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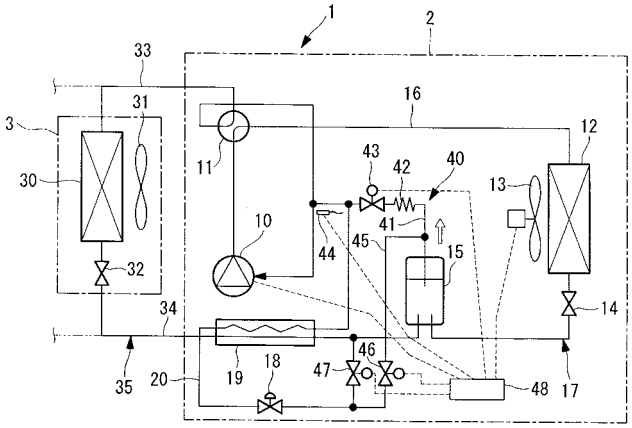
(54) AIR CONDITIONER AND REFRIGERANT AMOUNT DETECTION METHOD FOR AIR CONDITIONER

(57) An air conditioner and a refrigerant amount detection method for an air conditioner are provided that can always detect a refrigerant filling amount with high accuracy without specially providing heating means in a liquid level detecting circuit, even under a low outside air temperature. An air conditioner (1) that has a supercooling circuit (20) includes: a first liquid level detecting circuit (40) that connects a predetermined height position of a receiver (15) and an intake side of a compressor (10) via the supercooling circuit (20); a second liquid level detecting circuit (45) that is branched from a bypass circuit (41) of the first liquid level detecting circuit (40) and that acts as a bypass for leading refrigerant taken out from the receiver (15) to the supercooling circuit (20); a temperature detecting unit (44) that detects the temperature of refrigerant that has been decompressed by passing through the first liquid level detecting circuit (40) or the second liquid level detecting circuit (45); and a refrigerant amount detecting unit (48) that detects, by means of the temperature detecting unit (44), the temperature after decompression of refrigerant taken out from the receiver (15) via the first liquid level detecting circuit (40) or the second liquid level detecting circuit (45), and determines a refrigerant filling amount based on the temperature.

FIG. 1



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Description

{Technical Field}

[0001] The present invention relates to an air conditioner in which an optimal amount of refrigerant can always be filled at a time of installation, and a refrigerant amount detection method for an air conditioner.

{Background Art}

[0002] A multi-type air conditioner that is used for air-conditioning a building or the like has a configuration in which an outdoor unit that includes a compressor, a four-way switching valve, an outdoor heat exchanger, a heating expansion valve, a receiver, and an outdoor fan and the like, and a plurality of indoor units that include an indoor heat exchanger, a cooling expansion valve, and an indoor fan and the like, are connected at the installation site by gas refrigerant piping and liquid refrigerant piping. According to this kind of air conditioner, a predetermined amount of refrigerant is filled in advance into the outdoor unit, and when performing a test operation after installing the air conditioner at the installation site, refrigerant of an amount that corresponds to an insufficient amount of refrigerant in accordance with the length of piping that connects the outdoor unit and indoor units, the number of indoor units that are connected and the like, is additionally filled into the outdoor unit.

[0003] With respect to the aforementioned type of air conditioner, Patent Literature 1 (hereunder abbreviated as "PTL 1"} and Patent Literature 2 (hereunder abbreviated as "PTL 2") disclose technology configured to determine that a required amount of refrigerant is filled in a refrigerant circuit so that a filling amount of refrigerant that is additionally added to an outdoor unit need not depend on operations at the construction work level at the installation site. According to the aforementioned technology, a liquid level detecting circuit is provided that, when performing refrigerant filling operation, detects that a liquid refrigerant that is being accumulated inside a receiver in a refrigerant circuit has reached a predetermined liquid level. By detecting that liquid refrigerant of a predetermined liquid level is accumulated in the receiver by means of the liquid level detecting circuit, it is possible to ensure that an appropriate amount of refrigerant is always added to an outdoor unit.

[0004] The aforementioned PTL 1 discloses technology in which a bypass circuit that includes an on/off valve, a decompression mechanism, and a temperature detecting unit is connected to a compressor intake side from a predetermined height position of a receiver. Further, PTL 2 discloses technology in which an on/off valve, a decompression mechanism, heating means and a temperature detecting unit are provided in a bypass circuit. According to the technology disclosed in PTL 2, the temperature of a refrigerant after decompression is measured in a case where gas refrigerant in a saturated state is taken out from the receiver to the bypass circuit and a case where liquid refrigerant in a saturated state is taken out from the receiver to the bypass circuit, respectively, and a refrigerant amount is determined by detecting that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based on a temperature difference between the two measured temperatures.

{Citation List}

{Patent Literature}

[0005]

{PTL 1}
Japanese Unexamined Patent Application, Publication No. 2002-350014 (see Fig. 1)
{PTL 2}
The Publication of Japanese Patent No. 3719246 (see Fig. 1)

{Summary of Invention}

{Technical Problem}

[0006] However, in the case of the technology disclosed in PTL 1, when gas refrigerant in a saturated state is taken out and decompressed under pressure conditions in which the outside air temperature or the like is high, a discharge-side pressure (high pressure) of the compressor increases, and the slope of a saturated gas line descends diagonally from the upper left to the lower right on a pressure-enthalpy diagram, the refrigerant may enter a two-phase state of gas and liquid. In such case, there is the problem that there is a risk that a sudden drop in the temperature of the refrigerant will be detected and it will be erroneously determined that the liquid refrigerant has reached a predetermined liquid level, and consequently the detection accuracy can not be ensured.

[0007] To solve the above described problem, in the technology disclosed in PTL 2, a configuration is adopted that attempts to improve detection accuracy by providing heating means that heats refrigerant that has been decompressed by a decompression mechanism in a liquid level detecting circuit. According to that technology, a temperature difference can be adequately ensured by utilizing a fact that when refrigerant taken out from a receiver is in a gaseous state, an increase in the temperature thereof produced by heating is large, while when refrigerant taken out from a receiver is in a liquid state, thermal energy produced by heating is consumed as latent heat of vaporization and an increase in the temperature thereof is small. However, since it is essential to provide heating means in the liquid level detecting circuit, there is the problem that the configuration is complicated. Further, with respect to the technology disclosed in both PTL 1 and PTL 2, there is the inherent problem that when a discharge-side pressure (a high-pressure pressure) is

not increased sufficiently due to a low outside air temperature or the like, a degree of superheat of gas refrigerant that is taken out of a receiver can not be ensured, and thus the detection accuracy declines.

[0008] The present invention has been made in view of the above described circumstances, and an object of the present invention is to provide an air conditioner and a refrigerant amount detection method for an air conditioner which can always detect a refrigerant filling amount with high accuracy even under a condition of a low outside air temperature, without specially providing heating means in a liquid level detecting circuit.

{Solution to Problem}

[0009] To solve the above-described problems, the air conditioner and refrigerant amount detection method for an air conditioner of the present invention employ the following solutions.

That is, an air conditioner according to a first aspect of the present invention constitutes a closed-cycle refrigerant circuit in which an outdoor unit that includes a compressor, an outdoor heat exchanger, a heating expansion valve, a receiver that stores a liquid refrigerant, and a supercooling circuit that, after diverting a flow of one part of a liquid refrigerant and decompressing the refrigerant by means of a decompression mechanism, causes the refrigerant to exchange heat with a liquid refrigerant at a supercooling heat exchanger and returns the refrigerant to an intake side of the compressor and the like, and an indoor unit that includes an indoor heat exchanger and a cooling expansion valve and the like are connected by gas refrigerant piping and liquid refrigerant piping; the air conditioner including: a first liquid level detecting circuit in which an on/off valve and a decompression mechanism are interposed in a bypass circuit that connects a predetermined height position of the receiver and an intake side of the compressor via the supercooling circuit; a second liquid level detecting circuit that is branched from the bypass circuit and in which an on/off valve is interposed that acts as a bypass for leading a refrigerant that is taken out from the receiver to an inlet side of a decompression mechanism of the supercooling circuit; a temperature detecting unit that detects a temperature of decompressed refrigerant that passes through the supercooling circuit including the first liquid level detecting circuit or the second liquid level detecting circuit; and a refrigerant amount detecting unit that detects, by means of the temperature detecting unit, a temperature after decompression of a refrigerant that is taken out from the receiver via the first liquid level detecting circuit or the second liquid level detecting circuit, and determines a refrigerant filling amount based on the temperature.

