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# (54) OUTDOOR UNIT COMPRISING A RELEASE DEVICE

(57) The present disclosure relates to an outdoor unit for a heat pump system including a refrigerant circuit. The outdoor unit comprises an outdoor unit casing accommodating an electric box including a control unit, a compressor, a fan, a release device, and a heat source heat exchanger. The release device is connected to the refrigerant circuit. The control unit is configured to operate the release device upon detection of a refrigerant leakage in the refrigerant circuit and the release device is configured to release refrigerant from the refrigerant circuit in a direction away from at least the electric box.

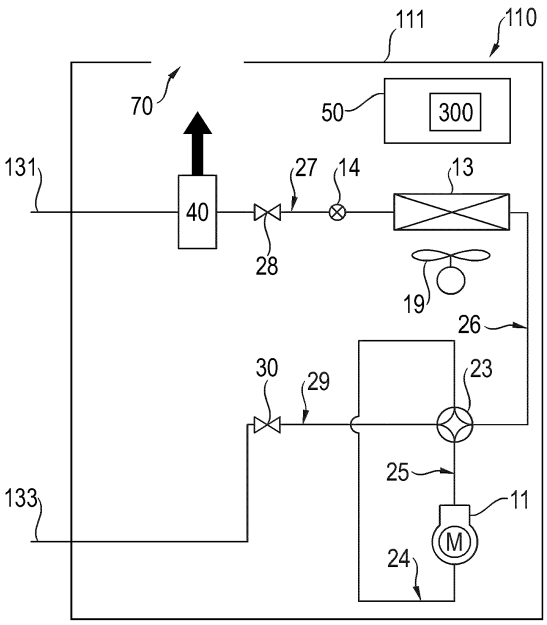


Fig. 2a

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## Description

### TECHNICAL FIELD

**[0001]** The present disclosure relates to an outdoor unit comprising a release device, which outdoor unit can be used for a heat pump system including a refrigerant circuit. Examples of such heat pump systems are air conditioning systems for cooling at a usage side, air conditioning and heating system for cooling and/or heating at a usage side, and heating, ventilation and air conditioning (HVAC) systems.

### BACKGROUND ART

**[0002]** In general, heat pump systems comprising a compressor, a utilization side heat exchanger accommodated in an indoor unit, an expansion mechanism, and a heat source side heat exchanger accommodated in an outdoor unit, which are fluidly connected in series to constitute a refrigerant circuit, are known in the prior art. Such refrigerant circuits enable, for example, cooling and heating depending on the direction of flow of the refrigerant circulating in the refrigerant circuit.

**[0003]** Nowadays, heat pump systems often use flammable and/or toxic refrigerants. Examples of well-known refrigerants are R32, carbon dioxide, and propane. Those refrigerants ask for specific safety measures to, in the event of a leakage in the indoor unit, prevent that a mass of refrigerant leaks into the indoor space accommodating the indoor unit exceeding a predetermined value.

**[0004]** A well-known safety measure to prevent the same is the so-called pump-down operation. Thereby, in case of leakage in the indoor unit, refrigerant is pumped from the indoor unit towards and into an outdoor unit accommodating the heat source side heat exchanger. Accordingly, the mass of refrigerant leaking into the indoor space can be minimized.

**[0005]** Alternatively, or additionally, shut-off valves to shut off the indoor unit from the remainder of the refrigerant circuit may be provided. Thereby the mass of refrigerant leaking into the indoor space may be limited to the amount trapped in the indoor unit.

**[0006]** A yet alternative safety measure is known from JP 5292940 B2 disclosing to quickly reduce the pressure in the refrigerant circuit by venting the refrigerant to the outside. The reduction of pressure results in less refrigerant escaping through the leak in the indoor space. Generally, in case of flammable refrigerants, it is not permitted for environmental and safety reasons to release the flammable refrigerant into the atmosphere. However, when carbon dioxide is used as a refrigerant this concern does not apply for being non-flammable. Also, by venting it to the atmosphere it can be ensured that carbon dioxide mixes quickly enough with the surrounding air not to exhibit the toxic effect it has on humans and animals compared to being released in closed spaces. Thus, for carbon dioxide based heat pump systems this safety measure is particularly interesting. JP 5292940 B2 teaches a release valve connected to the refrigerant circuit in the outdoor unit and to discharge/release the refrigerant in the refrigerant circuit to the atmosphere through this release valve in the instance a leak is detected.

**[0007]** However, the venting of the pressurized refrigerant to atmospheric pressure results in a sharp temperature drop of the released refrigerant, which may easily reach temperatures well below the freezing point of water. This is a downside of the safety measure known from JP 5292940 B2 because any component of the outdoor unit exposed to the discharged stream of cold refrigerant will likewise undergo rapid cooling. This may not only lead to damage or excessive wear of these components due to thermal stress, for moving components this may also result in them getting clogged due to moisture in the air condensing and freezing. In particular, electrical components exposed to a cold stream of refrigerant may permanently be damaged or experience a temporary malfunction when moisture condenses on them. Furthermore, if components of the outdoor unit get hit by the high-pressure gas stream of released refrigerant, the impact may cause direct mechanical damage or stress. Hence, as the mechanical and electrical components may also serve to control additional safety measures to be taken in the event of a leakage, the overall safety of the heat pump system may be compromised.

### SUMMARY OF THE INVENTION

**[0008]** In view of the above, it is an object of the present disclosure to provide an improved and safer outdoor unit for a heat pump system. It is a further objective of the present disclosure to minimize damage to or malfunction of components accommodated in the outdoor unit resulting from being exposed to refrigerant released to the atmosphere as safety measure.

**[0009]** This objective is solved by an outdoor unit according to claim 1. The dependent claims describe optional features and preferred embodiments.

**[0010]** According to a first aspect, an outdoor unit for a heat pump system including a refrigerant circuit comprises an outdoor unit casing. The outdoor unit casing accommodates an electric box including a control unit, a compressor, a fan, a release device, and a heat source heat exchanger. The release device is connected to the refrigerant circuit. The control unit is configured to operate the release device upon detection of a refrigerant leakage in the refrigerant circuit. The release device is configured to release refrigerant from the refrigerant circuit in a direction away from at least the electric box.

**[0011]** Optionally, the direction away from at least the electric box may also include a direction away from any of the compressor, the fan, the heat source heat exchanger or any other component accommodated in the outdoor

unit casing.

**[0012]** In the context of this disclosure, the term "direction away from at least the electric box" means that this direction is not pointed directly towards the electric box.

**[0013]** In the first aspect, since the release device is configured to release refrigerant in a direction away from at least the electric box, damage to the electric box and the control unit caused by refrigerant released from the release device hitting the electric box can be prevented. Furthermore, a malfunction of the control unit or any other electrical component housed in the electrical box due to the rapid cooling and condensation of moisture can be avoided in the event of a detected leak. In particular, if carbon dioxide is used as refrigerant the pressure of the refrigerant in the refrigerant circuit can reach several tenth to above hundred bar. As the objective of the release device is to quickly reduce the pressure inside the refrigerant circuit, the release device will normally allow the refrigerant to be discharged at a high pressure. Such a high-pressure stream of refrigerant may also mechanically damage any component located in the direction of the released refrigerant. Thus, a further effect of the invention according to the first aspect is preventing such mechanical damage.

**[0014]** In a second aspect, the outdoor unit casing further comprises an opening, wherein the release device is configured to release the refrigerant in the direction to the opening.

**[0015]** In this preferred embodiment, the released refrigerant may exit the outdoor unit casing directly through the opening. The refrigerant does not bounce back from a wall of the casing, which may again result in released refrigerant hitting the electric box causing damage or malfunction of the electric components arranged therein. Furthermore, there is no built-up of cold refrigerant gas inside the outdoor unit casing leading to condensation of moisture and formation of water ice inside the outdoor unit casing.

**[0016]** In a third aspect, the outdoor unit according to the second aspect has an outdoor unit casing comprising a bottom plate, a plurality of side plates, and a top plate. The opening is provided in the bottom plate and/or in the top plate.

**[0017]** The terms "bottom", "top", "side" refer to the orientation of the outdoor unit as intended when being installed as part of the heat pump system.

**[0018]** In this preferred embodiment, the released refrigerant vents to the bottom and/or top of the outdoor unit. Typically, on the installation site these are the sides where no other objects are installed. Any object surrounding the outdoor unit, for example the outdoor unit of another heat pump system, will thus not be affected in the event of a refrigerant release. Instead, in the preferred embodiment the refrigerant may directly vent towards a floor or the sky.

**[0019]** In a fourth aspect, the outdoor unit according to the second aspect has an outdoor unit casing comprising a bottom plate, a plurality of side plates, and a top plate. The opening is provided in at least one of the plurality of side plates.

**[0020]** Although having an opening in the top or bottom plate is preferable when one intends to let the refrigerant directly vent to the atmosphere, in case it is required to guide the refrigerant to another location, for example as an additional safety measure, the installation of field piping for this purpose can more easily be realized on side plates of the outdoor unit casing than on the top or the bottom.

**[0021]** In a fifth aspect, the outdoor unit according to any one of the second to fourth aspects has a release device comprising a blow-off mechanism and a release opening. The release opening is configured to release refrigerant via the blow-off mechanism in the direction to the opening.

**[0022]** In this preferred embodiment, the blow-off mechanism ensures that the refrigerant can be released in a controlled manner.

**[0023]** In a sixth aspect, the refrigerant circuit in the outdoor unit according to the fifth aspect further comprises a refrigerant release pipe that branches from the refrigerant circuit in the outdoor unit. The blow-off mechanism is arranged in the refrigerant release pipe and the release opening is provided at one end of the refrigerant release pipe. The release opening is configured to release the refrigerant via the refrigerant release pipe and the blow-off mechanism in the direction to the opening.

**[0024]** In this preferred embodiment, since the refrigerant circuit comprises a refrigerant release pipe and the release opening is provided at one end of the refrigerant release pipe, it is possible to guide the released refrigerant via the refrigerant release pipe out of the release opening towards the opening of the casing. In the instance that there is only limited space in the outdoor unit casing it may not be possible to find a suitable location in the refrigerant circuit that would allow to attach the blow-off device such that refrigerant may be vented to the opening in the casing without first being directed towards the electric box. Thus, by using a refrigerant release pipe branching of the refrigerant circuit the refrigerant may be guided through that narrow space avoiding exposure of the electric box to the cold refrigerant.

