing air to the indoor heat exchangers 21A, 21B, 21C are disposed so as to be adjacent to the indoor heat exchangers 21A, 21B, 21C.

[0024] A compressor 16 is connected to the refrigerant pipe 14 which is connected to the outdoor heat exchanger groups 11A, 11B, and an accumulator 17 is connected to the suction side of the compressor 16 while a four-way valve 18 is connected to the discharge side of the compressor 16 through an oil separator 26.

[0025] The compressor 16 is joined to a gas engine 30 through a power transmission belt (not shown), and driven by the gas engine 30. The gas engine 30 is cooled by cooling water flowing in an engine refrigerant system 31. In the engine cooling system 31, the gas engine 30, a cooling water bypass valve 38, a cooling water three-way valve 32, a waste heat withdrawing heat exchanger 33, a reserve tank 39 and a cooling water pump 34 are connected to a first cooling system pipe 35. A second cooling system pipe 36 to which a radiator 37 disposed so as to be adjacent to each outdoor heat exchanger 19A is connected to the cooling water three-way valve 32 at one end thereof, and connected to the suction side of the cooling water pump 34 at the other end thereof. The plural outdoor heat exchanger groups 11A, 11B, the compressor 16, the gas engine describe later, etc. are mounted in one housing, and constitute an outdoor unit 11.

[0026] The cooling water three-way valve 32 is opened to the radiator 37 side under cooling operation. By actuating the cooling water pump 34, cooling water is introduced into the radiator 37 to be radiated, and cools the gas engine 30.

[0027] Under heating operation of the air conditioner 10, the cooling water three-way valve 32 is opened to the waste heat withdrawing heat exchanger (sub evaporator) 33 side. At this time, by actuating the cooling water pump 34, the cooling water is introduced into the waste heat withdrawing heat exchanger 33, and heat-exchanged with liquid refrigerant circulated in the refrigerant pipe 14 at the outdoor side as described later to heat the refrigerant flowing in the refrigerant pipe 14 at the outdoor side, whereby the liquid refrigerant is evaporated and supplied to the suction side of the compressor 16 as gas refrigerant.

[0028] A cooling water bypass valve 38 is provide between the gas engine 30 and the cooling water three-way valve 32, and the cooling water bypass valve 38 is connected to the flow-in side of the cooling water pump

34.

[0029] The outdoor heat exchangers 19A, 19B and the outdoor expansion valves 24A, 24B as the pressure-reducing devices are successively connected to the four-way valve 18 into which refrigerant discharged from the compressor 16 flows, and a super-cooling heat exchanger (sub cooler) 42 is connected to the four-way valve 18 through these elements. Furthermore, outdoor fans 20A and 20B for making outdoor fan flow through the outdoor heat exchangers 19A, 19B are disposed so as to be adjacent to the outdoor heat exchangers 19A, 19B.

[0030] By switching the four-way valve 18, the air conditioner 10 is set to cooling operation or heating operation. That is, when the four-way valve 18 is switched to the heating side, refrigerant flows as indicated by a solid line arrow α, and the indoor heat exchangers 21A, 21B, 21C serve as condensers while the outdoor heat exchangers 19 serve as evaporators, whereby the operation state of the air conditioner is set to the heating operation state. Accordingly, each of the indoor heat exchangers 21A, 21B, 21C heats each room.

[0031] On the other hand, when the four-way valve 18 is switched to the cooling operation side, refrigerant flows as indicated by a broken-line arrow β, and the outdoor heat exchangers 19 serve as condensers while the indoor heat exchangers 21A, 21B, 21C serve as evaporators, whereby the operation state of the air conditioner is set to the cooling operation state. Accordingly, each of the indoor heat exchangers 21a, 21B, 21C cools each room.

[0032] Under heating operation, the valve opening degree of each of the outdoor expansion valve 24 and the indoor expansion valves 22a, 22B, 22C is adjusted in accordance with the air-conditioning load.

[0033] Furthermore, under cooling operation, the valve opening degree of each of the indoor expansion valves 22A, 22B, 22C is adjusted in accordance with the air-conditioning load, and the outdoor expansion valve 24 is fully opened.

[0034] In the outdoor heat exchanger groups 11A, 11B, a bypass pipe 51 is connected between the refrigerant high-pressure side (at the discharge side of the compressor 16) and the refrigerant low-pressure side (in front of the accumulator 17 in the example of Fig. 1), and a bypass valve 52 is provided to the bypass pipe 51.

[0035] The outdoor heat exchanger 11 is provided with a liquid pipe 53 for properly supplying liquid refrigerant flowing in the refrigerant pipe 14 at the outdoor side through the waste heat withdrawing heat exchanger 33 to the front side of the accumulator 17 provided at the suction side of the compressor 16 , and a liquid valve 54 is provided to the liquid pipe 53. A super-cooling heat exchanger 42 is provided between the liquid valve 54 and the waste heat withdrawing heat exchanger 33.

[0036] The super-cooling heat exchanger 42 is a plate fin type heat exchanger, and the super-cooling heat exchanger 42 is provided so that liquid refrigerant as cooling-side refrigerant which is expanded in the liquid valve 54 and flows at the evaporation side of the super-cooling heat exchanger 42 can be heat-exchanged with liquid refrigerant as cooled-side refrigerant which is condensed in the outdoor heat exchanger 19 and flows at the condensation side of the super-cooling heat exchanger 42. Accordingly, the super-cooling heat exchanger 42 cools the liquid refrigerant flowing at the condensation side of the super-cooling heat exchanger 42 to super-cool the liquid refrigerant. Or, the super-cooling heat exchanger 42 increases the super-cooling degree of the liquid refrigerant flowing at the condensation side while the liquid refrigerant has been already under the super-cooling state.