[0010] The air conditioner according to the first aspect includes: a first liquid level detecting circuit in which an on/off valve and a decompression mechanism are interposed in a bypass circuit that connects a predetermined height position of a receiver and an intake side of a compressor via a supercooling circuit; a second liquid level detecting circuit that is branched from the bypass circuit and in which an on/off valve is interposed that acts as a bypass for leading a refrigerant that is taken out from the receiver to an inlet side of a decompression mechanism of the supercooling circuit; a temperature detecting unit that detects a temperature of decompressed refrigerant that passes through the supercooling circuit including the first liquid level detecting circuit or the second liquid level detecting circuit; and a refrigerant amount detecting unit that detects, by means of the temperature detecting unit, a temperature after decompression of a refrigerant that is taken out from the receiver via the first liquid level detecting circuit or the second liquid level detecting circuit, and determines a refrigerant filling amount based on the temperature. Accordingly, under a temperature condition of a cooling rating extent, by allowing refrigerant to flow from the receiver into the first liquid level detecting circuit and detecting a refrigerant temperature after decompression in a case where a saturated gas refrigerant is taken out from the receiver and a case where a saturated liquid refrigerant is taken out from the receiver, respectively, it is possible to reliably detect that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based on a temperature difference between the two detected refrigerant temperatures. On the other hand, under a condition of a low outside air temperature, in a case where the pressure of the receiver decreases due to a decrease in a high pressure and a saturated gas refrigerant is taken out, it has not been possible to adequately ensure a degree of superheat even if a refrigerant temperature after decompression is detected and, consequently, it has not been possible to make a rigorous distinction between such a case and a case in which a saturated liquid refrigerant is taken out, and there has been the possibility that an erroneous determination will be made. However, even under such a condition, by causing a saturated gas refrigerant that is taken out from the receiver to flow into the supercooling circuit via the second liquid level detecting circuit, the gas refrigerant is heated by being caused to exchange heat with liquid refrigerant at the supercooling heat exchanger and the degree of superheat can be sufficiently increased. Hence, it is possible to reliably detect that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based on a temperature difference between such a case and a case where a saturated liquid refrigerant is taken out from the receiver. Accordingly, the above described temperature difference can be sufficiently ensured under a wide range of temperature conditions without being influenced by fluctuations in a high pressure caused by an outside air temperature or the like, and a refrigerant filling amount can be detected with high accuracy. It is therefore possible to fill an optimum amount of refrigerant that is neither excessive nor insufficient to enable stable operation of the air conditioner. Further, since refrigerant can be heated utilizing the supercooling circuit, it is not necessary to specially provide heating means on the first liquid level

detecting circuit side, and thus the configuration can be simplified.

[0011] An air conditioner according to a second aspect of the present invention is in accordance with the above described air conditioner, wherein an electromagnetic on/off valve that is closed at a time of refrigerant filling operation and is opened at a time of normal cooling or heating operation is provided in a vicinity of a branch portion from the refrigerant circuit of the supercooling circuit.

[0012] Since the air conditioner according to the second aspect is provided with an electromagnetic on/off valve that is closed at a time of refrigerant filling operation and is opened at a time of normal cooling or heating operation in a vicinity of a branch portion from the refrigerant circuit of the supercooling circuit, switching between refrigerant filling operation and normal cooling or heating operation can be simply carried out by only performing an operation to open or close the electromagnetic on/off valve. Therefore, in addition to enhancing the capacity at a time of normal operation, the supercooling circuit is also used as a liquid level detecting circuit at a time of refrigerant filling operation, and can contribute to improving the accuracy of detecting a refrigerant filling amount.

[0013] An air conditioner according to a third aspect of the present invention constitutes a closed-cycle refrigerant circuit in which an outdoor unit that includes a compressor, an outdoor heat exchanger, a heating expansion valve, and a receiver that stores a liquid refrigerant and the like, and an indoor unit that includes an indoor heat exchanger and a cooling expansion valve and the like are connected by gas refrigerant piping and liquid refrigerant piping; the air conditioner including: a liquid level detecting circuit in which an on/off valve and a decompression mechanism are interposed in a bypass circuit that connects a predetermined height position of the receiver and an intake side of the compressor; a hot gas bypass circuit including an on/off valve and a decompression mechanism that is capable of introducing a portion of a hot gas from a discharge side of the compressor to the intake side thereof; a temperature detecting unit that is capable of detecting a temperature of a refrigerant that passes through the liquid level detecting circuit or a refrigerant in which the refrigerant that passes through the liquid level detecting circuit and a hot gas that is introduced via the hot gas bypass circuit are mixed; and a refrigerant amount detecting unit that detects, by means of the temperature detecting unit, a temperature after decompression of a refrigerant that is taken out from the receiver to the liquid level detecting circuit or of a mixed refrigerant composed of the refrigerant that is taken out from the receiver and a refrigerant that is introduced via the hot gas bypass circuit, and determines a refrigerant filling amount based on the temperature.

[0014] The air conditioner according to the third aspect includes: a liquid level detecting circuit in which an on/off valve and a decompression mechanism are interposed in a bypass circuit that connects a predetermined height position of a receiver and an intake side of a compressor; a hot gas bypass circuit that includes an on/off valve and a decompression mechanism that is capable of introducing a portion of a hot gas from a discharge side of the compressor to the intake side thereof; a temperature detecting unit that is capable of detecting a temperature of a refrigerant that passes through the liquid level detecting circuit or a refrigerant in which the refrigerant that passes through the liquid level detecting circuit and a hot gas that is introduced via the hot gas bypass circuit are mixed; and a refrigerant amount detecting unit that detects, by means of the temperature detecting unit, a temperature after decompression of a refrigerant that is taken out from the receiver to the liquid level detecting circuit or of a mixed refrigerant composed of the refrigerant that is taken out from the receiver and a refrigerant that is introduced via the hot gas bypass circuit, and determines a refrigerant filling amount based on the temperature. Accordingly, under a temperature condition of a cooling rating extent, a refrigerant temperature after decompression can be detected in a case where a gas refrigerant in a saturated state is taken out from the receiver to the liquid level detecting circuit and a case where a saturated liquid refrigerant is taken out from the receiver to the liquid level detecting circuit, respectively, and it is possible to detect that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based on a temperature difference between the two detected refrigerant temperatures. On the other hand, under a condition of a low outside air temperature, in a case where the pressure inside the receiver decreases due to a decrease in a high pressure and a saturated gas refrigerant is taken out, it has not been possible to adequately ensure a degree of superheat even if a refrigerant temperature after decompression is detected and, consequently, it has not been possible to make a rigorous distinction between such a case and a case in which a saturated liquid refrigerant is taken out, and there has been the possibility that an erroneous determination will be made. However, even under such a condition, since the degree of superheat can be sufficiently ensured by heating the saturated gas refrigerant that is taken out from the receiver by mixing the gas refrigerant with a hot gas that is introduced via the hot gas bypass circuit, it is possible to detect that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based on a temperature difference between such a case and a case where a saturated liquid refrigerant is taken out. Accordingly, the above described temperature difference can be sufficiently ensured under a wide range of temperature conditions without being influenced by fluctuations in a high pressure caused by an outside air temperature or the like, and a refrigerant filling amount can be detected with high accuracy. It is therefore possible to fill an optimum amount of refrigerant that is neither excessive nor insufficient to enable stable operation of the air conditioner.

[0015] A refrigerant amount detection method for an air conditioner according to a fourth aspect of the present

invention is a refrigerant amount detection method for the above described air conditioner that, at a time of refrigerant filling operation, under a temperature condition of a cooling rating extent, performs liquid-level detection by closing the second liquid level detecting circuit by means of the on/off valve and using the first liquid level detecting circuit, and under a condition of a low outside air temperature, performs liquid-level detection by closing the first liquid level detecting circuit by means of the on/off valve and using the second liquid level detecting circuit.

[0016] According to the fourth aspect, in the above described air conditioner, at a time of refrigerant filling operation, under a temperature condition of a cooling rating extent, detection of a liquid level is performed by closing the second liquid level detecting circuit by means of the on/off valve and using the first liquid level detecting circuit, and under a condition of a low outside air temperature, detection of a liquid level is performed by closing the first liquid level detecting circuit by means of the on/off valve and using the second liquid level detecting circuit. As a result, without being influenced by an outside air temperature, by using either of the first liquid level detecting circuit and the second liquid level detecting circuit, it is possible to detect under a wide range of temperature conditions that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based on a temperature difference between a case where a saturated gas refrigerant is taken out from the receiver and a case where a saturated liquid refrigerant is taken out from the receiver, and thus a refrigerant filling amount can be detected with high accuracy. Accordingly, it is possible to fill an optimum amount of refrigerant that is neither excessive nor insufficient into the air conditioner.