**[0025]** In a seventh aspect, the outdoor unit to any one of the first to sixth aspects is for the heat pump system, in which the refrigerant circuit comprises a first refrigerant pipe and a second refrigerant pipe that connect the outdoor unit to an indoor unit. The refrigerant circuit in the outdoor unit further comprises an outdoor liquid pipe connecting to the first refrigerant pipe, an outdoor gas pipe connecting to the second refrigerant pipe, a liquid-side shut-off valve in the outdoor liquid pipe, and a gas-side shut-off valve in the outdoor gas pipe. The refrigerant release device is either connected to the outdoor liquid pipe between the liquid-side shut-off valve and the first refrigerant pipe or connected to the outdoor gas pipe between the gas-side shut-off valve and the second

refrigerant pipe.

**[0026]** In other words, the release device is connected to a portion of the outdoor liquid pipe and a portion of the outdoor gas pipe that is in between the liquid-side shut-off valve and gas-side shut-off valve, respectively, and an indoor-side portion of the refrigerant circuit.

**[0027]** In this preferred embodiment, in the event of a leakage in the indoor unit, the one or both shut-off valves may be closed, for example, by the control unit. Thereby, refrigerant in the indoor-side portions of the refrigerant circuit may safely be released by the release device to reduce its pressure in the indoor-side portion, while at the same time refrigerant can be trapped in the outdoor-side portion of the refrigerant circuit. Thus, excessive loss of refrigerant can be avoided and potential harm to the environment can be minimized. Additionally, the release may happen faster as there is less mass to be discharged from the refrigerant circuit.

**[0028]** In an eighth aspect, the refrigerant release device in the outdoor unit according to the seventh aspect is further connected to the respective other one of the outdoor liquid pipe and the outdoor gas pipe via a bypass pipe having a bypass valve.

**[0029]** In this preferred embodiment, since both the outdoor liquid pipe and the outdoor gas pipe are connected to the release device, in the event of a leakage refrigerant may be vented even quicker than in the embodiment, in which the release valve is provided only in either the liquid or gas pipe, by opening the bypass valve. In the normal operation mode the bypass valve is closed to prevent a direct connection between the liquid-side and gas-side of the refrigerant circuit. The bypass valve is preferably controlled by the control unit.

**[0030]** Another advantage of the outdoor unit according to the eighth aspect over an outdoor unit, in which a first release device is connected to the outdoor liquid pipe and a separate second release device is connected to the outdoor gas pipe (see the tenth aspect below), is a potential reduction of costs. Bypass valves are standard components in refrigerant circuits and tend to be cheaper than a release device, which requires a rather precise trigger mechanism. Additionally, since a release device needs to have a trigger mechanism, in which the trigger is for example provided by a heat input, preferably combined with a pressure difference, or by a mechanical input, having two release devices would require synchronizing the trigger mechanism and/or making sure that both devices get triggered at all. For the example of a trigger mechanism requiring a heat input from a heater, having only one such release device combined with a bypass valve saves power compared to having two of these release devices. In an example, in which the release device requires not only a heat input but also a certain pressure difference to get triggered, as it is the case for a bursting disc, for example, in the instance where a first release device gets triggered in a higher pressure portion of the refrigerant circuit, this may cause an overall drop in the system pressure. This may result into the second release device in a lower pressure portion potentially being subject to only a small pressure difference anymore. In this scenario, it nevertheless has to be ensured that the second release device gets reliably triggered and using potentially different release devices may be preferable from a safety perspective, This, however, increases costs. Hence, also in this scenario having only one release device combined with a bypass valve between the portions of the refrigerant circuit having different pressures may be advantageous over having two release devices.

**[0031]** In a ninth aspect, the outdoor unit according to any one of the second to fourths aspects has a release device comprising a first release device and a second release device.

**[0032]** In this preferred embodiment by having two release devices, it is possible to vent the refrigerant at two distinct locations at the refrigerant circuit, thereby reducing the refrigerant pressure in the refrigerant circuit more effectively and quickly. Typically, the refrigerant circuit has portions in which the pressure of the refrigerant differs from each other, for example, portions upstream and downstream of an expansion valve or the compressor. To account for these different pressure regions, it is preferrable to have different release valves at these portions with different release characteristics. It is also preferrable to have a first release device and a second release device, optionally, even more release devices, in a scenario, in which portions of the refrigerant circuit have been shut-off from one another in the event of a detected leakage, for example, by additional safety measures. With the preferred embodiment such portions may be vented if a release device is available in the portion.

**[0033]** In a tenth aspect, the refrigerant circuit in the outdoor unit of the ninth aspect is separated in a liquid refrigerant portion and a gas refrigerant portion at the compressor. The first release device comprises a first refrigerant release pipe branching from the liquid refrigerant portion, wherein a first blow-off mechanism is arranged in the first refrigerant release pipe. The second release device comprises a second refrigerant release pipe branching from the gas refrigerant portion, wherein a second blow-off mechanism is arranged in the second refrigerant release pipe. Each of the first refrigerant release pipe and the second refrigerant release pipe has one end for releasing refrigerant. The one end of the first refrigerant release pipe is configured to release the refrigerant via the first refrigerant release pipe and the first blow-off mechanism in the direction to the opening and the one end of the second refrigerant release pipe is configured to release the refrigerant via the second refrigerant release pipe and the second blow-off mechanism in the direction to the opening.

**[0034]** In this preferred embodiment, the blow-off mechanisms ensure that the refrigerant can be released in a controlled manner. Furthermore, by having a first refrigerant release pipe and a second refrigerant release pipe

the released refrigerant can be guided separately to the opening in the casing. This allows to attach the blow-off mechanisms at portions of the refrigerant circuit that, for example due to the available space inside the outdoor unit casing, would otherwise only allow to a release the refrigerant in a direction towards the electric box.

**[0035]** In an eleventh aspect, the one end of the first refrigerant release pipe and the one end of the second refrigerant release pipe of the outdoor unit according to the tenth aspect are configured to protrude outwards of the outdoor unit casing through the opening.

**[0036]** In this preferred embodiment, since the ends for releasing the refrigerant protrude outwards of the outdoor unit casing through the opening, the released refrigerant is safely guided in a direction to the opening and thereby away from the electric box. The refrigerant is then ultimately released outside of the outdoor unit casing and cannot cause any harm to any components of the heat pump system inside the outdoor unit casing.

**[0037]** In a twelfth aspect, the first and second refrigerant release pipes of the outdoor unit according to the tenth or eleventh aspect are fixed to the outdoor unit casing near the one end of the first and second refrigerant release pipes.

**[0038]** By fixing the refrigerant release pipes near their one end functioning as the release opening vibration of the refrigerant pipes that may occur when refrigerant is flowing through the release pipes can be suppressed. Such vibration may damage a connection of the release pipes to the refrigerant circuits or may in extreme cases of vibration result in the refrigerant being accidentally released in the direction towards the electric box.

**[0039]** In a thirteenth aspect, the one end of the first refrigerant release pipe and the one end of the second refrigerant release pipe of the outdoor unit according to any one of the tenth to twelfth aspects merge into a manifold pipe. One end of the manifold pipe that is not connected to the first and second refrigerant release pipe is configured to release the refrigerant. This one end may, thus, also be called a free end.

**[0040]** In this preferred embodiment the overall piping can be reduced. It may, for example, suffice to guide refrigerant released via the first release device and refrigerant released via the second release by separate refrigerant release pipes only to a certain location in the outdoor unit casing to avoid releasing the refrigerant in the direction towards the electric box. Downstream of this location the pipes may be joined in the manifold pipe to save costs and reduce complexity of the piping.

**[0041]** In a fourteenth aspect, the one end of the manifold pipe of the outdoor unit casing according to the thirteenth aspects protrudes out of the outdoor unit casing through the opening.

**[0042]** In this preferred embodiment, since the end of the manifold for releasing the refrigerant protrude outwards of the outdoor unit casing through the opening, the released refrigerant is safely guided in a direction to the opening and thereby away from the electric box. The refrigerant is then ultimately released outside of the outdoor unit casing and cannot cause any harm to any components of the heat pump system inside the outdoor unit casing.

**[0043]** In a fifteenth aspect, the manifold pipe of the outdoor unit according to the thirteenth or fourteenth aspects is fixed to the outdoor unit casing near the one end of the manifold pipe.

**[0044]** When refrigerant is flowing through the release pipes and the manifold pipe vibration of these pipes may occur. Such vibration may damage a connection of the refrigerant release pipes to the refrigerant circuit and a connection of the refrigerant release pipes to the manifold pipe. It may, in extreme cases of vibration, also result in the refrigerant being accidentally released in the direction towards the electric box. By fixing the manifold pipe near its one end functioning as the release opening the vibration may be suppressed.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0045]**

Figure 1 shows a schematic piping diagram of a heat pump system comprising an outdoor unit according to an embodiment of the present disclosure.

Figure 2a shows an outdoor unit according to an embodiment of the present disclosure.

Figure 2b shows a first modification of the outdoor unit shown in Figure 2a.

Figure 2c shows a second modification of the outdoor unit shown in Figure 2a.

Figure 3a shows an outdoor unit according to a second embodiment of the present disclosure.

Figure 3b shows a first modification of the outdoor unit shown in Figure 3a.

Figure 3c shows a second modification of the outdoor unit shown in Figure 3a.

Figure 4a shows an outdoor unit according to a third embodiment of the present disclosure.

Figure 4b shows a modification of the outdoor unit shown in Figure 4a.

Figure 5a shows an outdoor unit according to a fourth embodiment of the present disclosure.

Figure 5b shows a modification of the outdoor unit shown in Figure 5a.

Figure 6 shows an outdoor unit according to a fifth embodiment of the present disclosure.

## DESCRIPTION OF EMBODIMENTS

**[0046]** Hereinafter, embodiments according to the present disclosure will be described in detail with reference to the accompanying drawings in order to describe the disclosure using illustrative examples. Further modifications of certain individual features described in this context can be combined with other features of the described embodiments to form further embodiments of the disclosure. Throughout the drawings, the same reference numerals are used for the same or similar elements.

**[0047]** Figure 1 shows a basic schematic piping diagram of a heat pump system 100 well known in the art comprising an outdoor unit 110 according to an embodiment of the present disclosure.

**[0048]** The heat pump system 100 may be a device that performs cooling and/or heating of indoor spaces, such as in a building, through a vapor compression refrigeration cycle. In the heat pump system, carbon dioxide or propane may be used as refrigerant. The used refrigerant may be a natural refrigerant with low global warming potential, which may potentially be released to the outside or atmosphere.

**[0049]** The heat pump system 100 shown in Figure 1 is a single-heat pump system, which includes an outdoor unit 110 (which may also be referred to as heat source unit) and an indoor unit 120 (which may also be referred to as usage unit or utilization-side unit). The heat pump system 100 may, however, also be implemented as a multi-heat pump system, which includes a single or multiple outdoor units 110 and a plurality of indoor units 120.