[0037] A receiver tank 71 is connected in parallel to the liquid valve 54, and also in parallel to the outdoor heat exchangers 19A, 19B, and an inlet valve 72 (= first valve) is connected between the inlet pipe 71U side of the receiver tank 71 and the refrigerant pipe 14, and an outlet valve 73 (= second valve) is connected between the outlet pipe 71D side of the receiver tank 71 and the liquid pipe 53. In this case, the inlet valve 72 and the outlet valve 73 are constructed by electromagnetic valves,however,they may be constructed by electrically-operated valve. The operation of the inlet valve 72 and the outlet valve 73 will be described later.

[0038] Furthermore, a discharge-side pressure detecting sensor 74 for detecting the discharge-side pressure of the refrigerant (refrigerant high-pressure side pressure) is provided at the discharge side of the compressor 16, and a suction side pressure detecting sensor 78 for detecting the suction-side pressure of the refrigerant (refrigerant low-pressure side pressure) is provided at the suction side of the compressor 16. Furthermore, there is provided a controller 75 for controlling the operation of the inlet valve 72 and the outlet valve 73 and also the receiver tank 71 on the basis of the discharge-side pressure detected by the discharge-side pressure detecting sensor 74 and the suction-side pressure detected by the suction-side pressure detecting sensor 78. The controller 75 controls the whole of the outdoor heat exchanger 11.

[0039] The accumulator 17 executes gas-liquid separation on gas refrigerant which flows into the compressor 16 after it is evaporated at the evaporation side of the super-cooling heat exchanger 42.

[0040] Next, the operation of the air conditioner according to this embodiment will be described.

[0041] First, the operation under heating operation according to the present invention will be described.

[0042] Under heating operation of the air conditioner 10, the four-way valve 18 is switched to the heating side, so that gas refrigerant flows as indicated by a solid-line arrow α. The gas refrigerant compressed by the compressor 16 flows into the indoor heat exchangers 21A, 21B, 21C.

[0043] The gas refrigerant flowing in the indoor heat exchangers 21A, 21B, 21C is heat-exchanged with indoor air in the indoor heat exchangers 21A, 21B, 21C to heat the room, and condensed to become liquid refrigerant.

[0044] The liquid refrigerant flowing out from the indoor heat exchangers 21A, 21B, 21C flows through the indoor expansion valves 22A, 22B, 22C and the condensation side of the super-cooling heat exchanger 42 into the outdoor heat exchangers 19A, 19B.

[0045] At this time, a part of the liquid refrigerant flowing through the indoor expansion valves 22A, 22B, 22C is branched from the main flow of the liquid refrigerant, and flows to the super-cooling cycle 101 side.

[0046] Here, the flow of the liquid refrigerant after it is branched and the operation of the receiver tank 71 will be described in detail.

[0047] Fig. 2 is a processing flowchart under heating operation to change the operation mode of the receiver tank according to this embodiment.

[0048] First, it is assumed that the air conditioner is under stop state in the initial state. In this case, under the stop state (step S11), the controller 75 of the air conditioner sets the inlet valve 72 connected to the receiver tank 71 to a close state and sets the outlet valve 73 to an open state, whereby the operation mode of the receiver tank is set to a second mode in which the receiver tank 71 is prohibited from functioning as a receiver tank in which extra refrigerant is stocked (step S12).

[0049] Subsequently, when the start of the heating operation is instructed by a user (step S13), it is determined whether the compressor 16 is under operation or not (step S14).

[0050] If the operation of the compressor 16 is stopped in the determination of the step S14 (step S14; No), the processing is set to a standby state.

[0051] If the compressor 16 is under operation in the determination of the step S14 (step S14; Yes), the controller 75 determines on the basis of the discharge side pressure detected by the discharge-side pressure detecting sensor 74 whether the refrigerant pressure level of the discharge side (refrigerant high-pressure side) of the compressor 16 is under an excessively high state in which the refrigerant pressure level concerned exceeds a refrigerant pressure level range proper to the load (step S15).

[0052] If the refrigerant pressure level of the discharge side of the compressor 16 is under the excessively high state concerned (step S15; Yes), the processing shifts to the processing of reducing the refrigerant pressure to set the refrigerant pressure level to the refrigerant pressure level range proper to the load. That is, in order to reduce the refrigerant pressure, the controller 75 determines whether the present operation mode of the receiver tank 71 is the second mode or not (step S16). If the present operation mode of the receiver tank 71 is not the second mode in the determination of the step S16 (step S16; No), the processing is shifted to step S24 described later.

[0053] If the present operation mode of the receiver tank 71 is the second mode in the determination of the step S16 (step S16; Yes), the controller 75 executes a switching preparatory operation of adjusting the pressure difference between the inlet valve 72 and the outlet valve 73 connected to the receiver tank 71 on the basis of the pressure detected by each of the inlet side pressure sensor 76 and the outlet side pressure sensor 77 so that the pressure difference concerned is equal to a predetermined pressure difference under which the inlet valve 72 and the outlet valve 73 can be surely operated (step S18).

[0054] When the pressure difference between the inlet valve 72 and the outlet valve 73 connected to the receiver tank 71 is set to the predetermined pressure difference which can make the inlet valve 72 and the outlet valve 73 operate surely by the switching preparatory operation, the controller 75 sets the inlet valve 72 and the outlet valve 73 connected to the receiver tank 71 to the open state and the close state respectively, and sets the operation mode of the receiver tank 71 to a first mode in which the receiver tank 71 functions as a buffer tank for absorbing pressure variation of the refrigerant (step S18).