[0017] A refrigerant amount detection method for an air conditioner according to a fifth aspect of the present invention is a refrigerant amount detection method for the above described air conditioner that, at a time of refrigerant filling operation, performs liquid-level detection under a temperature condition of a cooling rating extent by using only the liquid level detecting circuit, and performs liquid-level detection under a condition of a low outside air temperature by using both the liquid level detecting circuit and the hot gas bypass circuit.

[0018] According to the fifth aspect, in the above described air conditioner, at a time of refrigerant filling operation, detection of a liquid level is performed using only the liquid level detecting circuit under a temperature condition of a cooling rating extent, and is performed using both the liquid level detecting circuit and the hot gas bypass circuit under a condition of a low outside air temperature. As a result, without being influenced by an outside air temperature, by using either the liquid level detecting circuit or the liquid level detecting circuit and the hot gas bypass circuit, it is possible to detect under a wide range of temperature conditions that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based on a temperature difference between a case where a saturated gas refrigerant is taken out from the receiver and a case where a saturated liquid refrigerant is taken out from the receiver, and thus a refrigerant filling amount can be detected with high accuracy. Accordingly, it is possible to fill an optimum amount of refrigerant that is neither excessive nor insufficient into the air conditioner.

{Advantageous Effects of Invention}

[0019] According to the air conditioner and the refrigerant amount detection method for an air conditioner of the present invention, under a temperature condition of a cooling rating extent, by allowing a refrigerant to flow from the receiver into the first liquid level detecting circuit and detecting a refrigerant temperature after decompression in a case where a saturated gas refrigerant is taken out from the receiver and a case where a saturated liquid refrigerant is taken out from the receiver, respectively, it is possible to reliably detect that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based on a temperature difference between the two detected refrigerant temperatures. On the other hand, under a condition of a low outside air temperature, by causing a saturated gas refrigerant that is taken out from the receiver to flow into the supercooling circuit via the second liquid level detecting circuit, the saturated gas refrigerant is heated by being caused to exchange heat with liquid refrigerant at the supercooling heat exchanger and the degree of superheat can be sufficiently increased. Hence, it is possible to reliably detect that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based on a temperature difference between such a case and a case where a saturated liquid refrigerant is taken out from the receiver. Accordingly, the above described temperature difference can be sufficiently ensured under a wide range of temperature conditions without being influenced by fluctuations in a high pressure caused by an outside air temperature or the like, and a refrigerant filling amount can be detected with high accuracy. It is therefore possible to fill an optimum amount of refrigerant that is neither excessive nor insufficient to enable stable operation of the air conditioner. Further, since refrigerant can be heated utilizing the supercooling circuit, it is not necessary to specially provide heating means on the first liquid level detecting circuit side, and thus the configuration can be simplified.

[0020] Further, according to the air conditioner and the refrigerant amount detection method for an air conditioner of the present invention, under a temperature condition of a cooling rating extent, a refrigerant temperature after decompression can be detected in a case where a gas refrigerant in a saturated state is taken out from the receiver to the liquid level detecting circuit and a case where a saturated liquid refrigerant is taken out from the receiver to the liquid level detecting circuit, respectively, and it is possible to detect that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based

on a temperature difference between the two detected refrigerant temperatures. On the other hand, under a condition of a low outside air temperature, since the degree of superheat can be sufficiently increased by heating the saturated gas refrigerant that is taken out from the receiver by mixing the gas refrigerant with a hot gas that is introduced via the hot gas bypass circuit, it is possible to detect that liquid refrigerant of a predetermined liquid level is accumulated in the receiver based on a temperature difference between such a case and a case where a saturated liquid refrigerant is taken out. Accordingly, the above described temperature difference can be sufficiently ensured under a wide range of temperature conditions without being influenced by fluctuations in a high pressure caused by an outside air temperature or the like, and a refrigerant filling amount can be detected with high accuracy. It is therefore possible to fill an optimum amount of refrigerant that is neither excessive nor insufficient to enable stable operation of the air conditioner.

{Brief Description of Drawings}

[0021]

{Fig. 1} Fig. 1 is a refrigerant circuit diagram of an air conditioner according to a first embodiment of the present invention.

{Fig. 2} Fig. 2 is a pressure-enthalpy diagram in a case where, in the air conditioner shown in Fig. 1, a saturated gas refrigerant is caused to flow in a bypassing manner through a first liquid level detecting circuit at a time of a high temperature.

{Fig. 3} Fig. 3 is a pressure-enthalpy diagram in a case where, in the air conditioner shown in Fig. 1, a saturated liquid refrigerant is caused to flow in a bypassing manner through the first liquid level detecting circuit at a time of a high temperature.

{Fig. 4} Fig. 4 is a pressure-enthalpy diagram in a case where, in the air conditioner shown in Fig. 1, a saturated gas refrigerant is caused to flow in a bypassing manner through the first liquid level detecting circuit at a time of a low temperature.

{Fig. 5} Fig. 5 is a pressure-enthalpy diagram in a case where, in the air conditioner shown in Fig. 1, a saturated gas refrigerant is caused to flow in a bypassing manner through a second liquid level detecting circuit at a time of a low temperature.

{Fig. 6} Fig. 6 is a refrigerant circuit diagram (one portion is omitted) of an air conditioner according to a second embodiment of the present invention.

{Fig. 7} Fig. 7 is a pressure-enthalpy diagram in a case where, in the air conditioner shown in Fig. 6, a mixed refrigerant of a saturated gas refrigerant and a hot gas is caused to flow in a bypassing manner through a liquid level detecting circuit and a hot gas bypass circuit at a time of a low temperature.

{Fig. 8} Fig. 8 is a pressure-enthalpy diagram in a case where, in the air conditioner shown in Fig. 6, a mixed refrigerant of a saturated liquid refrigerant and a hot gas is caused to flow in a bypassing manner through a liquid level detecting circuit and a hot gas bypass circuit at a time of a low temperature.

{Description of Embodiments}

[0022] Embodiments of the present invention are described hereunder with reference to the drawings.

{First Embodiment}

[0023] A first embodiment of the present invention is described hereunder using Fig. 1 to Fig. 5.

Fig. 1 is a refrigerant circuit diagram of an air conditioner according to the first embodiment of the present invention.

An air conditioner 1 is a multi-type air conditioner that is used to air condition a building or the like. The air conditioner 1 includes an outdoor unit 2 and a plurality of indoor units 3 that are connected to each other in parallel (only one indoor unit 3 is shown in Fig. 1).

[0024] The outdoor unit 2 includes a compressor 10 that compresses a refrigerant, a four-way switching valve 11 that switches a circulation direction of a refrigerant, an outdoor heat exchanger 12 that causes a heat exchange to take place between outside air and a refrigerant, an outdoor fan 13 that causes outside air to flow through the outdoor heat exchanger 12, a motor-operated expansion valve for heating (heating expansion valve) 14, and a receiver 15 that accumulates condensed liquid refrigerant. An outdoor-side refrigerant circuit 17 is constituted by connecting the compressor 10, the four-way switching valve 11, the outdoor heat exchanger 12, the motor-operated expansion valve for heating 14, and the receiver 15 in sequence through refrigerant piping 16.

[0025] The refrigerant circuit 17 is provided with a supercooling circuit 20 configured to carry out supercooling of a liquid refrigerant in a supercooling heat exchanger 19 by diverting one portion of the liquid refrigerant, and after decompressing the liquid refrigerant using a supercooling expansion valve (decompression mechanism) 18, returning the liquid refrigerant to an intake side of the compressor 10 via the supercooling heat exchanger 19.

[0026] An indoor heat exchanger 30, an indoor fan 31 that causes indoor air to circulate through the indoor heat exchanger 30, a motor-operated expansion valve for cooling (cooling expansion valve) 32 and the like are arranged inside the indoor unit 3. The indoor unit 3 and the outdoor unit 2 are connected through gas refrigerant piping 33 and liquid refrigerant piping 34 to thereby constitute a closed-cycle refrigerant circuit 35. A plurality of the indoor units 3 are connected in parallel through gas refrigerant piping 33 and liquid refrigerant piping 34 that branches from the gas refrigerant piping 33 and the liquid refrigerant piping 34.