**[0050]** As illustrated in Figure 1, the refrigerant circuit 130 may have a first refrigerant pipe 131 and a second refrigerant pipe 133 that connect the outdoor unit 110 and the indoor unit 120.

**[0051]** In this two-pipe configuration, the first refrigerant pipe 131 corresponds to a liquid carrying pipe, generally also referred to merely as "liquid pipe", and the second refrigerant pipe 133 corresponds to a low-pressure gas carrying pipe, generally also referred to merely as "gas pipe".

**[0052]** Figure 2a shows a first embodiment of the outdoor unit 110 of the heat pump system 100 in more detail.

**[0053]** The outdoor unit 110 (heat source unit) has an outdoor unit casing 111 to which the first and second refrigerant pipes 131, 133 are directly or indirectly connected, usually via service ports. The portion of the refrigerant circuit 130 inside the outdoor unit 110 is formed as described hereunder.

**[0054]** The refrigerant contained in the refrigerant circuit 130 is carbon dioxide or propane.

**[0055]** The outdoor unit 110 in this first embodiment includes a compressor 11 with a motor and a heat source heat exchanger 13 (outdoor heat exchanger). In addition, the outdoor unit 110 includes a four-way valve 23 acting as a switching mechanism that switches the operating state between a cooling operation/mode, in which the heat source heat exchanger 13 functions as a condenser, and heating operation/mode, in which the heat source heat exchanger 13 functions as an evaporator. The four-way valve 23 is connected to the suction side of the compressor 11 via a suction pipe 24. The discharge side of the compressor 11 is connected to the four-way valve 23 via a discharge pipe 25. The four-way valve 23 is connected to the gas side of the heat source heat exchanger 13 via a first outdoor gas pipe 26. The liquid side of the heat source heat exchanger 13 is connected to the first refrigerant pipe 131 (liquid pipe) via an outdoor liquid pipe 27. An expansion valve 14 is located in the outdoor liquid pipe 27.

**[0056]** The connection portion of the outdoor liquid pipe 27 with respect to the first refrigerant pipe 131 is provided with a liquid-side shut-off valve 28.

**[0057]** The four-way valve 23 is connected to the second refrigerant pipe 133 (gas pipe) via a second outdoor gas pipe 29. The connection portion of the second outdoor gas pipe 29 with respect to the second refrigerant pipe 133 is provided with a gas side shut-off valve 30. In addition, the outdoor unit 110 further comprises an outdoor fan 19 driven by an outdoor fan motor.

**[0058]** The outdoor unit casing 111 further comprises an opening 70. In the embodiment shown in Figure 2a the opening 70 is located on a top plate of the outdoor unit casing. "Top" in this context means the side that is facing the sky when the outdoor unit is installed at its site of operation. The opening 70 may be formed as a cut-out of the top plate of the outdoor unit casing 111. It may also be formed by a mesh, grille, or the like that allow gas to exit the opening 70. The opening 70 may also be formed in a duct attached to the outdoor unit casing 70.

**[0059]** The outdoor unit casing also comprises a release device 40. The release device 40 is connected to the refrigerant circuit. In the embodiment shown in Figure 2a, the release device 40 is connected to a portion of the outdoor liquid pipe 27 between the liquid-side shut-off valve 28 and first refrigerant pipe 131. In other words, flow of the refrigerant is such that the release device 40 is located downstream of the liquid-side shut-off valve 28 viewed from the discharge side of the compressor 11 in a cooling operation mode of the heat pump system 100 and upstream of the liquid-side shut-off valve 28 viewed from the suction side of the compressor 11 in a heating operation mode of the heat pump system 100. Hence, even when liquid-side shut-off valve 28 is closed for some reason, the release device 40 will still connected to an indoor-side portion of the refrigerant circuit.

**[0060]** Additionally, the outdoor unit casing 111 accommodates an electric box 50 that houses a control unit 300. The electric box may also house any other electric components required for the operation of the outdoor unit 110 and the heat pump system 100 to which it is attached. The control unit 300 may control the heat pump system 100 and specifically the outdoor unit 110. The control unit 300

may thus control the opening and closing of any one of the expansion valve 14, the liquid-side shut-off valve 28, the gas-side shut-off valve 30, and the four-way valve 23 or a combination thereof. It may also control the operation of the fan 19 and the compressor 11. In particular, the control unit 300 also controls the release device 40.

**[0061]** The control unit 300 is configured to operate the outdoor unit 110 and thereby the heat pump system 100 in a release operation mode. This may be the result of receipt of a signal by the control unit 300 that a refrigerant leakage is detected in the refrigerant circuit 130 of the heat pump system 100. In the release operation mode, the release device 40 is operated for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

**[0062]** The control unit 300 may be configured to, in a normal operation mode, i.e., the cooling mode or heating mode, operate the release device 40 to allow a refrigerant flow in the first refrigerant pipe 131 and the second refrigerant pipe 133. In the normal operation mode, no refrigerant is released from the refrigerant circuit 130 via the release device 40. The control unit 300 may further be configured to, in a release operation mode, open the expansion valve 14. Although not preferred, the control unit 300 may operate or switch the four-way valve 23 in a release operation mode.

**[0063]** Furthermore, the control unit 300 may be configured to, in a release operation mode, close one or both of the liquid-side shut-off valve 28 and the gas-side shut-off valve 30. Closing these valves has the effect that part of the refrigerant is trapped in the outdoor-side portion of the refrigerant circuit 130, where it causes no harm, while the pressure of the refrigerant in the indoor-side portion of the refrigerant circuit 130 may still be reduced by releasing the refrigerant through the release device 40. Thereby, at least a part of the refrigerant may be maintained in the refrigerant circuit 130, which may be re-used when normal operation of the heat pump system 100 can be resumed.

**[0064]** The release device 40 is configured such, that in the release operation mode refrigerant is released in a direction away from the electric box 50. The direction in which the refrigerant is released to the outside of the refrigerant circuit is indicated in Figure 2a by an arrow. The arrow is indicative of the main component of momentum of the released refrigerant. As can be seen, the electric box 50 is not positioned in the direction of the released refrigerant. Instead, the release device 40 is configured such that the released refrigerant is vented in the direction towards the opening 70 of the outdoor unit casing 111.

**[0065]** Therefore, with an outdoor unit according to this first embodiment it is possible to reduce the pressure in the refrigerant circuit 130 quickly in the case a leakage is detected by venting the refrigerant through the release device 40. At the same time, this discharge of refrigerant is not harmful to electrical components inside the electric box 50, as the cold high-pressure stream of gaseous refrigerant expelled from the release device 40 is directed towards the opening 70 of the outdoor unit casing 111. Thermal stress, mechanical stress, condensation of moisture, built-up of water ice is effectively suppressed with this embodiment according to the disclosed invention.

**[0066]** Figure 2b and Figure 2c show modifications of the outdoor unit 110 according to the first embodiment. In the first modification shown in Figure 2b, the opening 70 is in the bottom plate of the outdoor unit casing 111. Accordingly, to allow refrigerant to be released in the direction of the opening 70, the release device 40 is configured to vent refrigerant downwards in the direction to the opening 70. Similarly, in the second modification shown in Figure 2c the opening 70 is located on the left-hand side (in the view of Figured 2c) of outdoor unit casing 111 (left side plate). It goes without saying, that the opening may be formed on any other side plate of the outdoor unit casing and that the release device may release the refrigerant to any other direction, which is not the direction towards the electric box 50.

**[0067]** In yet alternative modifications of the first embodiment (not shown) the release device 40 is connected to a portion of the second outdoor gas pipe 29 between the gas-side shut-off valve 30 and second refrigerant pipe 133. Function and effects of these modifications are similar to what has been described above.

**[0068]** Figure 3a shows a second embodiment of the outdoor unit 110 according to the disclosure. The configuration is similar to that of the first embodiment, so that only differences will be described. The release device 40 in this embodiment comprises a refrigerant release pipe 61 and a blow-off mechanism 81. The refrigerant release pipe 61 is branched-off the outdoor liquid pipe 27. A portion of the refrigerant release pipe 61 is interrupted by the blow-off mechanism 81. In the release operation mode, the control unit 300 controls the blow-off mechanism 81 to open. Then, refrigerant can flow from the outdoor liquid pipe 27 through the refrigerant release pipe 61. The refrigerant leaves the refrigerant release pipe 61 at the release opening 71, which is located at the free end of the refrigerant release pipe 61. As in the first embodiment, refrigerant is released towards the opening 70 and thereby in a direction away from the electric box 50. By using a refrigerant release pipe 61 it is possible to more effectively guide the blown-off refrigerant away from the electric box 50.

**[0069]** Figure 3b shows a first modification of the outdoor unit according to the second embodiment. In this modification the refrigerant release pipe 61 extends all the way through the outdoor unit casing 111 and ends in the vicinity of the opening 70. In this modified embodiment the released refrigerant can be guided safely away from the electric box 50, further reducing the risk of damaging the components housed therein or causing a malfunction. Although not shown, in this modification it is particularly easy to attach the free end of the refrigerant release pipe 61 to a wall or plate of the outdoor unit casing

111 to prevent the refrigerant release pipe 61 from vibrating upon discharging refrigerant.

**[0070]** Figure 3c shows a second modification of the outdoor unit according to the second embodiment. In this modification the refrigerant release pipe 61 protrudes through the opening 70 to the outside of the outdoor unit casing 111, causing even less harm to any components inside the outdoor unit. Similar to the first modification, the refrigerant release pipe 61 can easily be attached to the outdoor unit casing 111, thereby reducing vibrations. In principle, the refrigerant release pipe 61 may extend to any suitable location outside of the outdoor unit 110. It may be desirable, for example, to guide the released refrigerant to a location, where venting has less of a safety risk to the surrounding. It may also be desirable to connect multiple refrigerant release pipes from different heat pump systems to let them vent at a centralized location.

**[0071]** As for the first embodiment, the release pipe 61 may in alternative modifications be connected to the second outdoor gas pipe 29.

**[0072]** Figure 4a shows a third embodiment of an outdoor casing 110 according to the disclosure. In this embodiment the release device 40 comprises a first release device 40.1 and a second release device 40.2. The configuration of the first release device 40.1 is identical to that shown in Figure 3a. It comprises a first refrigerant release pipe 61.1 with a first release opening 71.1 and a first blow-off mechanism 81.1. In addition to the embodiment shown in Figure 3a, the release device 40 now comprises the second release device 40.2. The second release device 40.2 is connected to a portion of the second outdoor gas pipe 29 between the gas-side shut-off valve 30 and the second refrigerant pipe 133. The second release device 40.2 is configured analogous to the first release device 40.1, that is, it comprises a second refrigerant release pipe 61.2 with a second release opening 71.2 and a second blow-off mechanism 81.2. The second release opening 71.2 is configured such that it directs released refrigerant away from the electric box 50. Preferably, the second release opening 71.2 is positioned such that released refrigerant does in particular not affect the operation of the first release device 40.1.