[0055] In the first mode, the discharge-side refrigerant pressure of the compressor 16 can be prevented from excessively increasing, and this is particularly effective to a small-capacity indoor unit operation under heating operation or a high indoor/outdoor temperature operation.

[0056] Subsequently, the controller determines whether the stop of the operation of the air conditioner 10 is instructed by the user (step S19).

[0057] If the stop of the operation of the air conditioner 10 is instructed in the determination of the step S19 (step S19; Yes), the processing shifts to the step S11, and stops the operation of the air conditioner.

[0058] If the stop of the operation of the air conditioner 10 is not instructed in the determination of the step S19 (step S19; No), the processing shifts to the step S14 again, and the same processing is subsequently executed.

[0059] On the other hand, if the refrigerant pressure level at the discharge side of the compressor 16 does not exceed the refrigerant pressure level range proper to the load in the determination of the step S15 (step S15; No), it is determined whether the refrigerant pressure level at the discharge side of the compressor 16 exceeds the refrigerant pressure level range proper to the load and is set to an excessively low state (step S20).

[0060] If the refrigerant pressure level at the discharge side of the compressor 16 exceeds the refrigerant pressure level range proper to the load and is set to the excessively low state (step S20; Yes) in the determination of step S20, it is determined whether the present operation mode of the receiver tank 71 is set to the first mode for making the receiver tank 71 function as a buffer tank for adsorbing the pressure variation of the refrigerant (step S21).

[0061] If the present operation mode of the receiver tank 71 is not set to the first mode for making the receiver tank 71 function as the buffer tank (step S21; No), the processing is shifted to step S24 described later.

[0062] If the present operation mode of the receiver tank 71 is the first mode for making the receiver tank 71 as a buffer tank in the determination of the step S21 (step S21; Yes), the switching preparatory operation of adjusting the pressure difference between the inlet valve 72 and the outlet valve 73 connected to the receiver tank 71 so that the pressure difference concerned is equal to a predetermined pressure difference under which the inlet valve 72 and the outlet valve 73 can be surely operated (step S22).

[0063] When the pressure difference between the inlet valve 72 and the outlet valve 73 connected to the receiver tank 71 is equal to the predetermined pressure difference under with the inlet valve 72 and the outlet valve 73 can be surely operated by the switching preparatory operation, the controller 75 sets the inlet valve 72 connected to the receiver tank 71 to the close state while setting the outlet valve 73 to the open state, thereby setting the second mode in which the receiver tank 71 is made to function as the buffer tank (step S23).

[0064] In this second mode, the operation can be performed so that the pressure at the discharge side of the compressor 16 (at the refrigerant high-pressure side) can be kept high, and high COP operation can be performed under heating operation.

[0065] Subsequently, the controller 75 shifts the processing to step S19 to perform the same processing.

[0066] On the other hand, if the present operation mode of the receiver tank 71 is not the second mode in the determination of the step S16 (step S16; No), the controller determines whether the present operation mode of the receiver tank is the first mode or not (step S24).

[0067] If the present operation mode of the receiver tank 71 is not the first mode in the determination of the step S24, the processing is shifted to the step S19 to perform the same processing.

[0068] If the present operation mode of the receiver tank 71 is the first mode in the determination of the step S24 (step S24; Yes), the controller 75 determines whether the refrigerant flow amount in the liquid valve 54 is short or the like (step S25).

[0069] If the refrigerant flow amount is not short in the liquid valve 54 in the determination of the step S25, that is, if the refrigerant flow amount is sufficient in the liquid valve 54, the controller 75 shifts the processing to the step S19 to perform the same processing.

[0070] If the refrigerant flow amount is short in the liquid valve 54 in the determination of the step S25 (step S25; Yes), the controller 75 performs the switching preparatory operation of adjusting the pressure difference between the inlet valve 72 and the outlet valve 73 so that the pressure difference concerned is equal to a predetermined pressure difference under which the inlet valve 72 and the outlet valve 73 can be surely operated (step S26).

[0071] Subsequently, the controller 75 sets a third mode in which the inlet valve 72 and the outlet valve 73 connected to the receiver tank 71 are set to the open state to use the receiver tank 71 as a part of the liquid circuit containing the liquid valve 54 and make the refrigerant flow through the receiver tank 71 (step S27), and shifts the processing to the step S19 to perform the same processing. In this third mode, the deficiency of the refrigerant which flows through the liquid valve 54 and flows into the waste heat withdrawing heat exchanger (sub evaporator) 33 (see Fig. 1)is compensated.

[0072] The liquid refrigerant flowing in the super-cooling cycle 101 flows to the evaporation side of the super-cooling heat exchanger 42. Accordingly, the liquid refrigerant as the cooled-side refrigerant flowing at the condensation side of the super-cooling heat exchanger 42 is heat-exchanged with the gas refrigerant as the cooling-side refrigerant which flows at the evaporation side of the super-cooling heat exchanger 42 and evaporates, whereby the liquid refrigerant flowing at the condensation side is cooled and set to a super-cooling state.

[0073] The refrigerant flowing at the evaporation side of the super-cooling heat exchanger 42 and the refrigerant flowing in the receiver tank 71 in the third mode flow into the waste heat withdrawing heat exchanger 33.