[0027] The air conditioner 1 is configured to be capable of performing cooling operation by causing the outdoor

heat exchanger 12 to function as a condenser and causing the indoor heat exchanger 30 to function as an evaporator. When performing cooling operation, the air conditioner 1 causes a refrigerant that has been discharged from the compressor 10 to circulate to the outdoor heat exchanger 12 side through the four-way switching valve 11, and causes the refrigerant to circulate in a clockwise direction in the order of the receiver 15, the supercooling heat exchanger 19, the motor-operated expansion valve for cooling 32, the indoor heat exchanger 30, the four-way switching valve 11, and the compressor 10. At this time, the cooling capacity can be improved by diverting liquid refrigerant to the supercooling circuit 20 at the supercooling heat exchanger 19, and causing the liquid refrigerant to exchange heat with decompressed refrigerant at the supercooling expansion valve (decompression mechanism) 18 to thereby supercool the liquid refrigerant.

[0028] Further, the air conditioner 1 is configured to be also capable of performing heating operation by causing the indoor heat exchanger 30 to function as a condenser and causing the outdoor heat exchanger 12 to function as an evaporator. When performing heating operation, the air conditioner 1 causes a refrigerant that has been discharged from the compressor 10 to circulate to the indoor heat exchanger 30 side through the four-way switching valve 11, and causes the refrigerant to circulate in a counterclockwise direction in the order of the supercooling heat exchanger 19, the receiver 15, motor-operated expansion valve for heating 14, the outdoor heat exchanger 12, the four-way switching valve 11, and the compressor 10.

[0029] In the air conditioner 1, the length of the gas refrigerant piping 33 and the liquid refrigerant piping 34 that connects the outdoor unit 2 and each indoor unit 3 changes variously according to the environment in which the air conditioner 1 is installed. Consequently, a predetermined amount of refrigerant is filled in advance in the outdoor unit 2, and when performing a test operation after installing the air conditioner 1 at the installation site, it is necessary to additionally fill an amount that corresponds to an insufficient amount of refrigerant in accordance with the length of piping that connects the outdoor unit 2 and the indoor units 3 as well as the number of indoor units 3 that are connected and the like. To enable an appropriate amount of refrigerant to be always filled without depending on operations at the construction work level at the installation site when additionally filling the refrigerant, a first liquid level detecting circuit 40, a second liquid level detecting circuit 45, and a refrigerant amount detecting unit 48 are incorporated into the air conditioner 1.

[0030] The first liquid level detecting circuit 40 includes: a bypass circuit 41 that can take a refrigerant out from a predetermined height position in the receiver 15 to an intake side of the compressor 10; and a decompression mechanism 42 that is composed of a capillary tube or an expansion valve or the like and an electromagnetic on/off valve 43 that are provided in the bypass circuit 41. The bypass circuit 41 is connected to and merged with the supercooling circuit 20 in a vicinity of a connecting portion at which the supercooling circuit 20 is connected to intake piping of the compressor 10. A temperature sensor (temperature detecting unit) 44 such as a thermistor is arranged at a position that is further on the intake piping side of the compressor 10 than the connecting and merging portion of the bypass circuit 41. The temperature sensor 44 detects a temperature of a refrigerant that has been decompressed at the decompression mechanism 42 or the decompression mechanism 18 and that flows inside the bypass circuit 41 and the supercooling circuit 20.

[0031] The second liquid level detecting circuit 45 branches from a position that is located before the decompression mechanism 42 in the bypass circuit 41 constituting the first liquid level detecting circuit 40, and includes an electromagnetic on/off valve 46 that is provided in a circuit that is connected to an inlet side of the supercooling expansion valve (decompression mechanism) 18 of the supercooling circuit 20. The second liquid level detecting circuit 45 constitutes a circuit that, when carrying out refrigerant filling operation, returns refrigerant that has been taken out from the receiver 15 to the intake side of the compressor 10 via the supercooling expansion valve (decompression mechanism) 18 and the supercooling heat exchanger 19 in the supercooling circuit 20. An electromagnetic on/off valve 47 is provided close to a branch portion of the supercooling circuit 20 in order to stop the flow of liquid refrigerant diverging to the supercooling circuit 20 at such time.

[0032] The refrigerant amount detecting unit 48 is provided to determine whether or not an appropriate amount of a refrigerant has been filled based on a detection temperature of the temperature sensor 44. The refrigerant amount detecting unit 48 is configured to be able to determine, during refrigerant filling operation, whether or not an appropriate amount of refrigerant has been filled based on a temperature difference between a detection temperature from the temperature sensor 44 in a case where liquid refrigerant accumulates in the receiver 15 and the liquid level thereof reaches a height position at which the bypass circuit 31 opens and liquid refrigerant in a saturated state is taken out to the first liquid level detecting circuit 40 or the second liquid level detecting circuit 45, and a detection temperature from the temperature sensor 44 in a case where a gas refrigerant in a saturated state is taken out to the first liquid level detecting circuit 40 or the second liquid level detecting circuit 45 during a period until the liquid refrigerant reaches a predetermined height position.

[0033] The refrigerant amount detecting unit 48 has a function that closes the electromagnetic on/off valve 47 provided in the supercooling circuit 20 when performing refrigerant filling operation, and also performs opening/closing control of the electromagnetic on/off valves 43 and 46 when determining whether to perform liquid-level

detection using either the first liquid level detecting circuit 40 or the second liquid level detecting circuit 45 in accordance with an outside air temperature or a high-pressure side pressure or the like. More specifically, when using the first liquid level detecting circuit 40, the refrigerant amount detecting unit 48 opens the electromagnetic on/off valve 43 and closes the electromagnetic on/off valve 46, and when using the second liquid level detecting circuit 45, the refrigerant amount detecting unit 48 closes the electromagnetic on/off valve 43 and opens the electromagnetic on/off valve 46.

[0034] Next, refrigerant filling operation and a method of detecting a refrigerant filling amount are described in further detail referring to Fig. 2 to Fig. 5.

Refrigerant filling operation is performed by operating the refrigerant circuit 35 as a cooling cycle. At this time, the outdoor fan 13 is controlled so that a condensing pressure at the outdoor heat exchanger 12 becomes a predetermined value, and a degree of opening of the motor-operated expansion valve for cooling 32 is controlled so that a predetermined degree of superheat is applied to refrigerant at an outlet of the indoor heat exchanger 30. Thus, a refrigerant can be filled into the refrigerant circuit 35 as a state in which a liquid refrigerant of a predetermined density is filled inside the liquid refrigerant piping 34.

[0035] At this time, the electromagnetic on/off valve 47 in the supercooling circuit 20 is closed and, for example, when the outside air temperature is a high temperature of a cooling rating extent, the electromagnetic on/off valve 43 is opened and the electromagnetic on/off valve 46 is closed, while, in contrast, when the outside air temperature is low, the electromagnetic on/off valve 43 is closed and the electromagnetic on/off valve 46 is opened. When operation is continued in this state, the circulating amount of refrigerant in the refrigerant circuit 35 is gradually increased, and the liquid level of refrigerant in the receiver 15 gradually rises. This is because the vaporized amount of refrigerant at the indoor heat exchanger 30 and the condensed amount of refrigerant at the outdoor heat exchanger 12 are balanced, and condensed liquid refrigerant gradually accumulates in the receiver 15 in an amount corresponding to a refrigerant amount that is filled from outside.

[0036] Here, in a case where the electromagnetic on/off valve 43 is opened and the electromagnetic on/off valve 46 is closed when the outside air temperature is a high temperature of a cooling rating extent, during a period until liquid refrigerant accumulates in the receiver 15 up to a height position at which the bypass circuit 41 opens, a saturated gas refrigerant inside the receiver 15 flows into the first liquid level detecting circuit 40. When the liquid level of liquid refrigerant rises as far as the height position at which the bypass circuit 41 opens, liquid refrigerant in a saturated state flows into the first liquid level detecting circuit 40. When the outside air temperature is high and a high pressure rises, it is sufficient to lower the high pressure by controlling the rotational speed of the compressor 10, the rotational speed of the outdoor fan 13, or the like.

[0037] The saturated gas refrigerant and the saturated liquid refrigerant are respectively decompressed into a decompressed state by the decompression mechanism 43. By detecting the temperature of the refrigerant with the temperature sensor 44, the refrigerant amount detecting unit 48 can detect that liquid refrigerant of a predetermined liquid level has been accumulated in the receiver 15 by observing a temperature difference between a case where the temperature has dropped from a state of a saturated gas refrigerant and a case where the temperature has dropped from a state of a saturated liquid refrigerant. Thus, the refrigerant amount detecting unit 48 determines that refrigerant of a required amount has been filled, and at that time the refrigerant filling operation is ended.