**[0073]** The second release device 40.2 may also be controlled by the control unit 300 in the release operation mode. This control may be independent from the control of the first release device 40.1, but the control unit 300 may also control both release devices in parallel in the same manner. With two release devices 40.1 and 40.2 at different portions of the refrigerant circuit 130, pressure of the refrigerant in the refrigerant circuit 130 may be reduced more quickly suppressing the amount of leaking refrigerant more effectively. With the second refrigerant release device 40.2 the overall safety of the heat pump system can also be increased in the event of a leakage, should, for example, the first release device 40.1 not work properly, or the leakage occur in a portion of the refrigerant circuit 130, which for some reason is shut off the first release device 40.1 but not the second release device 40.2 (or vice versa).

**[0074]** Figure 4b shows again a minor modification of the outdoor unit according to the third embodiment. In this modification, similar to the modification shown in Figure 3b, the first release pipe 61.1 and the second release pipe 61.2 extend inside the outdoor unit casing 111 all the way towards the opening 70. The effects of this configuration are similar to that discussed above for Figure 3b.

**[0075]** Figure 5a shows a fourth embodiment of an outdoor unit 110 according to the invention. In addition to the fourth embodiment, the outdoor unit 110 further comprises a manifold pipe 90. The first refrigerant release pipe 40.1 and the second refrigerant release pipe 40.2 are connected at their respective release openings 71.1 and 71.2 to this manifold pipe 90 within the outdoor unit casing 111. The manifold pipe 90 has one end 91, acting as the release opening, that is a free end not connected to the first and second refrigerant release pipes 61.1 and 62.2. The one end 91 is directed away from the electric box 50 and towards the opening 70. With the manifold pipe 90 piping inside the outdoor unit 11 can be simplified while released refrigerant can effectively be guided away via the two release devices 40.1 and 40.2.

**[0076]** Figure 5b shows again a minor modification of the outdoor unit according to the fourth embodiment. In this modification, similar to the modification shown in Figure 3b, the free end 91 of the manifold pipe 90 extends inside the outdoor unit casing 111 all the way towards the opening 70 and then protrudes outwards of the outdoor unit casing 111. The effects of this configuration are similar to that discussed above for Figure 3b.

**[0077]** Figure 6 shows a fifth embodiment of an outdoor unit 110 according to the invention. This embodiment is very similar to the first and second embodiment and in addition comprises a bypass pipe 43 that connects the outdoor gas pipe 29 to the release device 40.

**[0078]** In the fifth embodiment, the release pipe 61, just like in Figures 2a-c, is branched off from the outdoor liquid pipe 27 and the bypass pipe 43 additionally connects the second outdoor gas pipe 29 to said release pipe 61.

**[0079]** Put differently, both the outdoor liquid pipe 27 and the second outdoor gas pipe 29 are connected to and merge into the release pipe 61. This allows to obtain a faster release of the refrigerant from the refrigerant circuit compared to the first or second embodiment because the refrigerant can be released from both the outdoor gas pipe 29 and the outdoor liquid pipe 27 at the same time.

**[0080]** In the shown embodiment, the bypass pipe 43 is connected to a portion of the release pipe 61, which directly connects to the outdoor liquid pipe 27. Hence, in this embodiment the presence of a bypass valve 44 is required in the bypass pipe 43 to prevent a direct connection between a liquid-side and gas-side of the refrigerant circuit 130.

**[0081]** However, in a modification (not shown), the release device 40 may comprise a three-way valve, of

which a first connection port is connected to the release opening 71, a second connection port is connected to the outdoor liquid pipe 27 via the release pipe 61, and a third connection port is connected to the outdoor gas pipe 29 via the bypass pipe 43. For example, the blow-off mechanism of the release device 40 may be implemented as or comprise such a three-way valve. In such a modification, a dedicated bypass-valve is not required.

**[0082]** In the fifth embodiment, the control unit 300 is configured to open the bypass valve 44 upon the detection of a refrigerant leakage to allow refrigerant to directly flow from the second outdoor gas pipe 29 through the bypass pipe 43 to the release pipe 61. The control unit 300 is configured to control the bypass valve 44 in such a manner that it is kept closed during a normal operation of the heat pump system 100. Accordingly, no refrigerant can flow via the bypass pipe 43 and its bypass valve 44 to the release pipe 61 and the connected blow-off mechanism 81. The bypass valve 44 may, thus, be configured as a bypass two-way valve or a bypass check valve, which merely allows a refrigerant flow towards the release pipe 61 and away from the outdoor gas pipe 29 once the control unit 300 induced an opening of the same.

**[0083]** Even though not illustrated, in the fifth embodiment it is alternatively possible to branch off the release pipe 61 from the second outdoor gas pipe 29 and to provide the bypass pipe 43 between the outdoor liquid pipe 27 and the release pipe 61.

## REFERENCE LIST

**[0084]**

| | |
|---|---|
| 100 | heat pump system |
| 110 | outdoor unit |
| 111 | outdoor unit casing |
| 11 | compressor |
| 13 | heat source heat exchanger (outdoor heat exchanger) |
| 14 | expansion valve |
| 19 | outdoor fan |
| 23 | four-way valve (switching mechanism) |
| 24 | suction pipe |
| 25 | discharge pipe |
| 26 | first outdoor gas pipe |
| 27 | outdoor liquid pipe |
| 28 | liquid-side shut-off valve |
| 29 | second outdoor gas pipe |
| 30 | gas-side shut-off valve |
| 40 | release device |
| 40.1 | first release device |
| 40.2 | second release device |
| 43 | bypass pipe |
| 44 | bypass valve |
| 50 | electric box |
| 61 | refrigerant release pipe |
| 61.1 | first refrigerant release pipe |
| 61.2 | second refrigerant release pipe |
| 70 | opening |
| 71 | release opening |
| 71.1 | first release opening |
| 71.2 | second release opening |
| 81 | blow-off mechanism |
| 81.1 | first blow-off mechanism |
| 81.2 | second blow-off mechanism |
| 90 | manifold pipe |
| 91 | one end of manifold pipe (free end) |
| 120 | indoor unit (usage side unit) |
| 131 | first refrigerant pipe |
| 133 | second refrigerant pipe |
| 300 | control unit |

## Claims

**1.** An outdoor unit (110) for a heat pump system (100) including a refrigerant circuit (130), the outdoor unit (110) comprising:

an outdoor unit casing (111) accommodating:

an electric box (50) including a control unit (300),
a compressor (11),
a fan (19),
a release device (40), and
a heat source heat exchanger (13),

wherein the release device (40) is connected to the refrigerant circuit (130),
wherein the control unit (300) is configured to operate the release device (40) upon detection of a refrigerant leakage in the refrigerant circuit (130),
wherein the release device (40) is configured to release refrigerant from the refrigerant circuit in a direction away from at least the electric box.

**2.** The outdoor unit (110) according to claim 1,

wherein the outdoor unit casing (111) further comprises an opening (70),
wherein the release device (40) is configured to release the refrigerant in the direction to the opening (70).

**3.** The outdoor unit (110) according to claim 2, wherein the outdoor unit casing (111) comprises a bottom plate, a plurality of side plates, and a top plate,

wherein the opening (70) is provided in the bottom plate or
wherein the opening (70) is provided in the top plate.

**4.** The outdoor unit (110) according to claim 2, wherein the outdoor unit casing (111) comprises a bottom

plate, a plurality of side plates, and a top plate, wherein the opening is provided in at least one of the plurality of side plates.

**5.** The outdoor unit according to any one of claims 2 to 4, wherein the release device (40) comprises a blow-off mechanism (81) and a release opening (71),
wherein the release opening (71) is configured to release refrigerant via the blow-off mechanism in the direction to the opening (70).

**6.** The outdoor unit (110) according to claim 5,

wherein the refrigerant circuit (130) in the outdoor unit (110) further comprises a refrigerant release pipe (61) that branches from the refrigerant circuit (130) in the outdoor unit,
wherein the blow-off mechanism (81) is arranged in the refrigerant release pipe (61) and the release opening (71) is provided at one end of the refrigerant release pipe (61), and wherein the release opening (71) is configured to release the refrigerant via the refrigerant release pipe (61) and the blow-off mechanism (81) in the direction to the opening (70).

**7.** The outdoor unit (110) according to any one of claims 1 to 6,

wherein the refrigerant circuit (130) comprises a first refrigerant pipe (131) and a second refrigerant pipe (133) that connect the outdoor unit (110) to an indoor unit (120), and
wherein the refrigerant circuit (130) in the outdoor unit (110) further comprises an outdoor liquid pipe (27) connecting to the first refrigerant pipe (131), an outdoor gas pipe (29) connecting to the second refrigerant pipe (133), a liquid-side shut-off valve (28) in the outdoor liquid pipe (27), and a gas-side shut-off valve (30) in the outdoor gas pipe (29),
wherein the refrigerant release device (40) is either connected to the outdoor liquid pipe (27) between the liquid-side shut-off valve (28) and the first refrigerant pipe (131) or connected to the outdoor gas pipe (29) between the gas-side shut-off valve (30) and the second refrigerant pipe (133) .

**8.** The outdoor unit (110) according to claim 7,
wherein the refrigerant release device (40) is further connected via a bypass pipe (43) having a bypass valve (44) to the respective other one of the outdoor liquid pipe (27) and the outdoor gas pipe (29).

**9.** The outdoor unit (110) according to any one of claims 2 to 4, wherein the release device (40) comprises a first release device (40.1) and a second release device (40.2).

**10.** The outdoor unit (110) according to claim 9,

wherein the refrigerant circuit (130) in the outdoor unit (110) is separated in a liquid refrigerant portion and a gas refrigerant portion at the compressor (11),
wherein the first release device (40.1) comprises a first refrigerant release pipe (61.1) branching from the liquid refrigerant portion, wherein a first blow-off mechanism (81.1) is arranged in the first refrigerant release pipe (61.1),
wherein the second release device (40.2) comprises a second refrigerant release pipe (61.2) branching from the gas refrigerant portion, wherein a second blow-off mechanism (81.2) is arranged in the second refrigerant release pipe (40.2),
wherein each of the first refrigerant release pipe (61.1) and the second refrigerant release pipe (61.2) has one end for releasing refrigerant,
wherein the one end of the first refrigerant release pipe (61.1) is configured to release the refrigerant via the first refrigerant release pipe (61.1) and the first blow-off mechanisms (81.1) in the direction to the opening (70), and wherein the one end of the second refrigerant release pipe (61.2) is configured to release the refrigerant via the second refrigerant release pipe (61.2) and the second blow-off mechanisms (81.2) in the direction to the opening (70).