[0074] At this time, as described above, the cooling water three-way valve 32 of the gas engine 30 is opened to the waste heat withdrawing heat exchanger 33 side to cool the gas engine 30, and the cooling water withdrawing the waste heat is led to the waste heat withdrawing heat exchanger 33. Accordingly, the liquid refrigerant is heat-exchanged with the cooling water withdrawing the waste heat of the gas engine 30 in the waste heat withdrawing heat exchanger 33 and heated, so that the liquid refrigerant becomes gas refrigerant. The gas refrigerant concerned is subjected to gas-liquid separation in the accumulator 17, and then sucked into the compressor 16.

[0075] The liquid refrigerant which is cooled in the super-cooling heat exchanger 42 is passed through the outdoor expansion valve 24A or the outdoor expansion valve 24B and expanded, and then flows into the outdoor heat exchanger 19A or the outdoor heat exchanger 19B. Then, the liquid refrigerant flowing into the outdoor heat exchangers 19A, 19B is heat-exchanged with outdoor air in the outdoor heat exchangers 19A, 19B and evaporated, so that the liquid refrigerant becomes gas refrigerant. The gas refrigerant concerned passes through the four-way valve 18 and flows into the accumulator 17, and then it is subjected to gas-liquid separation in the accumulator 17 and then sucked into the compressor 16.

[0076] As described above, according to the present invention, when the discharge-side pressure of the compressor 16 is higher than the predetermined pressure range corresponding to the load under hating operation, the inlet valve 72 connected to the receiver tank 71 is set to the open state, and the outlet valve 73 is set to the close state, so that the refrigerant pressure can be prevented from excessively increasing during the operation of a small-capacity indoor unit or in the high indoor/outdoor temperature operation.

[0077] Furthermore, when the discharge-side pressure of the compressor 16 is lower than the predetermined pressure range corresponding to the load under heating operation, the inlet valve 72 is set to the close state and the outlet valve 73 is set to the open state, so that the operation can be performed with keeping the pressure at the refrigerant high-pressure side high even when the rotational number of the engine is set to a lower value as compared with a case where a conventional receiver tank is used, and the high COP operation can be performed in the rated capacity operation of the indoor unit or in the heating start-up operation under low indoor temperature.

[0078] Furthermore, when the discharge-side pressure of the compressor 16 is in or higher than the predetermined pressure range corresponding to the load and also the refrigerant flow amount at the liquid valve 54 is short, the liquid valve 54 is set to the close state and both the inlet valve 72 and the outlet valve 73 are set to the open state, so that the deficiency of the refrigerant flow amount can be compensated and thus a more proper operation state can be set. It is not necessarily required to close the liquid valve 54. In short, the refrigerant amount flowing into the waste heat withdrawing heat exchanger 33 may be secured by the parallel circuit of the receiver tank 71 and the liquid valve 54.

[0079] Next, the operation under cooling operation will be described.

[0080] First, the operation under cooling operation will be described.

[0081] As described above, under cooling operation of the air conditioner 10, the four-way valve 18 is switched to the cooling side, and gas refrigerant flows as indicated by a broken-line arrow β. The gas refrigerant compressed by the compressor 16 flows into the outdoor heat exchanger 19. The gas refrigerant flowing into the outdoor heat exchanger 19 is heat-exchanged with outdoor air in the outdoor heat exchangers 19A, 19B to be cooled, so that the gas refrigerant becomes liquid refrigerant.

[0082] The liquid refrigerant flowing out from the outdoor heat exchangers 19A, 19B flows through the condensation side of the super-cooling heat exchanger 42 and flows into the indoor units 12A, 12B, 12C. At this time, a part of the liquid refrigerant flowing through the condensation side of the super-cooling heat exchanger 42 is branched and flows into the super-cooling cycle 101. The liquid refrigerant flowing in the super-cooling cycle 101 flows to the evaporation side of the super-cooling heat exchanger 42 through the liquid valve 54. Accordingly, the gas refrigerant as the cooling-side refrigerant flowing at the evaporation side of the super-cooling heat exchanger 42 is evaporated, and also it is heat-exchanged with the liquid refrigerant as the cooled-side refrigerant flowing at the condensation side, thereby cooling the liquid refrigerant flowing at the condensation side and setting the liquid refrigerant to the super-cooling state.

[0083] The liquid refrigerant which is cooled in the super-cooling heat exchanger 42 and flows into the indoor units 12A, 12B, 12C is expanded in the indoor expansion valves 22A, 22B, 22C, and heat-exchanged with indoor air in the indoor heat exchangers 21A, 21B, 21C to cool the room, and also the liquid refrigerant is evaporated and becomes gas refrigerant.

[0084] The gas refrigerant flowing out from the indoor heat exchangers 21A, 21B, 21C flows into the accumulator 17 through the four-way valve 18, subjected to gas-liquid separation in the accumulator 17 and then sucked into the compressor 16.

[0085] Fig. 3 is a processing flowchart under heating operation to change the operation mode of the receiver tank according to this embodiment.

[0086] First, assuming that the air conditioner 10 is under stop state in the initial state, the controller 75 of the air conditioner sets the operation mode of the receiver tank under the stop state (step S31) to the secondmode in which the inlet valve 72 connected to the receiver tank 71 to the close state, the outlet valve 73 connected to the receiver tank 71 is set to the close state and the receiver tank 71 is prohibited from functioning as a receiver tank for stocking extra refrigerant (step S32).

[0087] Subsequently, when the start of the cooling operation is instructed by the user (step S33), it is determined whether the compressor 16 is under operation or not (step S34).

[0088] If the operation of the compressor 16 is stopped in the determination of the step S34 (step S34; No), the processing is set to the standby state.