[0038] In order to accurately detect whether or not an appropriate amount of refrigerant has been filled, it is desirable to adequately ensure the above described temperature difference. In the above described operation, when a saturated gas refrigerant is being taken out from the receiver 15 to the first liquid level detecting circuit 40, as shown in Fig. 2, if the pressure inside the receiver 15 is in the vicinity of 2 MPa (when the refrigerant is R410A), the refrigerant is decompressed by the decompression mechanism 43 and the temperature thereof falls to a point A, and a degree of superheat SH of a constant size can be ensured. In contrast, as shown in Fig. 3, when a saturated liquid refrigerant is taken out, the refrigerant is decompressed by the decompression mechanism 43 and evaporates, and thus the degree of superheat of refrigerant whose temperature has dropped to a point B is 0°C. Therefore, since a temperature difference of a fixed value or more can be ensured, it can be reliably detected that an appropriate amount of refrigerant has been filled.

[0039] However, when the outside air temperature is low, since the high pressure drops and the pressure inside the receiver 15 also drops, as shown in Fig. 4, in a case where a saturated gas refrigerant is taken out, the refrigerant is decompressed by the decompression mechanism 43 and the temperature falls to a point C. Hence, almost no degree of superheat SH can be ensured. Accordingly, a temperature difference can not be adequately ensured with respect to a case where the degree of superheat becomes °C when a saturated liquid refrigerant is taken out and decompressed by the decompression mechanism 43 and the temperature thereof falls. This is a cause of an erroneous determination. In particular, when the degree of superheat is 2 to 3°C or less, there is an increased possibility that an erroneous determination will be made.

[0040] Therefore, according to the present embodiment, a configuration is adopted such that, when a slope of a saturated gas line ascends diagonally from the lower left to the upper right on a pressure-enthalpy diagram at a time of a low outside air temperature at which the high pressure falls, the refrigerant taken out from the receiver

15 is caused to flow to the supercooling circuit 20 via the second liquid level detecting circuit 45 by switching the liquid level detecting circuit to the second liquid level detecting circuit 45 by closing the electromagnetic on/off valve 43 and opening the electromagnetic on/off valve 46. Thus, the refrigerant that is taken out to the supercooling circuit 20 via the second liquid level detecting circuit 45 is decompressed by the supercooling expansion valve (decompression mechanism) 18, and thereafter is heated by exchanging heat with liquid refrigerant at the supercooling heat exchanger 19 and evaporates, and is returned to the intake side of the compressor 10.

[0041] By detecting the temperature of the refrigerant that passes through the supercooling circuit 20 using the temperature sensor 44, a temperature difference of a fixed value or more between a case where a saturated gas refrigerant is taken out and a case where a saturated liquid refrigerant is taken out can be ensured. That is, as shown in Fig. 5, after the saturated liquid refrigerant is decompressed at the decompression mechanism 18 and the temperature thereof falls, the refrigerant is heated at the supercooling heat exchanger 19 and evaporated, and becomes a refrigerant that has a degree of superheat as 0 °C at a point D on the saturated gas line. In contrast, after the saturated gas refrigerant is decompressed and the temperature thereof has fallen to a point C, the degree of superheat SH is increased as far as a point E by heating the refrigerant at the supercooling heat exchanger 19. Consequently, a temperature difference can be adequately ensured, and the refrigerant amount detecting unit 48 can reliably detect that refrigerant of an appropriate amount has been filled.

[0042] Thus, even under a condition where a pressure on a high pressure side can not be ensured at a time of a low outside air temperature, by causing a saturated gas refrigerant that is taken out from the receiver 15 to flow into the supercooling circuit 20 through the second liquid level detecting circuit 45, the saturated gas refrigerant is heated by exchanging heat with a liquid refrigerant at the supercooling heat exchanger 19, and the degree of superheat can be adequately increased. Hence, based on a temperature difference with respect to a case in which a saturated liquid refrigerant is taken out, it can be reliably detected that a liquid refrigerant of a predetermined liquid level is accumulated in the receiver 15.

Accordingly, a temperature difference between a saturated gas refrigerant and a saturated liquid refrigerant can be adequately ensured under a wide range of temperature conditions without being influenced by fluctuations in a high pressure caused by an outside air temperature or the like and a refrigerant filling amount can be detected with high accuracy. Thus, it is possible to fill an optimum amount of refrigerant that is neither excessive nor insufficient to enable stable operation of the air conditioner 1. Further, since refrigerant can be heated utilizing the supercooling circuit 20, it is not necessary to specially provide heating means on the first liquid level detecting circuit 40 side, and hence the configuration can be simplified.

[0043] Furthermore, according to the present embodiment, the electromagnetic on/off valve 47 that is closed when performing refrigerant filling operation and opened when performing normal cooling or heating operation is provided in the vicinity of a branch portion from the refrigerant circuit 35 of the supercooling circuit 20. It is therefore possible to easily perform switching between refrigerant filling operation and normal cooling or heating operation by performing only an operation to open or close the electromagnetic on/off valve 47. Accordingly, in addition to enhancing the capacity at a time of normal cooling or heating operation, the supercooling circuit 20 is also used as a liquid level detecting circuit at a time of refrigerant filling operation, and can contribute to improving the accuracy of detecting a refrigerant filling amount. Further, since an existing temperature sensor provided in the supercooling circuit 20 can be used in a shared manner as the temperature sensor 44, a saving can be made with respect to the provision of a temperature sensor.

[Second Embodiment]

[0044] Next, a second embodiment of the present invention is described using Fig. 6 to Fig. 8.

The configuration of the present embodiment differs from the first embodiment in that a hot gas bypass circuit 50 is provided instead of the second liquid level detecting circuit 45. Since the remaining configuration is the same as the first embodiment, a description thereof is omitted below.

According to the present embodiment, as shown in Fig. 6, a configuration is adopted that includes: a liquid level detecting circuit 40 in which, similarly to the above described first liquid level detecting circuit 40, the decompression mechanism 42 constituted by a capillary tube or an expansion valve or the like and the electromagnetic on/off valve 43 are interposed in the bypass circuit 41 that connects a predetermined height position inside the receiver 15 and the intake side of the compressor 10; the hot gas bypass circuit 50 that includes an electromagnetic on/off valve 51 and a decompression mechanism 52 constituted by a capillary tube or an expansion valve or the like and that can introduce a portion of hot gas from a discharge side of the compressor 10 to an intake side thereof; and a temperature sensor 53 that detects a temperature of a refrigerant that has passed through the liquid level detecting circuit 40 or of a mixed refrigerant of a refrigerant that has passed through the liquid level detecting circuit 40 and a hot gas that is introduced by the hot gas bypass circuit 50.

[0045] According to the present embodiment, similarly to the first embodiment, the refrigerant amount detecting unit 48 is configured to be able to determine a refrigerant filling amount by detecting that liquid refrigerant of a predetermined liquid level has accumulated in the receiver 15 based on a detection value from the temperature sen-

sor 53. Further, the refrigerant amount detecting unit 48 has a function that, at a time of refrigerant filling operation, controls opening and closing of the electromagnetic on/off valves 43 and 51 when determining whether to use only the liquid level detecting circuit 40 or to also use the hot gas bypass circuit 50 to perform liquid-level detection in accordance with an outside air temperature or a high-pressure side pressure or the like. More specifically, when using only the liquid level detecting circuit 40, the electromagnetic on/off valve 43 is opened and the electromagnetic on/off valve 51 is closed, while when using both the liquid level detecting circuit 40 and the hot gas bypass circuit 50, the electromagnetic on/off valves 43 and 51 are both opened.

[0046] Thus, in addition to providing the liquid level detecting circuit 40 that includes the decompression mechanism 42 and the electromagnetic on/off valve 43 between a predetermined height position of the receiver 15 and the intake side of the compressor 10, the hot gas bypass circuit 50 in which the electromagnetic on/off valve 51 and the decompression mechanism 52 are interposed is provided between the discharge side and the intake side of the compressor 10, and a configuration is adopted such that a portion of hot gas discharged from the compressor 10 can be introduced to the intake side thereof via the hot gas bypass circuit 50. Thus, when the outside air temperature is a high temperature of a cooling rating extent, similarly to the first embodiment, by using only the liquid level detecting circuit 40 it is possible to ensure a temperature difference of a fixed value or more between a case where a saturated gas refrigerant is taken out from the receiver 15 and a case where a saturated liquid refrigerant is taken out therefrom. Hence, the refrigerant amount detecting unit 48 can reliably detect that an appropriate amount of refrigerant has been filled.