**11.** The outdoor unit (110) according to claim 10, wherein the one end of the first refrigerant release pipe (61.1) and the one end of the second refrigerant release pipe (61.2) are configured to protrude outwards of the outdoor unit casing (111) through the opening (70).

**12.** The outdoor unit (110) according to claim 10 or 11, wherein the first refrigerant release pipe (61.1) is fixed to the outdoor unit casing (111) near the one end of the first refrigerant release pipe and the second refrigerant release pipe (61.2) is fixed to the outdoor unit casing (111) near the one end of the second refrigerant release pipe.

**13.** The outdoor unit (110) according to any one of claims 10 to 12, wherein the one end of the first and second refrigerant release pipe merges into a manifold pipe (90), wherein one end of the manifold pipe (91) that is not connected to the first and second refrigerant release pipe is configured to release the refrigerant.

**14.** The outdoor unit (110) according to claim 13, wherein the one end of the manifold pipe (91) protrudes out of the outdoor unit casing (111) through the opening

(70).

**15.** The outdoor unit (110) according to claim 13 or 14, wherein the manifold pipe (90) is fixed to the outdoor unit casing (111) near the one end of the manifold pipe (91).

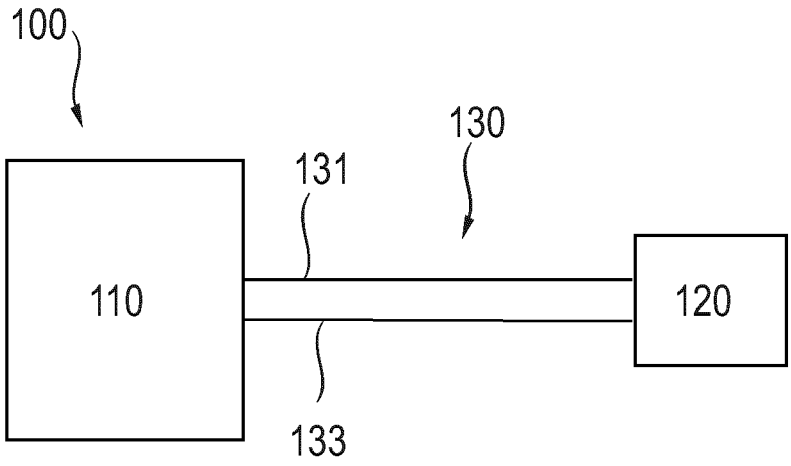


Fig. 1

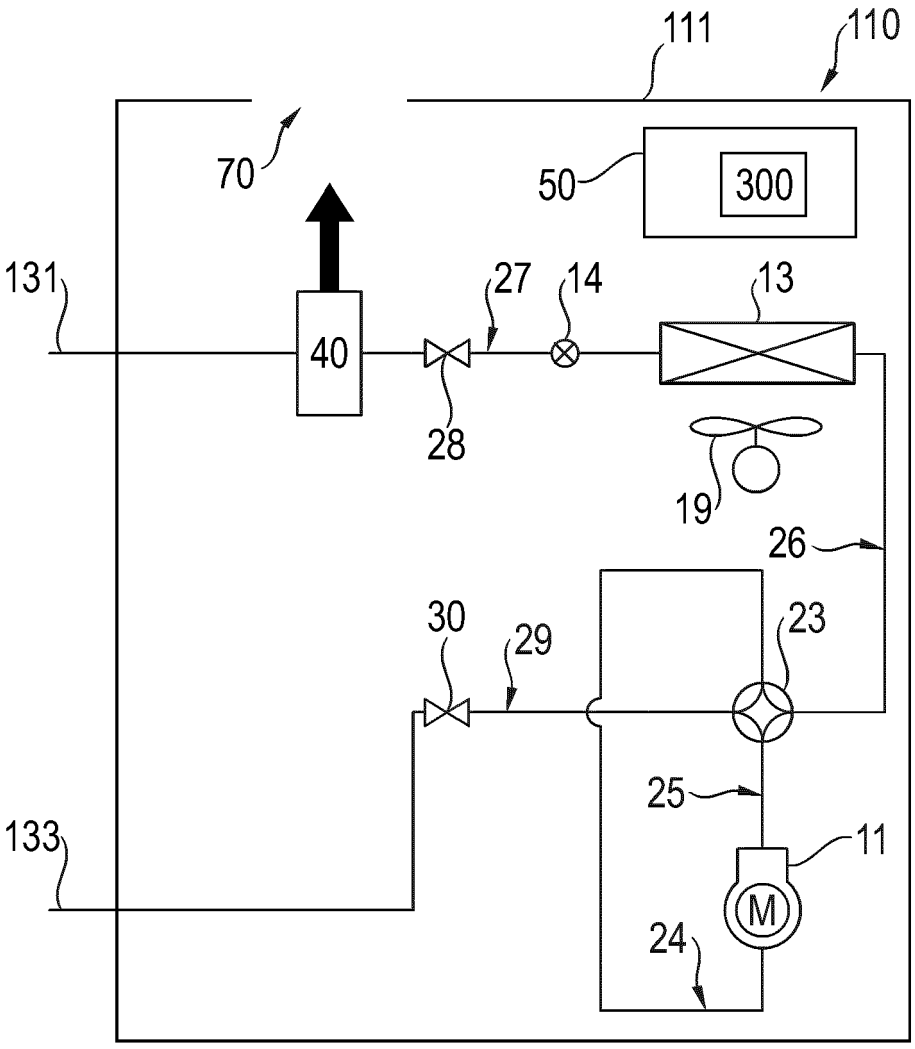


Fig. 2a

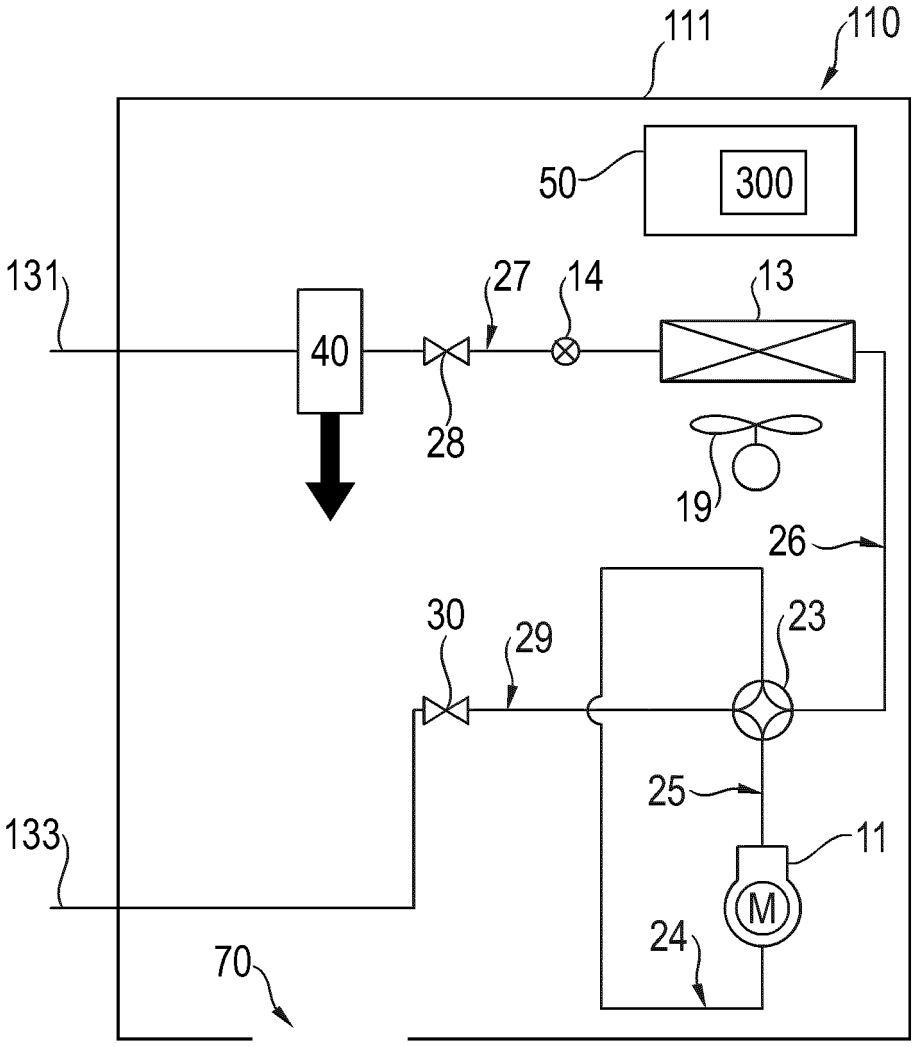


Fig.2b

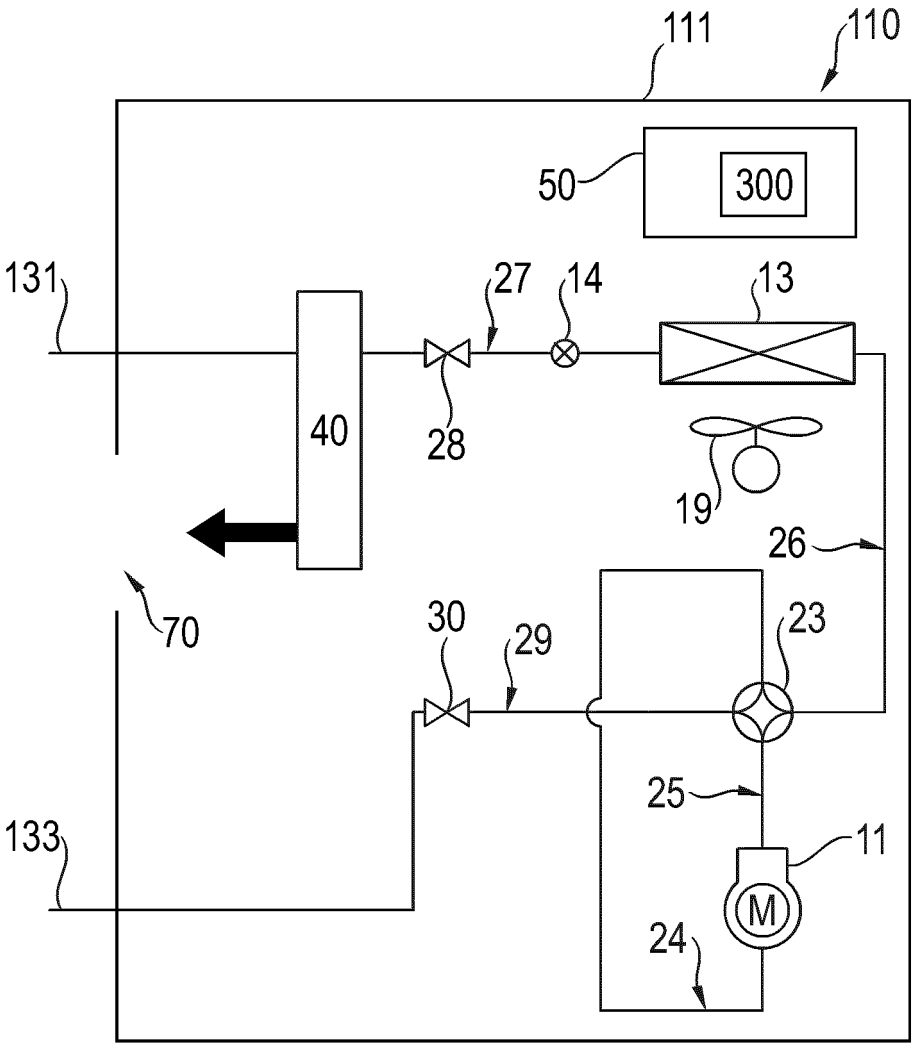


Fig.2c

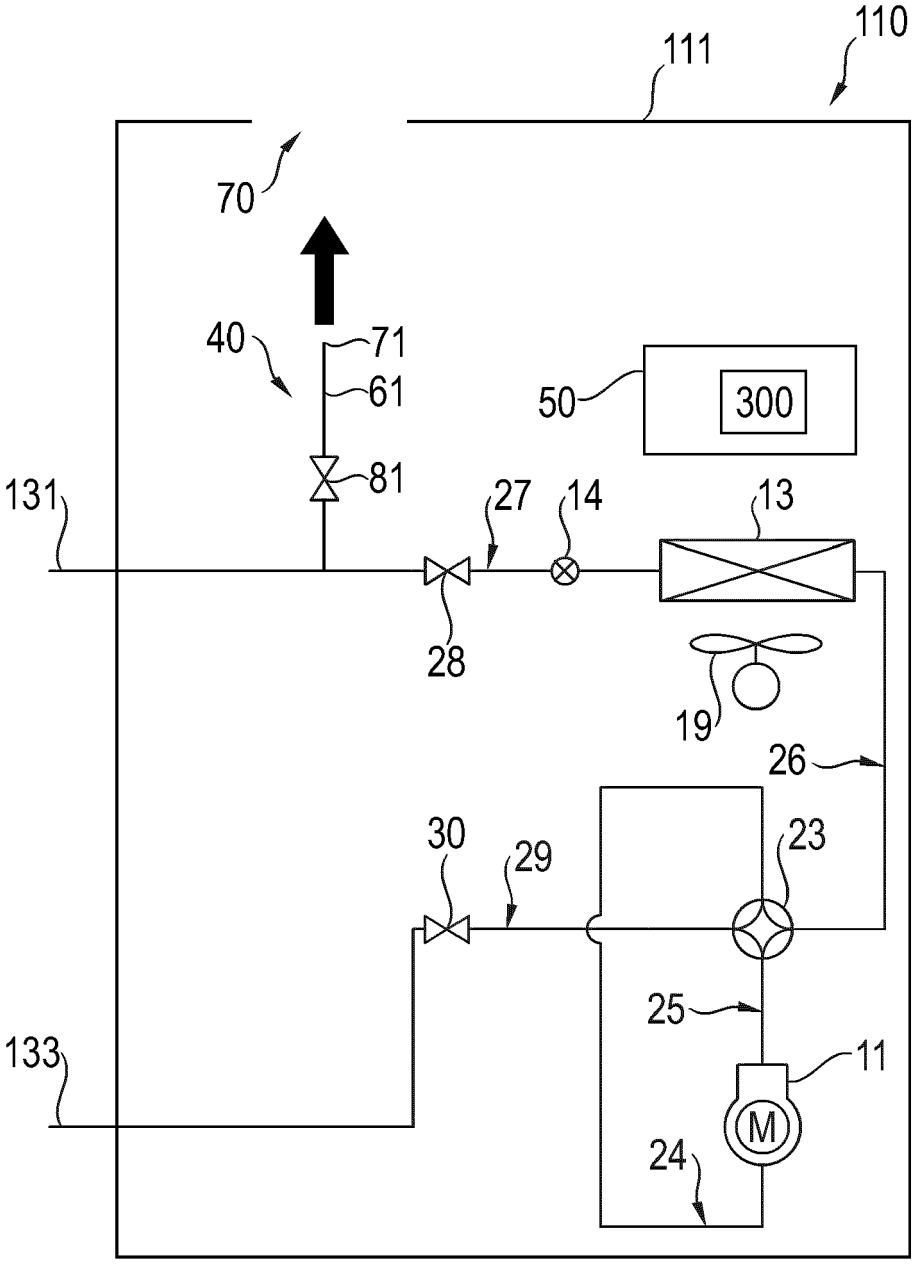
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Fig. 3a

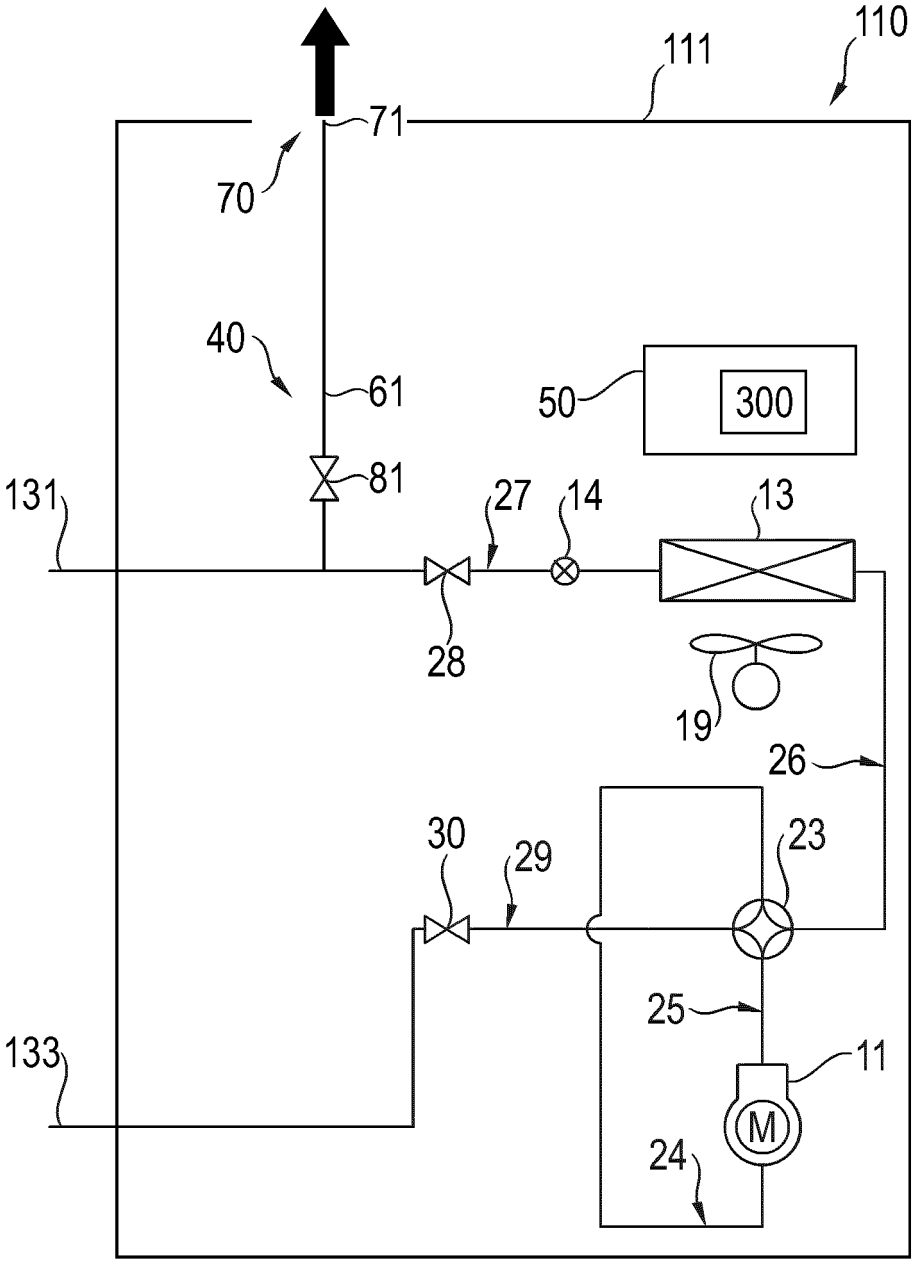
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Fig. 3b