[0089] If the operation of the compressor 16 is under operation in the determination of the step S14 (step S34; Yes), the controller 75 determines on the basis of the discharge-side pressure detected by the discharge-side pressure detecting sensor 74 whether the refrigerant pressure level of the discharge side of the compressor 16 (the refrigerant high-pressure side) exceeds the refrigerant pressure level range proper to the load and thus it is under an excessively high state (step S35).

[0090] If it is determined in step S35 that the refrigerant pressure level at the discharge side of the compressor 16 (the refrigerant high-pressure side) exceeds the refrigerant pressure level range proper to the load and thus it is excessively high (step S35; Yes), the processing is shifted to the processing of reducing the refrigerant pressure to set the refrigerant pressure level within the refrigerant pressure level range proper to the load. That is, in order to reduce the refrigerant pressure, the controller 75 determines whether the present operation mode of the receiver tank 71 is the second mode (step S36).

[0091] If it is determined in step S36 that the present operation mode of the receiver 71 is not the second mode (step S36; No), the processing is shifted to step S39 described later.

[0092] If it is determined in step S36 that the present operation mode of the receiver tank 71 is the second mode (step S36; Yes), the controller 75 executes the switching preparatory operation of adjusting the pressure difference between the inlet valve 72 and the outlet valve 73 connected to the receiver tank 71 on the basis of the pressure detected by each of the inlet-side pressure sensor 76 and the outlet-side pressure sensor 77 so that the pressure difference concerned is equal to the predetermined pressure difference under which the inlet valve 72 and the outlet valve 73 can be surely operated (step S37).

[0093] When the switching preparatory operation makes the pressure difference between the inlet valve 72 and the outlet valve 73 connected to the receiver tank 71 equal to the predetermined pressure difference under which the inlet valve 72 an the outlet valve 73 can be surely operated, the controller 75 sets the inlet valve 72 connected to the receiver tank 71 to the open state and sets the outlet valve 73 to the close state, thereby setting the present operation mode to the first mode in which the receiver tank 71 is made to function as a buffer tank for absorbing the pressure variation of the refrigerant (step S38).

[0094] In this first mode, the discharge-side refrigerant pressure of the compressor 16 can be prevented from excessively increasing.

[0095] Here, the reason why the operation is executed in the first mode under cooling operation will be described.

[0096] It is required to control the capacity (power) in accordance with the refrigerant pressure level at the suction side (low-pressure side) of the compressor under cooling operation. That is, the capacity is controlled in accordance with the refrigerant pressure level detected by the suction-side pressure detecting sensor 78, and thus the refrigerant pressure level at the discharge side (high-pressure side) of the compressor is increased, so that there occurs such a state that the operation is carried out under a state that the load of the engine 30 (= the driving load of the compressor) is large..

[0097] At this time, in the second mode, the receiver tank 71 functions as the buffer tank, and thus the refrigerant pressure level at the discharge side (refrigerant high-pressure side) of the compressor can be suppressed from being higher than a required value, and the air conditioner can be driven with reducing the load of the engine 30.

[0098] Subsequently, the controller 75 determines whether the stop of the operation of the air conditioner 10 is instructed by the user (step S39).

[0099] If it is determined in step S39 that the stop of the operation of the air conditioner 10 is instructed (step S39; Yes), the processing is shifted to step S31 to stop the operation of the air conditioner.

[0100] If it is determined in step S39 that the stop of the operation of the air conditioner 10 is not instructed (step S39; No), the processing is shifted to step S34 again, and the same processing is executed.

[0101] On the other hand, if it is determined in step S35 that the refrigerant pressure level at the discharge side of the compressor 16 does not exceed the refrigerant pressure level range proper to the load (step S35; No), it is judged whether the refrigerant capacity is short (refrigerant deficiency) (step S40).

[0102] If it is determined in step S40 that the refrigerant capacity is not short (refrigerant is not deficient) (step S40; No), the processing is shifted to step S39 to perform the same processing.

[0103] If it is determined in step S40 that the refrigerant capacity is short (refrigerant is deficient) (step S40; Yes), it is judged the present operation of the receiver tank 71 is set to the first mode in which the receiver tank 71 is made to function as a buffer tank for absorbing the pressure variation of the refrigerant (step S41).

[0104] If it is determined instep S41 that the present operation mode of the receiver tank 71 is not the first mode in which the receiver tank 71 is made to function as a buffer tank (step S41; No), the processing is shifted to step S39 to execute the same processing.

[0105] If it is determined in step S41 that the present operation of the receiver tank 71 is set to the first mode in which the receiver tank 71 is made to function as a buffer receiver (step S41; Yes), the controller executes the switching preparatory operation of adjusting the pressure difference between the inlet valve 72 and the outlet valve 73 connected to the receiver tank 71 is equal to the predetermined pressure difference under which the inlet valve 72 and the outlet valve 73 can be surely operated (step S42).

[0106] When the switching preparatory operation sets the pressure difference between the inlet valve 72 and the outlet valve 73 connected to the receiver tank 71 to the predetermined pressure difference under which the inlet valve 72 and the outlet valve 73 can be surely operated, the controller 75 sets the inlet valve 72 connected to the receiver tank 71 to the close state and sets the outlet valve 73 to the close state, thereby setting the receiver tank 71 to the second mode in which the receiver tank 71 functions as a buffer tank (step S43)>

[0107] Subsequently, the controller 75 shifts the processing to step S39 to executes the same processing.

[0108] On the other hand, if it is determined in step S36 that the present operation mode of the receiver tank 71 is not the second mode (step S36; No), the processing is shifted to step S39 to execute the same processing.