[0047] At a time of a low outside air temperature, opening the electromagnetic on/off valve 51 allows hot gas that has been decompressed at the decompression mechanism 52 to be introduced into the intake side of the compressor 10 via the hot gas bypass circuit 50, and the hot gas can be mixed with refrigerant that has been taken out to the liquid level detecting circuit 40 from the receiver 15 to thereby heat the refrigerant. Therefore, as shown in Fig. 7, after a saturated gas refrigerant that is taken out from the receiver 15 to the liquid level detecting circuit 40 is decompressed and the temperature thereof falls to a point F, the refrigerant is mixed with decompressed hot gas having a temperature at a point G, and the degree of superheat SH is increased to a point H. In contrast, as shown in Fig. 8, after a saturated liquid refrigerant that is taken out from the receiver 15 is decompressed and evaporated and the temperature thereof falls to a point I, even if the refrigerant is mixed with decompressed hot gas having a temperature at a point J and the temperature thereof increases to a point K, a degree of superheat can not be ensured. Accordingly, a temperature difference can be sufficiently ensured, and the refrigerant amount detecting unit 48 can reliably detect that an appropriate amount of refrigerant has been filled.

[0048] Therefore, even under a condition of a low outside air temperature, by heating refrigerant that is taken out from the liquid level detecting circuit 40 by mixing the refrigerant with hot gas from the discharge side of the compressor 10 that is introduced to the intake side thereof via the hot gas bypass circuit 50, it is possible to reliably detect that a liquid refrigerant of a predetermined liquid level is accumulated in the receiver 15 based on a temperature difference between a case where a saturated gas refrigerant is taken out and a case where a saturated liquid refrigerant is taken out. Accordingly, a temperature difference between a saturated gas refrigerant and a saturated liquid refrigerant can be adequately ensured under a wide range of temperature conditions without being influenced by fluctuations in a high pressure caused by an outside air temperature or the like. Hence, a refrigerant filling amount can be detected with high accuracy. It is thus possible to fill an optimum amount of refrigerant that is neither excessive nor insufficient to enable stable operation of the air conditioner 1.

[0049] Further, according to the present embodiment, since a configuration is adopted in which a refrigerant from the liquid level detecting circuit 40 is mixed directly with hot gas to heat the refrigerant, the temperature can be detected without a time delay. Therefore, the detection accuracy with respect to a refrigerant filling amount can be further enhanced. In addition, since an existing intake temperature sensor that is provided in the intake piping of the compressor 10 can be used in a shared manner as the temperature sensor 53, a saving can be made with respect to the provision of a temperature sensor.

[0050] The present invention is not limited to the inventions described in the foregoing embodiments, and appropriate modifications are possible within a range that does not depart from the spirit and scope of the present invention. For example, although the supercooling circuit 20 is omitted from the configuration of the above described second embodiment, naturally the invention according to the second embodiment may be applied to the air conditioner 1 that includes the supercooling circuit 20. Further, although according to the above described embodiments a configuration is adopted in which the bypass circuit 41 of the first liquid level detecting circuit (liquid level detecting circuit) 40 is insertedly connected from the top surface of the receiver 15, the bypass circuit 41 may be connected so as to open at a predetermined height position inside the receiver 15. Accordingly the bypass circuit 41 may be inserted from a side face or the underside of the receiver 15 and connected so as to open at a predetermined height position.

{Reference Signs List}

[0051]

1 Air conditioner

2 Outdoor unit
3 Indoor unit
10 Compressor
12 Outdoor heat exchanger
14 Motor-operated expansion valve for heating (heating expansion valve)
15 Receiver
18 Supercooling expansion valve (decompression mechanism)
19 Supercooling heat exchanger
20 Supercooling circuit
30 Indoor heat exchanger
32 Motor-operated expansion valve for cooling (cooling expansion valve)
33 Gas refrigerant piping
34 Liquid refrigerant piping
35 Refrigerant circuit
40 First liquid level detecting circuit (liquid level detecting circuit)
41 Bypass circuit
42 Decompression mechanism
43 Electromagnetic on/off valve
44 Temperature sensor (temperature detecting unit)
45 Second liquid level detecting circuit
46 Electromagnetic on/off valve
47 Electromagnetic on/off valve
48 Refrigerant amount detecting unit
50 Hot gas bypass circuit
51 Electromagnetic on/off valve
52 Decompression mechanism
53 Temperature sensor (temperature detecting unit)

Claims

1. An air conditioner that constitutes a closed-cycle refrigerant circuit in which an outdoor unit including a compressor, an outdoor heat exchanger, a heating expansion valve, a receiver that stores a liquid refrigerant, and a supercooling circuit that, after diverting a flow of one part of a liquid refrigerant and decompressing the refrigerant by means of a decompression mechanism, causes the refrigerant to exchange heat with a liquid refrigerant at a supercooling heat exchanger and returns the refrigerant to an intake side of the compressor and the like, and an indoor unit that includes an indoor heat exchanger and a cooling expansion valve and the like are connected by gas refrigerant piping and liquid refrigerant piping; the air conditioner comprising:

a first liquid level detecting circuit in which an on/off valve and a decompression mechanism are interposed in a bypass circuit that connects a predetermined height position of the receiver and an intake side of the compressor via the supercooling circuit;
a second liquid level detecting circuit that is branched from the bypass circuit and in which an on/off valve is interposed that acts as a bypass for leading a refrigerant that is taken out from the receiver to an inlet side of a decompression mechanism of the supercooling circuit;
a temperature detecting unit that detects a temperature of decompressed refrigerant that passes through the supercooling circuit including the first liquid level detecting circuit or the second liquid level detecting circuit; and
a refrigerant amount detecting unit that detects, by means of the temperature detecting unit, a temperature after decompression of a refrigerant that is taken out from the receiver via the first liquid level detecting circuit or the second liquid level detecting circuit, and determines a refrigerant filling amount based on the temperature.

2. The air conditioner according to claim 1, wherein an electromagnetic on/off valve that is closed at a time of refrigerant filling operation and is opened at a time of normal cooling or heating operation is provided in a vicinity of a branch portion from the refrigerant circuit of the supercooling circuit.

3. An air conditioner that constitutes a closed-cycle refrigerant circuit in which an outdoor unit that includes a compressor, an outdoor heat exchanger, a heating expansion valve, and a receiver that stores a liquid refrigerant and the like, and an indoor unit that includes an indoor heat exchanger and a cooling expansion valve and the like are connected by gas refrigerant piping and liquid refrigerant piping; the air conditioner comprising:

a liquid level detecting circuit in which an on/off valve and a decompression mechanism are interposed in a bypass circuit that connects a predetermined height position of the receiver and an intake side of the compressor;
a hot gas bypass circuit comprising an on/off valve and a decompression mechanism that is capable of introducing a portion of a hot gas from a discharge side of the compressor to the intake side thereof;
a temperature detecting unit that is capable of detecting a temperature of a refrigerant that passes through the liquid level detecting circuit or a refrigerant in which the refrigerant that passes through the liquid level detecting circuit and a hot gas that is introduced via the hot gas bypass circuit are mixed; and
a refrigerant amount detecting unit that detects, by means of the temperature detecting unit, a temperature after decompression of a refrigerant that is taken out from the receiver to the liquid level detecting circuit or of a mixed refrigerant

comprising the refrigerant that is taken out from the receiver and a refrigerant that is introduced via the hot gas bypass circuit, and determines a refrigerant filling amount based on the temperature.

4. A refrigerant amount detection method for an air conditioner according to claim 1 or 2 that, at a time of refrigerant filling operation, under a temperature condition of a cooling rating extent, performs liquid-level detection by closing the second liquid level detecting circuit by means of the on/off valve and using the first liquid level detecting circuit, and under a condition of a low outside air temperature, performs liquid-level detection by closing the first liquid level detecting circuit by means of the on/off valve and using the second liquid level detecting circuit.

5. A refrigerant amount detection method for an air conditioner according to claim 3 that, at a time of refrigerant filling operation, performs liquid-level detection under a temperature condition of a cooling rating extent by using only the liquid level detecting circuit, and performs liquid-level detection under a condition of a low outside air temperature by using both the liquid level detecting circuit and the hot gas bypass circuit.