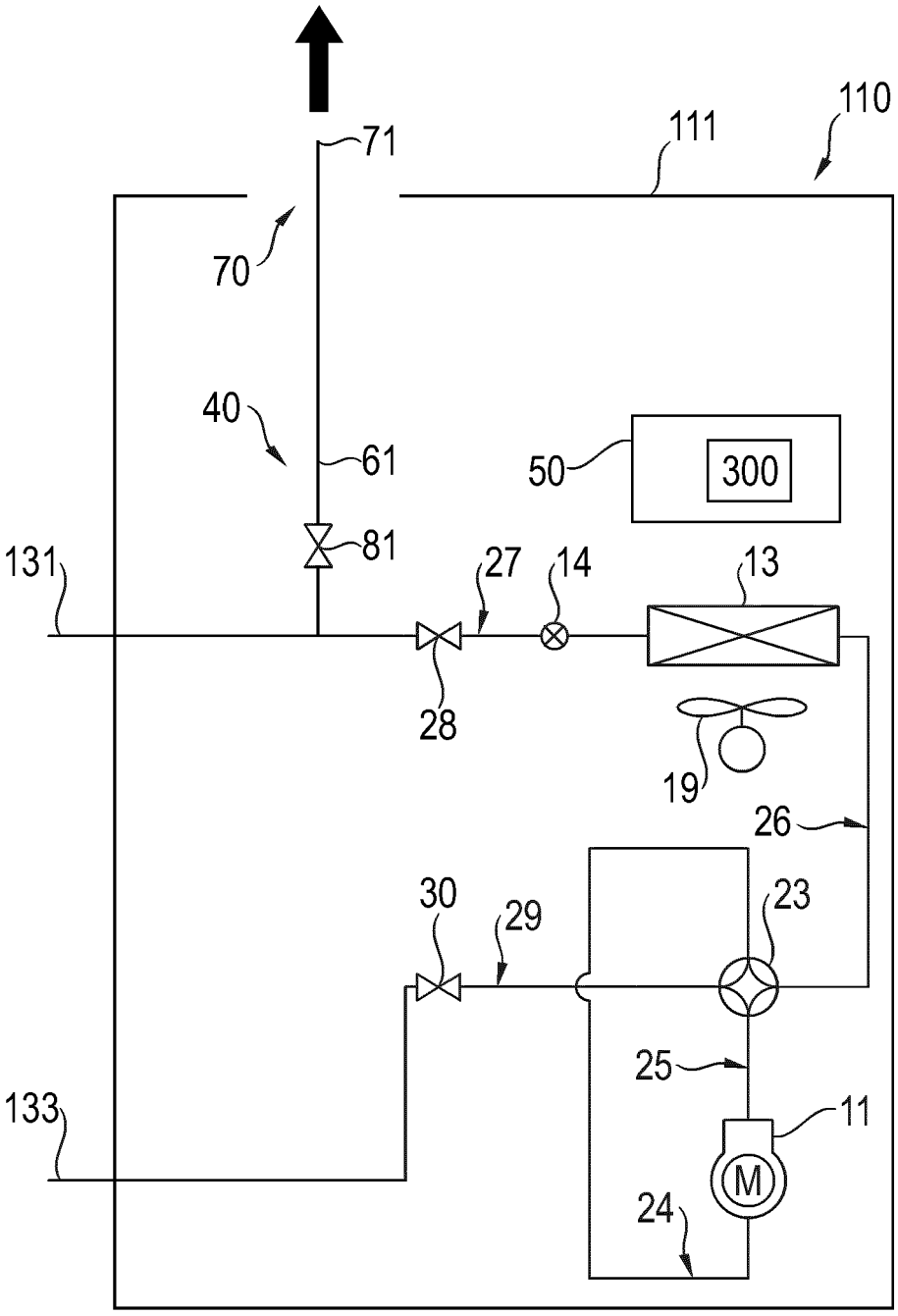
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Fig. 3c

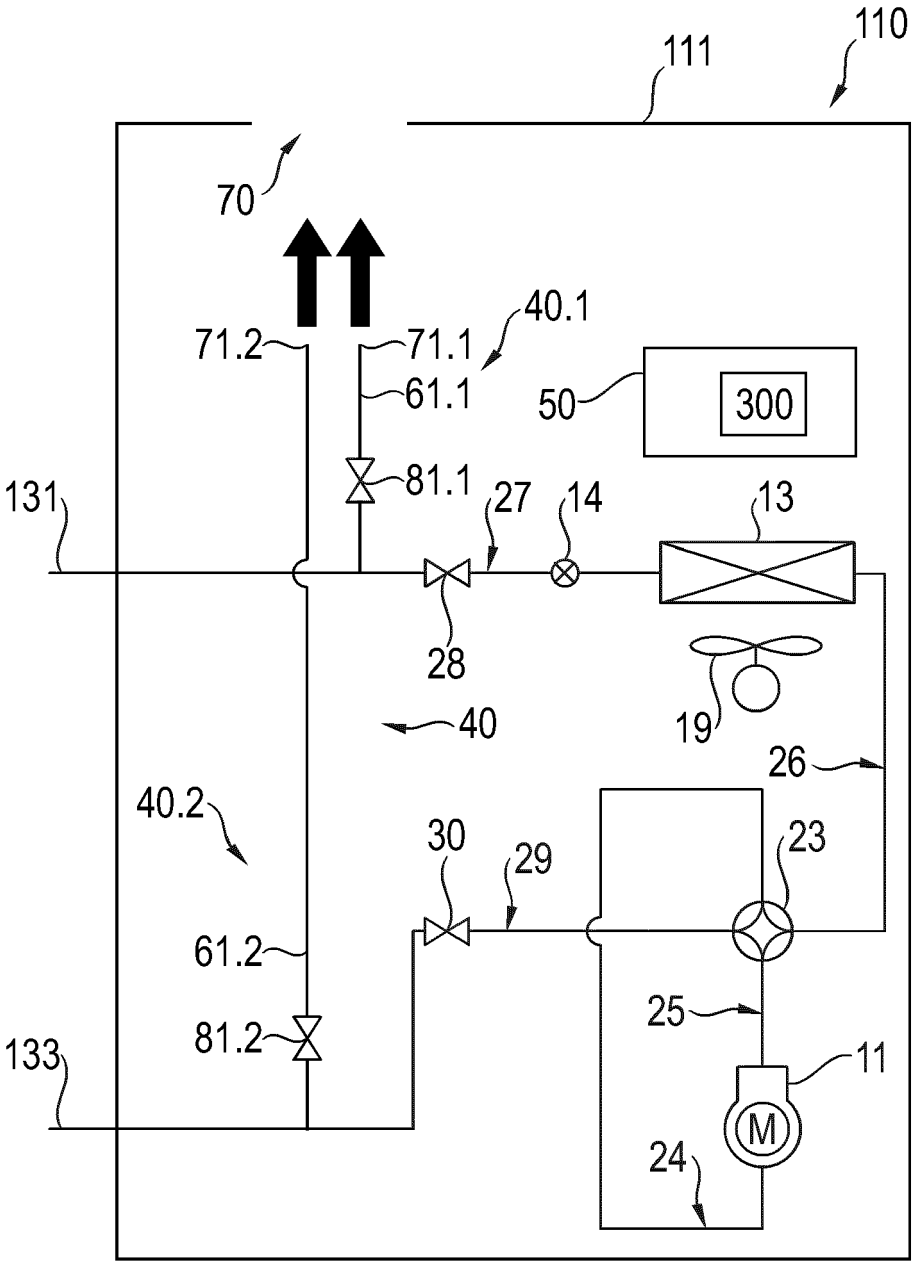
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Fig. 4a

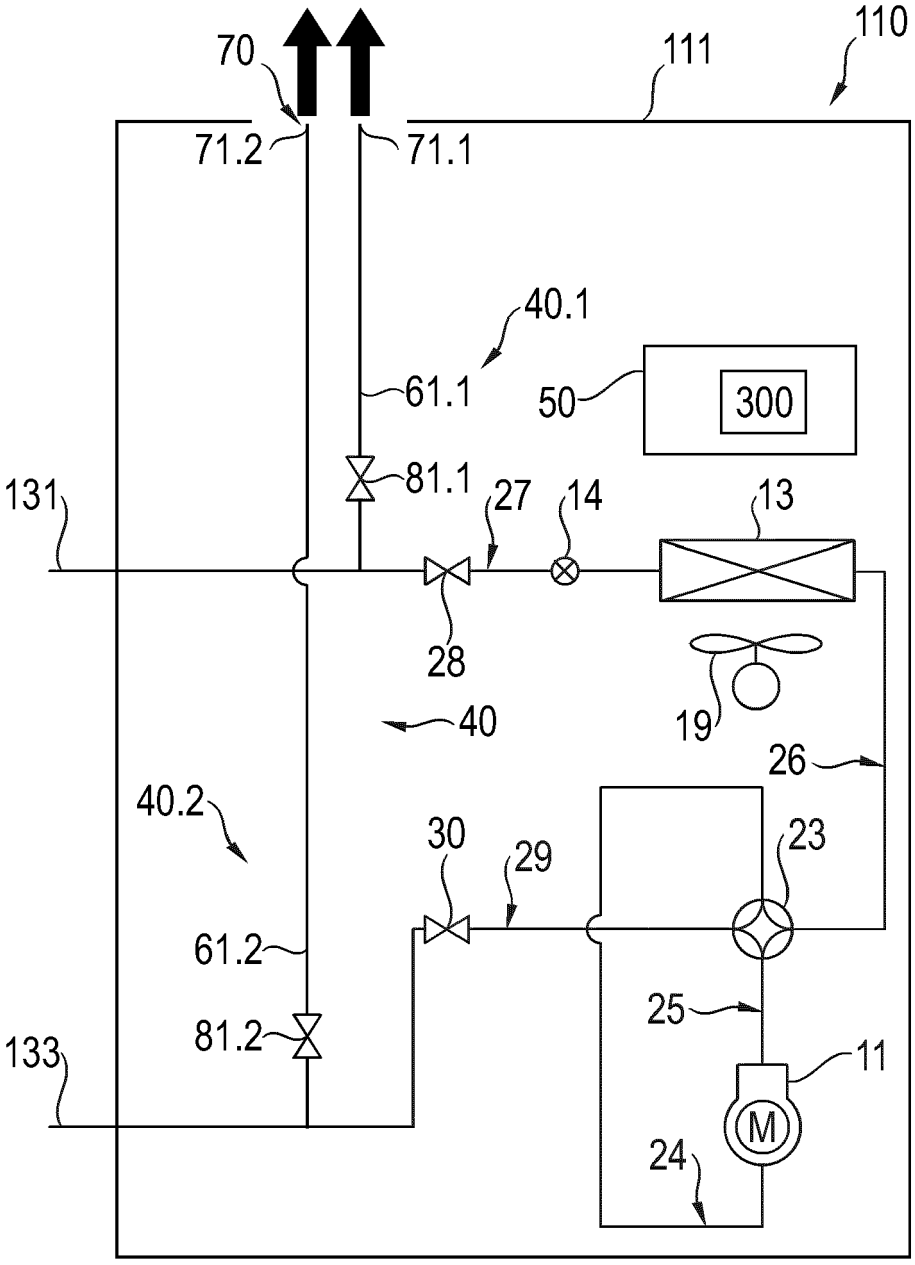
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Fig. 4b