[0109] As a result, under cooling operation, even when refrigerant remains in the receiver tank 71, refrigerant can be taken into the refrigerant circuit through the outlet valve 73 in accordance with the condition of the refrigerant circuit, and the refrigerant which unnecessarily remains in the receiver tank can be reduced, so that the cooling operation can be efficiently executed.

[0110] Furthermore, the refrigerant pressure level at the discharge side (high-pressure side) of the compressor can be suppressed from being needlessly increased due to the control of the capacity in accordance with the refrigerant pressure level at the suction side (low-pressure side) of the compressor, and the air conditioner can be driven with reducing the load of the engine 30.

[0111] As described above, according to this embodiment, the optimum refrigerant amount can be kept in accordance with the driving condition, and the refrigerant high pressure can be kept to the state under which the high COP operation can be performed, and the efficient air-conditioning operation can be performed.

[0112] Furthermore, the load of the driving source (the engine 30 in this invention) of the compressor can be suppressed from needlessly increasing.

Claims

1. An air conditioner (1) having a refrigerant circuit including a compressor (16), a four-way valve (18), outdoor heat exchangers (19, 19A, 19B) and indoor heat exchangers (21A, 21B, 21C) which are successively connected to one another through a refrigerant pipe (14), comprising:

a receiver tank (71) connected to the outdoor heat exchangers in parallel; and
a refrigerant bypass circuit (101) for making a part of refrigerant to the suction side of the compressor through the receiver tank while bypassing the outdoor heat exchangers under heating operation.

2. The air conditioner according to claim 1, wherein the refrigerant bypass circuit comprises a first valve (72) through which the refrigerant flows into the receiver tank, a second valve (73) through which the refrigerant flows out from the receiver tank, and a valve controller (75) for setting at least one of the first valve and the second valve to an open state under heating operation.

3. The air conditioner according to claim 1, wherein the valve controller sets the first valve to an open state and sets the second valve to a close state when refrigerant discharge pressure of the compressor is higher than a predetermined pressure range corresponding to a load under heating operation or cooling operation.

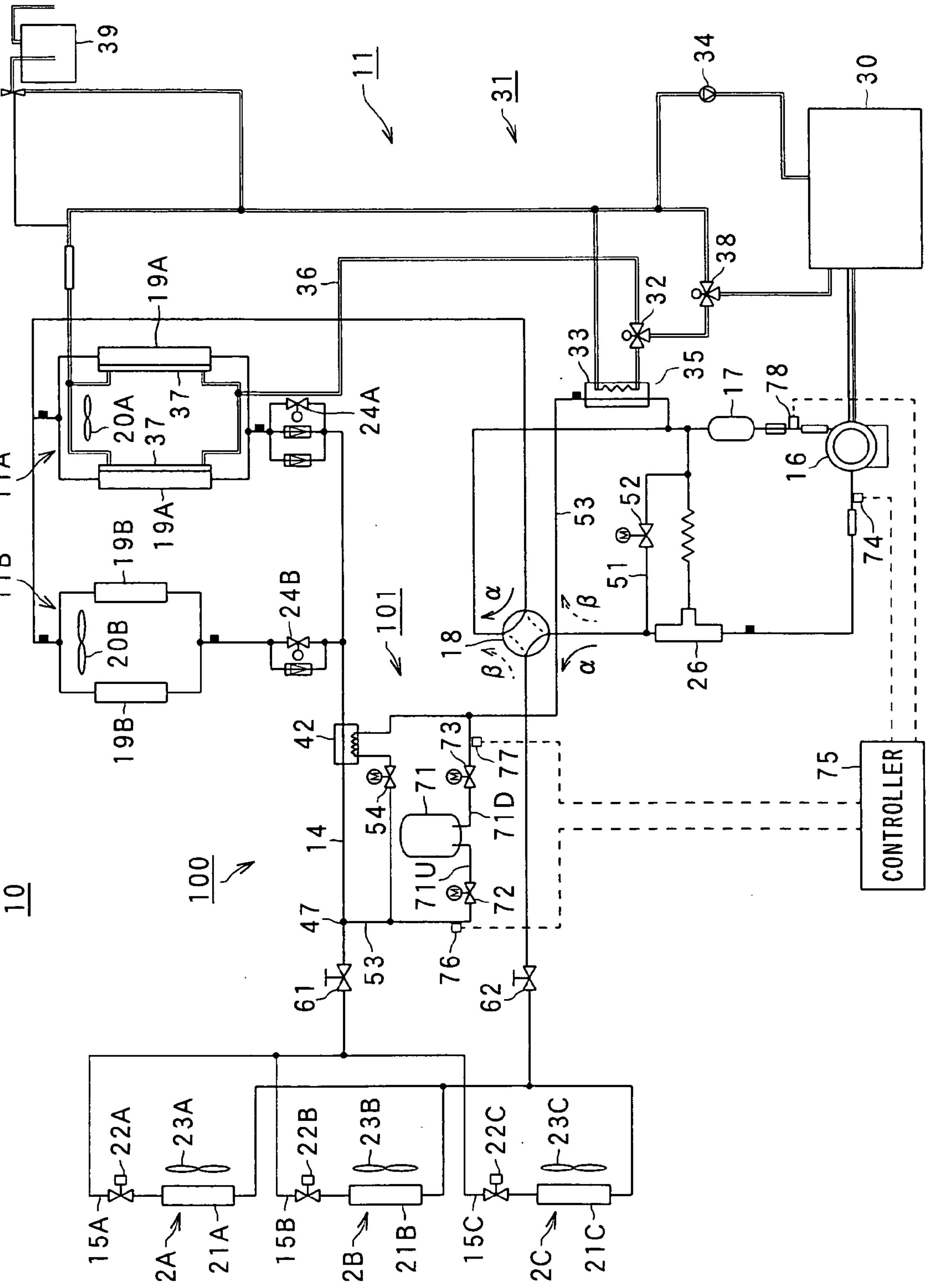
4. The air conditioner according to claim 1, wherein the valve controller sets the first valve to a close state and sets the second valve to an open state when the refrigerant discharge pressure of the compressor is lower than a predetermined pressure range under heating operation.