FIG. 1

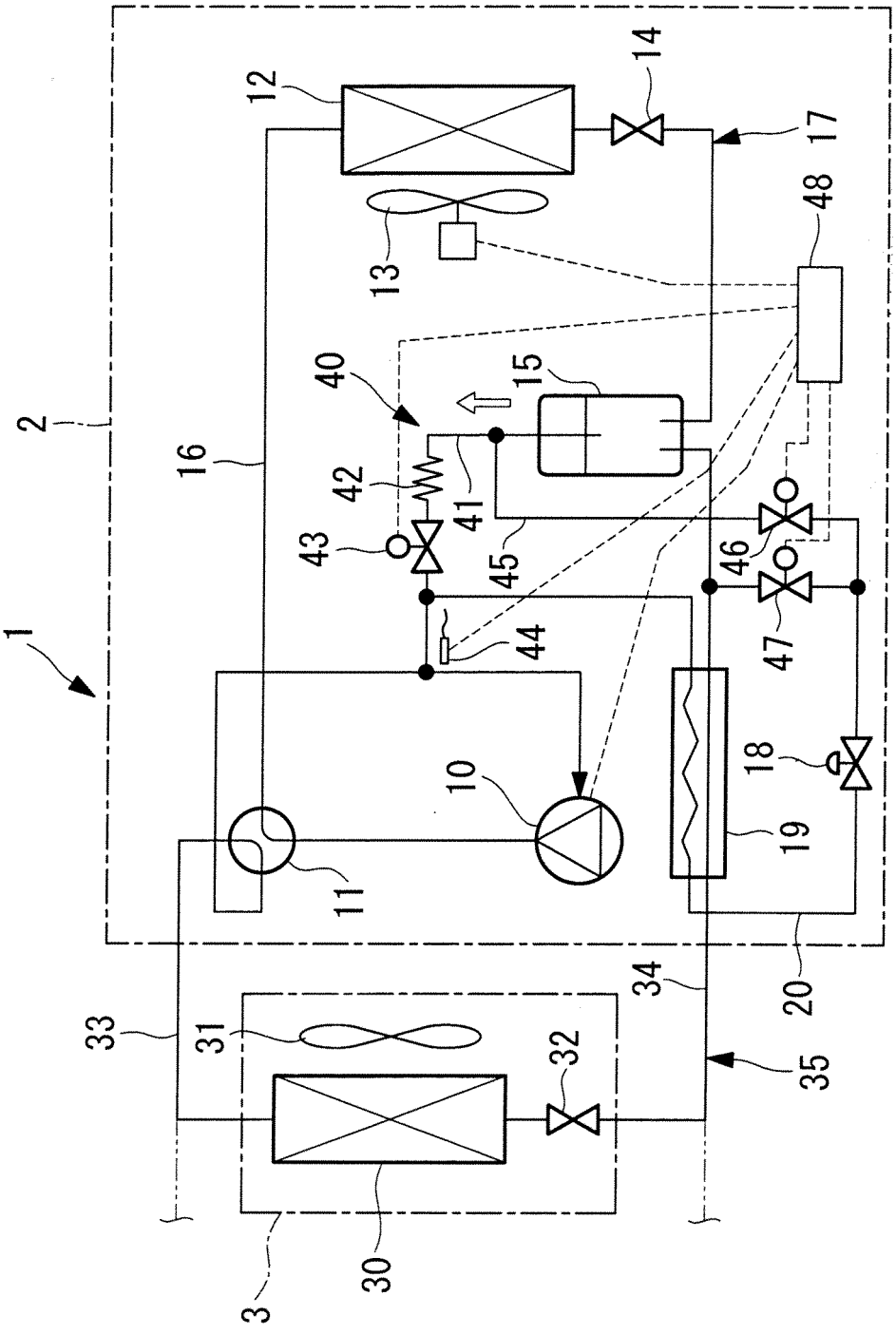
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FIG. 2