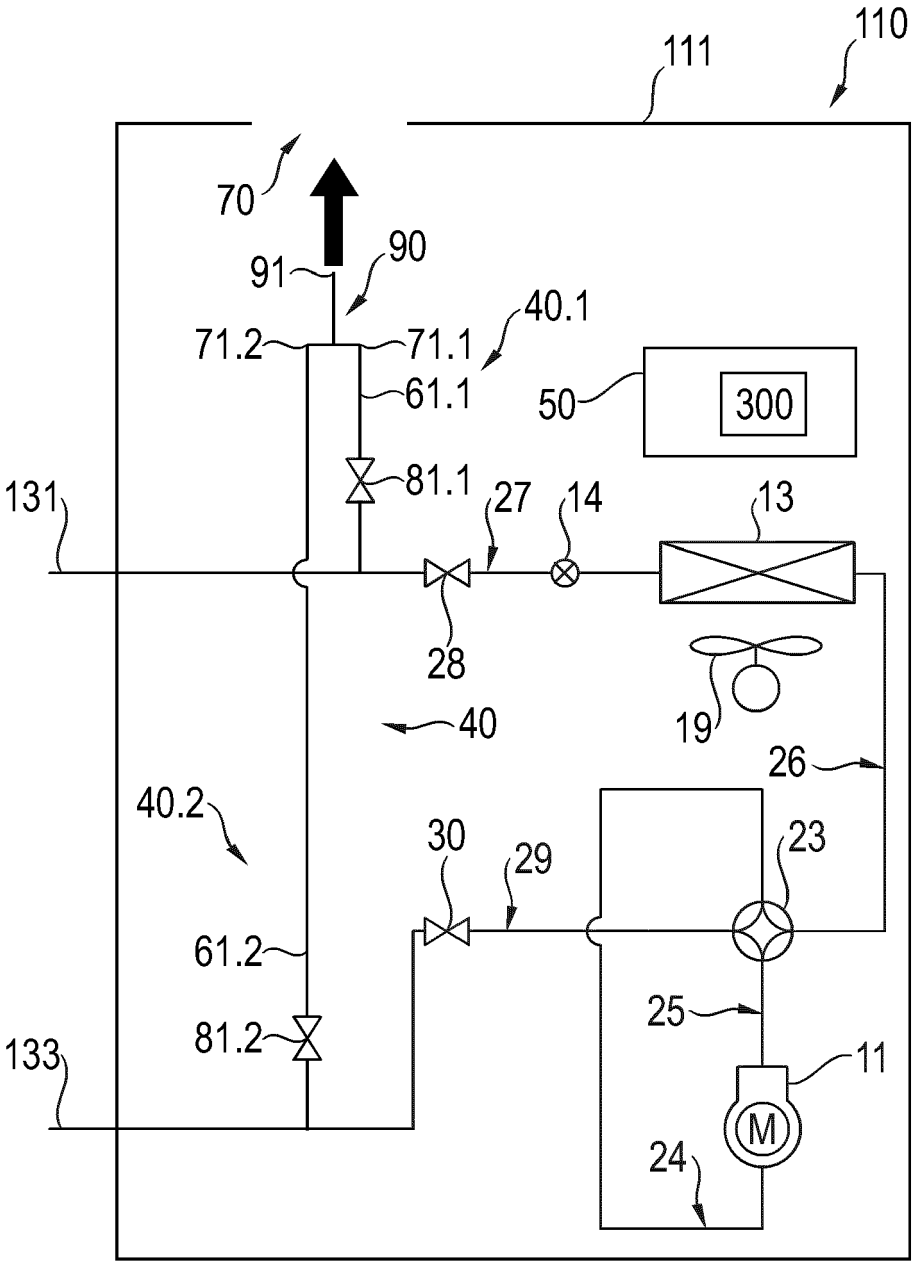
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Fig. 5a

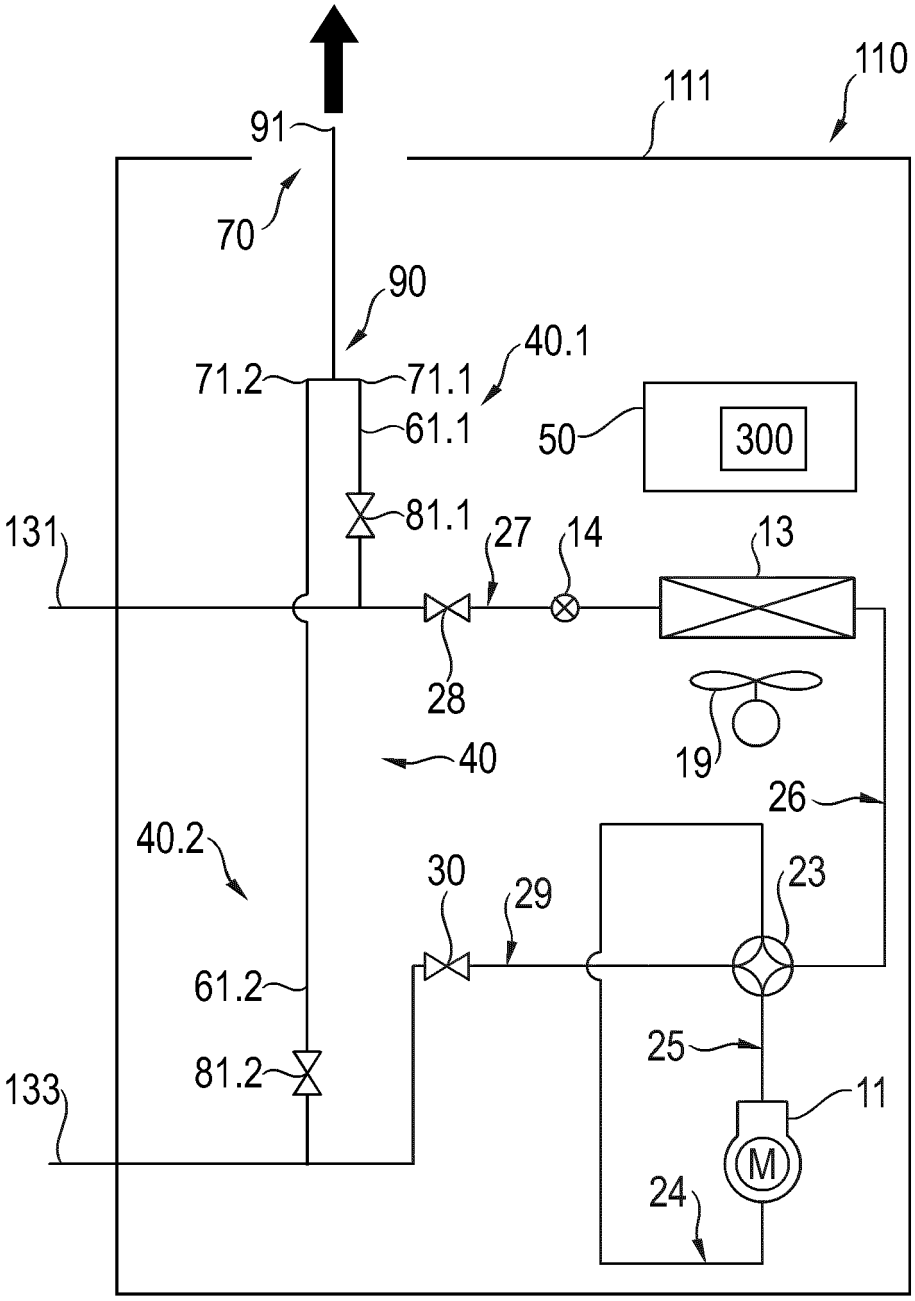
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Fig. 5b

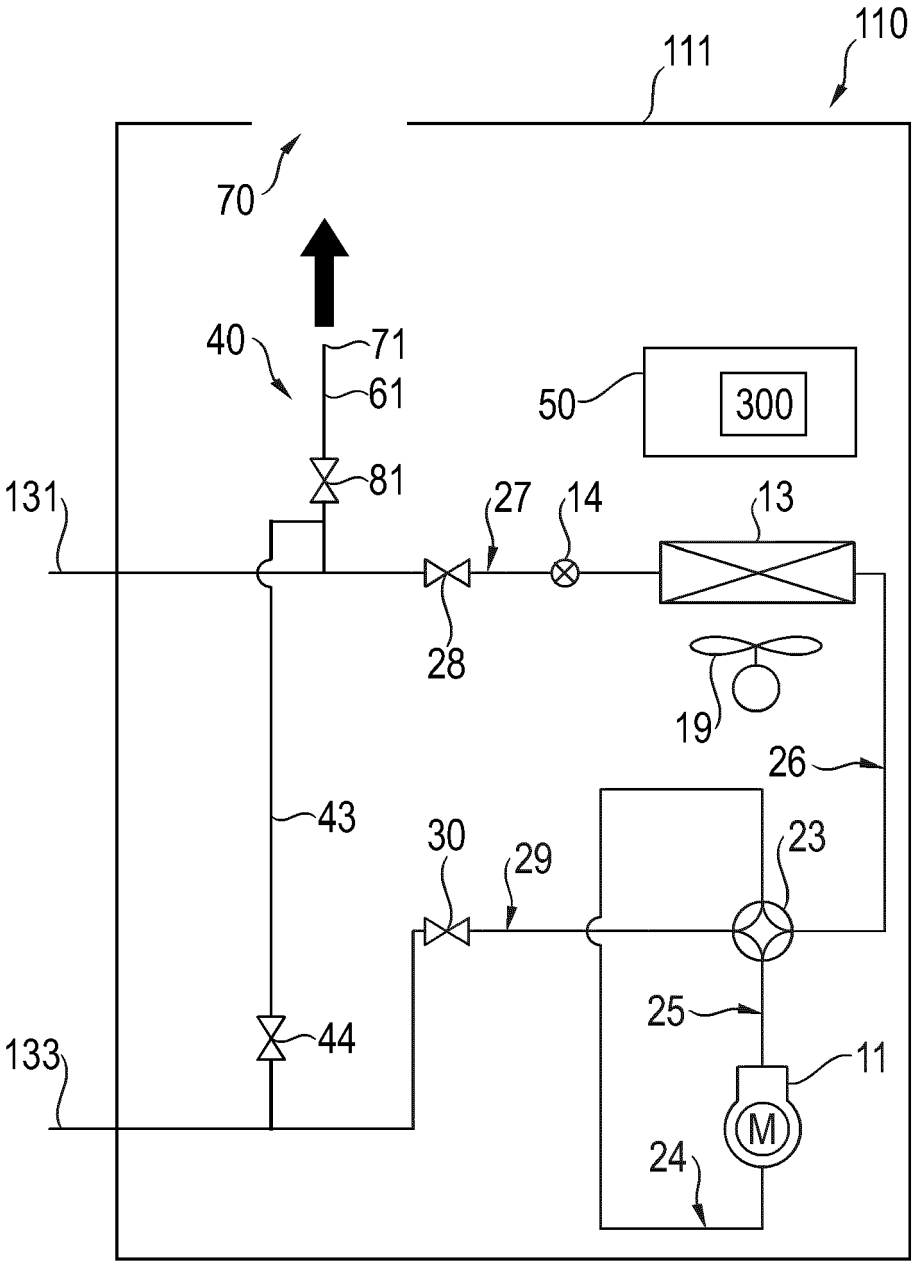
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Fig. 6

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# EUROPEAN SEARCH REPORT

Application Number
EP 24 18 9441

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The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
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| Munich | 29 November 2024 | Lepers, Joachim |

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X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

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