5. The air conditioner according to claim 1, further comprising a liquid valve (54) connected to the refrigerant pipe (14)in parallel to the receiver tank, and an evaporator (42) that is connected to the receiver tank in series, evaporates the refrigerant flowing in the liquid valve or the receiver tank and makes the evaporated refrigerant flow to the suction side of the compressor.

6. The air conditioner according to claim 5, wherein the valve controller sets the liquid valve to a close state and sets the first valve and the second valve to an open state when the refrigerant discharge pressure of the compressor is in or higher than the predetermined pressure range under heating operation and also the refrigerant flow amount at the liquid valve is short.

7. The air conditioner according to claim 1, wherein the first valve and the second valve are constructed as electromagnetic valves or electrically-operated valves.

FIG. 1


10
11
11A
11B
12A
12B
12C
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15B
15C
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21A
21B
21C
22A
22B
22C
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23B
23C
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24B
26
30
31
32
33
34
35
36
37
38
39
42
47
51
52
53
54
61
62
71
71U
71D
72
73
74
75
76
77
78
100
101
α
β
CONTROLLER

FIG. 2

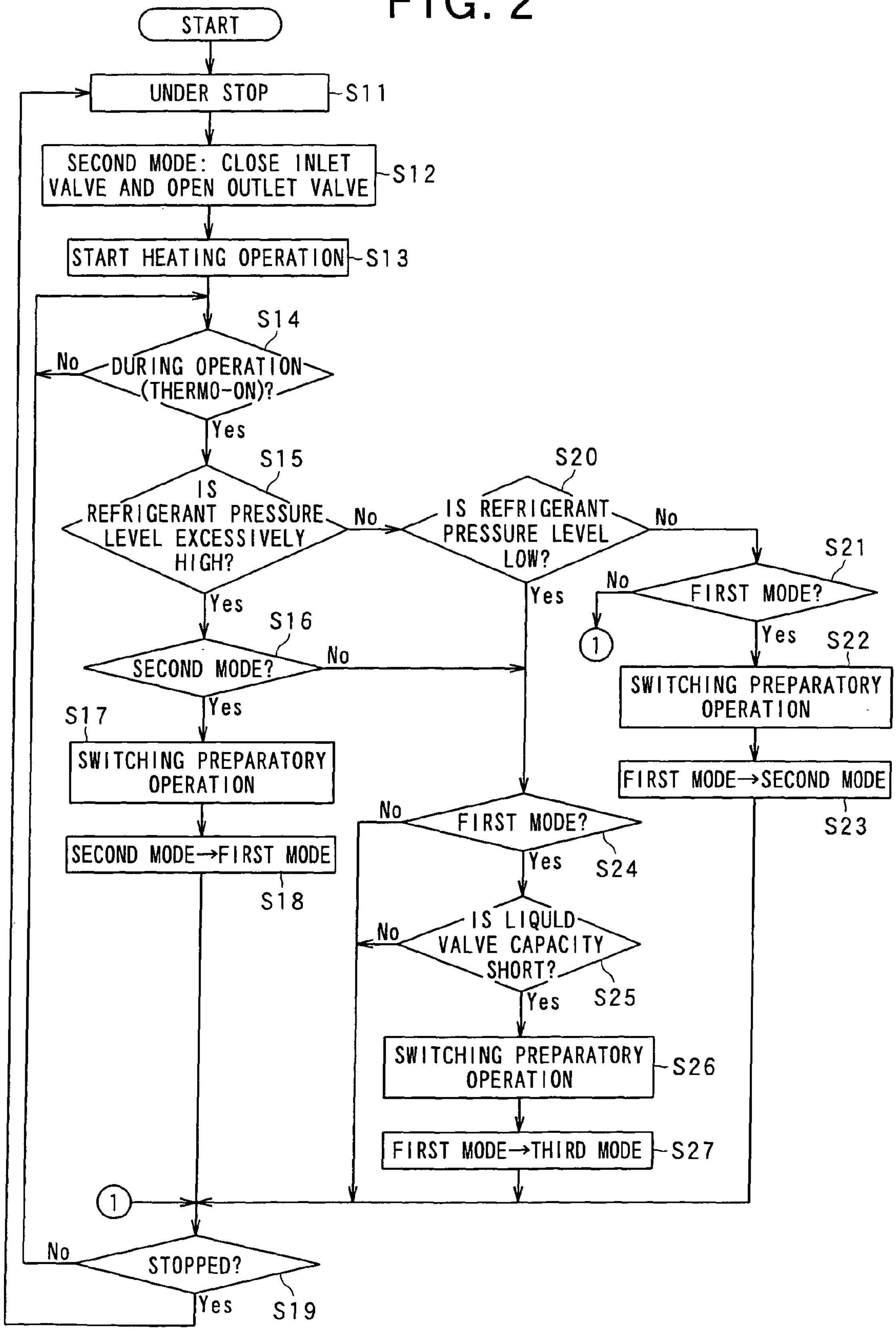
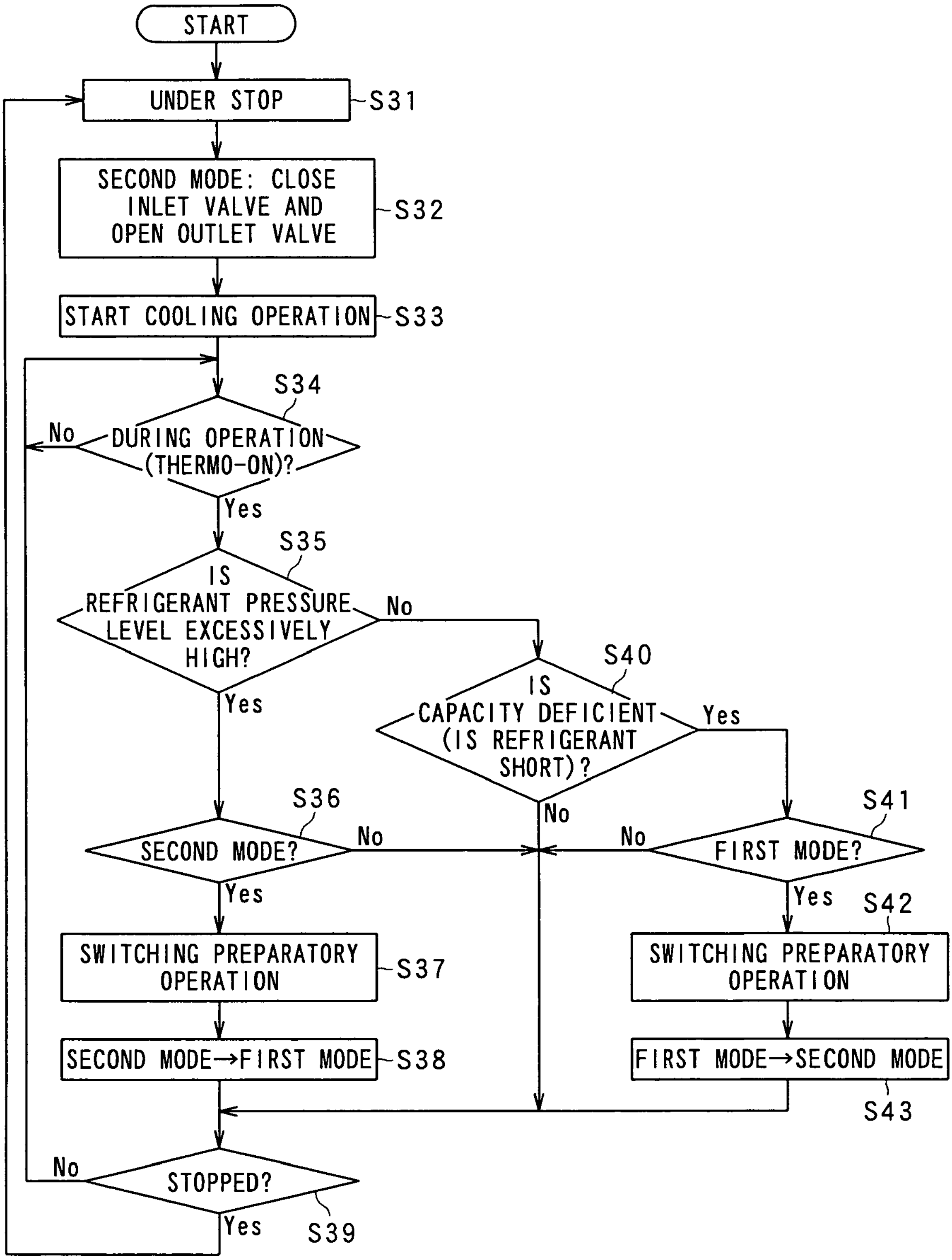