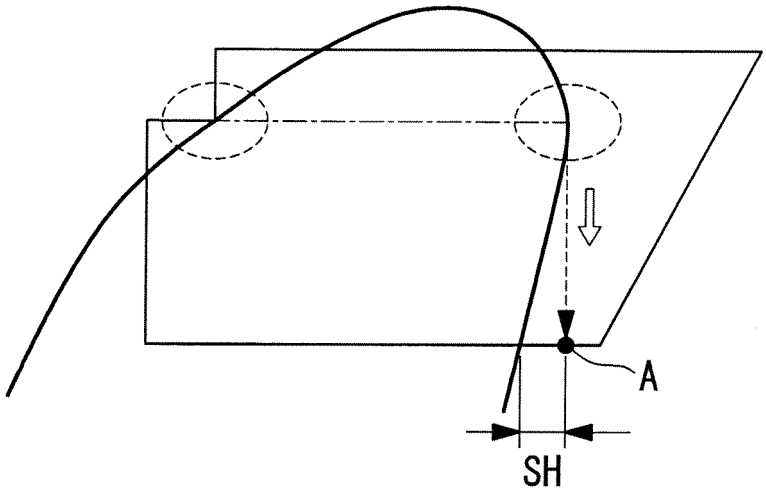


FIG. 3

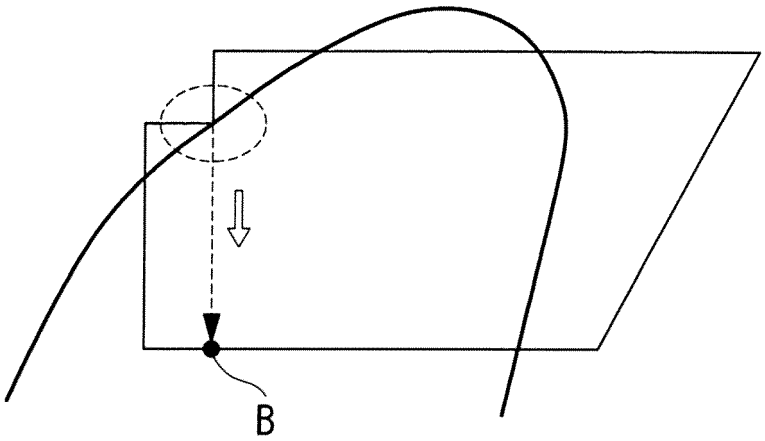


FIG. 4

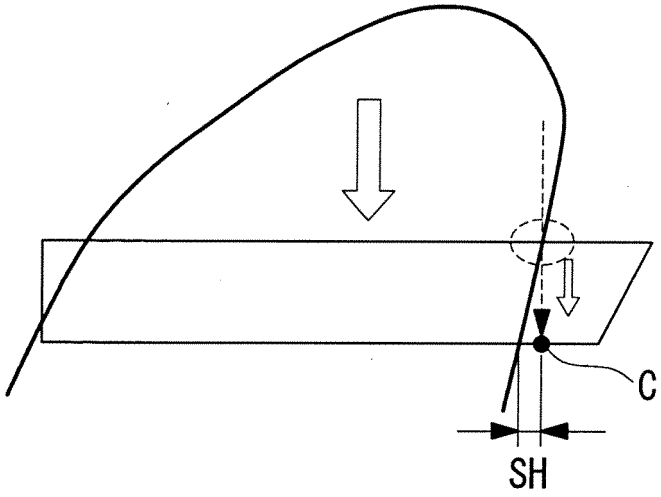


FIG. 5

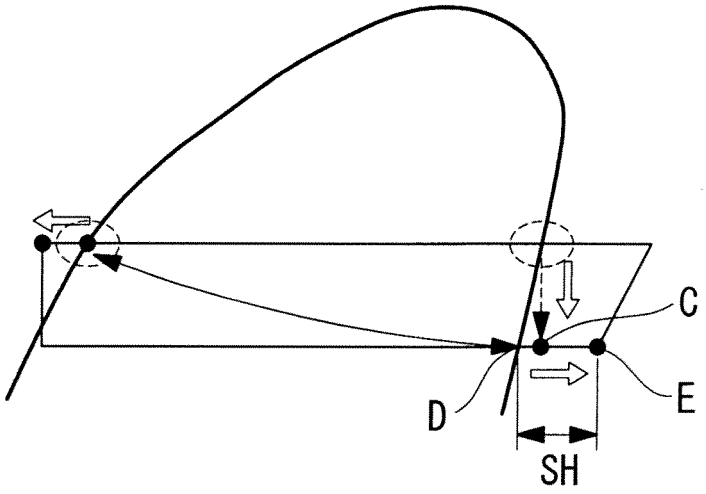


FIG. 6

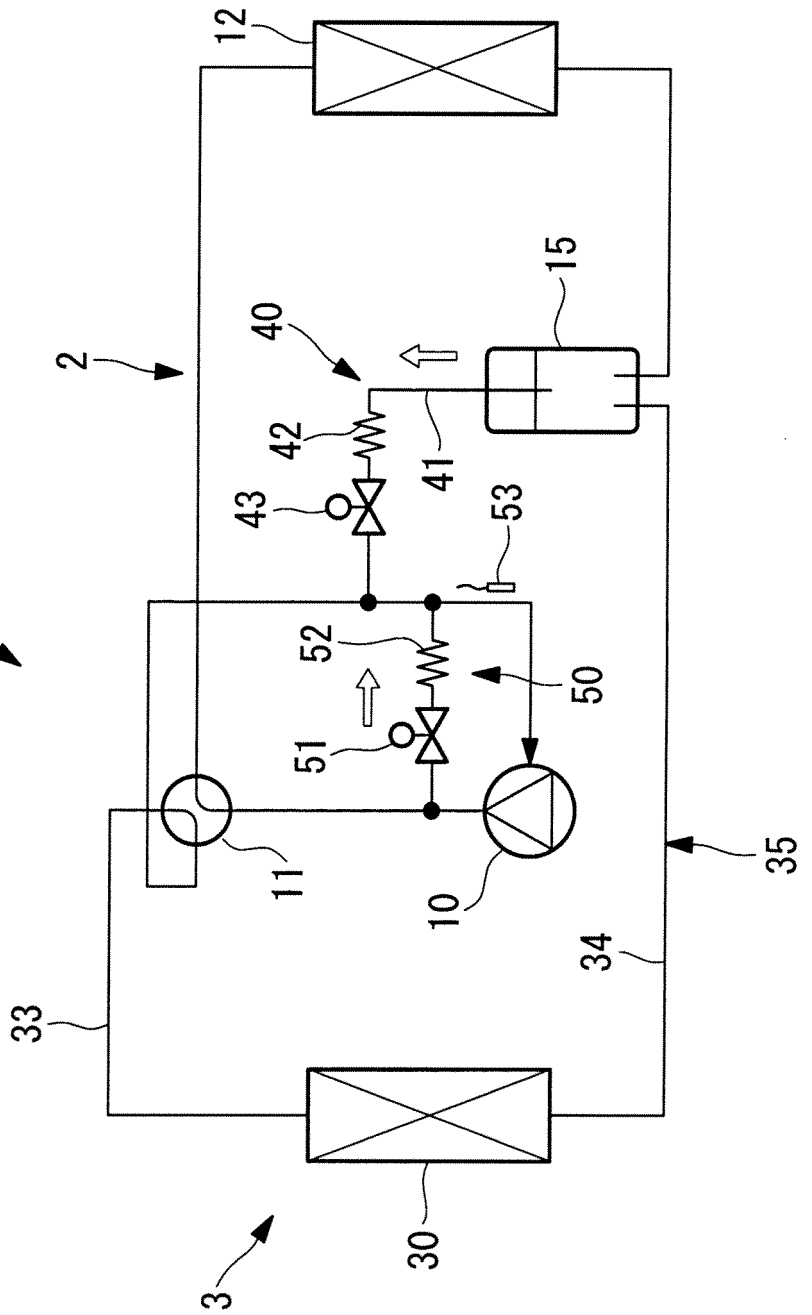


FIG. 7

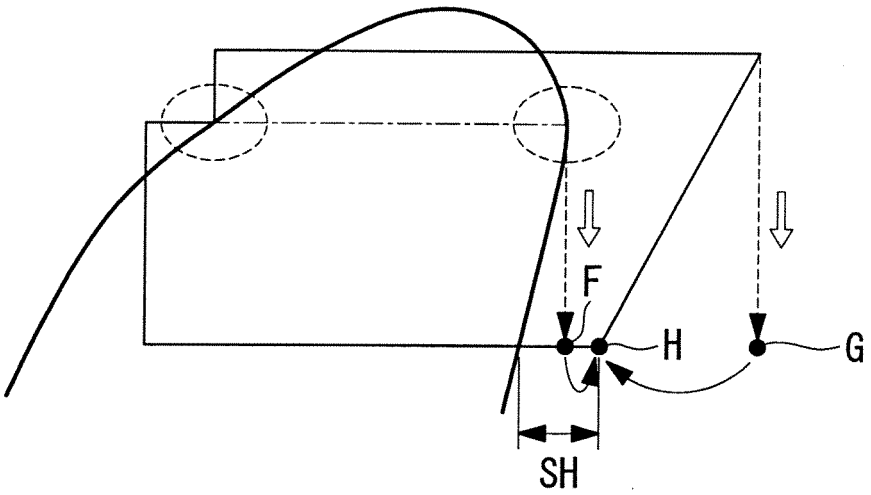
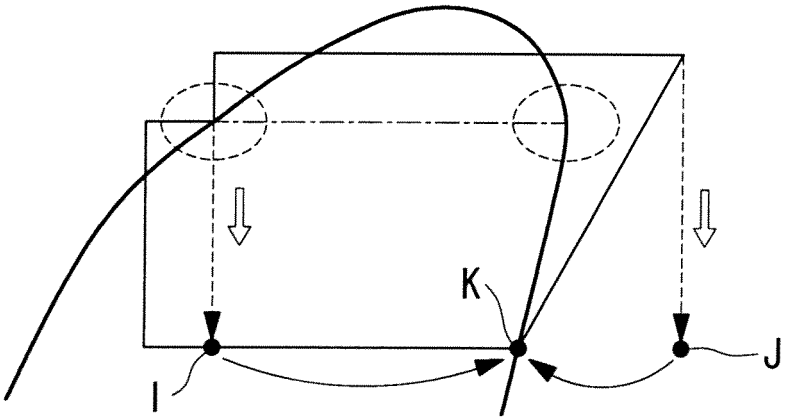


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/071481

A. CLASSIFICATION OF SUBJECT MATTER
F25B49/02(2006.01)i, *F25B1/00*(2006.01)i, *F25B45/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B49/02, F25B1/00, F25B45/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2011
Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2005-282885 A (Mitsubishi Heavy Industries, Ltd.), 13 October 2005 (13.10.2005), paragraphs [0095] to [0108]; fig. 4 (Family: none)	1-3 4,5
Y	JP 57-87570 A (Hitachi, Ltd.), 01 June 1982 (01.06.1982), page 1, right column, line 16 to page 2, lower left column, line 1; figures (Family: none)	1,2
Y	JP 2005-308393 A (Daikin Industries, Ltd.), 04 November 2005 (04.11.2005), paragraph [0045]; fig. 7 (Family: none)	3

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
18 February, 2011 (18.02.11)	01 March, 2011 (01.03.11)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/071481

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 5-60411 A (Daikin Industries, Ltd.), 09 March 1993 (09.03.1993), paragraphs [0051] to [0053]; fig. 7 & US 5067888 A & EP 308685 A2 & WO 1986/003713 A1 & CH 679470 A	3
A	JP 2007-139244 A (Fujitsu General Ltd.), 07 June 2007 (07.06.2007), entire text; fig. 1 to 7 (Family: none)	1-5

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/071481

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

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

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

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

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

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

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

The international search has revealed that the matter common to the inventions of claims 1-5 is described in document 1 (JP 2005-282885 A). Consequently, the common matter is not special technical features within the meaning of PCT Rule 13.2, second sentence. No requirement for unity of invention is exceptionally asked on the invention of claims 2 and 4. On the invention of claims 3 and 5, however, claim 1 and other common matter cannot be considered as a special technical feature within the meaning of PCT Rule 13.2, second sentence. Thus, no technical relationship within the meaning of PCT Rule 13 can be seen among those different inventions.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

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

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

☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/071481

The invention specifying matter of "a first liquid surface detecting circuit including an opening/closing valve and a pressure-reducing mechanism disposed in a bypass circuit for connecting a predetermined height position of said receiver and the suction side of said compressor via said super-cooling circuit" of claim 1 is not supported within the meaning of PCT Article 6. (What is disclosed in the description is "a first liquid surface detecting circuit 40 comprising: a bypass circuit 41 capable of extracting a coolant from a predetermined height position in a receiver 15 to the suction side of a compressor 10; and a pressure-reducing mechanism 42 and an electromagnetic opening/closing valve 43 disposed in the bypass circuit 41 and composed of a capillary tube, an expansion valve and so on, wherein the bypass circuit 41 is connected to merge into the super-cooling circuit 20 in the vicinity of a connecting section, at which a super-cooling circuit 20 is connected to the suction pipe of the compressor 10" (as extracted from paragraph [0029]), is different from the aforementioned invention specifying matter.)

Hence, the searches have been performed on the range which is supported by and disclosed in the description, that is, on "the first liquid surface detecting circuit including the opening/closing valve and the pressure-reducing mechanism disposed in the bypass circuit for connecting the predetermined height position of the receiver and the suction side of the compressor via the super-cooling circuit".

Form PCT/ISA/210 (extra sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- JP 2002350014 A **[0005]**
- JP 3719246 B **[0005]**