START
UNDER STOP
S11
SECOND MODE: CLOSE INLET VALVE AND OPEN OUTLET VALVE
S12
START HEATING OPERATION
S13
S14
DURING OPERATION (THERMO-ON)?
No
Yes
S15
IS REFRIGERANT PRESSURE LEVEL EXCESSIVELY HIGH?
No
Yes
S20
IS REFRIGERANT PRESSURE LEVEL LOW?
No
Yes
S21
FIRST MODE?
No
Yes
1
S22
SWITCHING PREPARATORY OPERATION
FIRST MODE→SECOND MODE
S23
S16
SECOND MODE?
No
Yes
S17
SWITCHING PREPARATORY OPERATION
SECOND MODE→FIRST MODE
S18
FIRST MODE?
No
Yes
S24
IS LIQULD VALVE CAPACITY SHORT?
No
Yes
S25
SWITCHING PREPARATORY OPERATION
S26
FIRST MODE→THIRD MODE
S27
1
STOPPED?
No
Yes
S19

FIG. 3


START
UNDER STOP
S31
SECOND MODE: CLOSE INLET VALVE AND OPEN OUTLET VALVE
S32
START COOLING OPERATION
S33
S34
DURING OPERATION (THERMO-ON)?
No
Yes
S35
IS REFRIGERANT PRESSURE LEVEL EXCESSIVELY HIGH?
No
Yes
S40
IS CAPACITY DEFICIENT (IS REFRIGERANT SHORT)?
Yes
No
S36
SECOND MODE?
No
Yes
S41
FIRST MODE?
No
Yes
SWITCHING PREPARATORY OPERATION
S37
SECOND MODE→FIRST MODE
S38
S42
SWITCHING PREPARATORY OPERATION
FIRST MODE→SECOND MODE
S43
STOPPED?
No
Yes
S39

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6281270 A **[0002]**