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(71) Applicant: **Daikin Europe N.V.**
8400 Oostende (BE)

(72) Inventors:
- **SCARPATI, Giuseppe**
  8400 Oostende (BE)
- **TACK, Lukas**
  8400 Oostende (BE)
- **CORNELIS, Kevin**
  8400 Oostende (BE)
- **STEEN, David**
  8400 Oostende (BE)
- **KOTANI, Takuya**
  8400 Oostende (BE)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) HEAT PUMP SYSTEM COMPRISING A RELEASE DEVICE AND METHOD FOR RELEASING REFRIGERANT FROM A HEAT PUMP SYSTEM

(57) The disclosure relates to a heat pump system comprising a refrigerant circuit connecting a compressor, a heat source heat exchanger, a first expansion valve, and a usage heat exchanger, the refrigerant circuit having an indoor portion and an outdoor portion, wherein the outdoor portion of the refrigerant circuit comprises the compressor, the heat source heat exchanger, and the first expansion valve, and the indoor portion of the refrigerant circuit comprises the usage heat exchanger, a control unit configured to control the heat pump system, a first release device arranged in the refrigerant circuit, and a second release device arranged in the refrigerant circuit, wherein the first release device and the second release device separate the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit, wherein the control unit is configured to, in a release operation mode upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system, operate the first release device and the second release device to shut off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit, and to release refrigerant from the indoor portion of the refrigerant circuit to the outside of the refrigerant circuit.

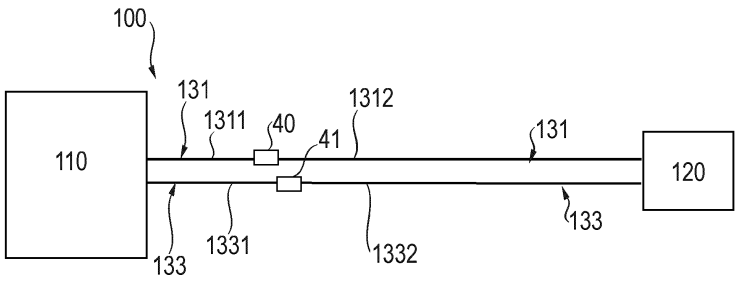

Fig. 1A

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat pump system comprising a release device and a method for releasing refrigerant from a heat pump system.

BACKGROUND ART

[0002] Nowadays, heat pump systems often use natural refrigerants. Natural refrigerants are alternatives to synthetic refrigerants such as chlorofluorocarbon (CFC), hydrochlorofluorocarbon (HCFC), and hydrofluorocarbon (HFC) based refrigerants. Unlike other refrigerants, natural refrigerants can be found in nature. One examples of a natural refrigerant is carbon dioxide. Carbon dioxide is a toxic refrigerant and has a considerably higher working pressure compared to other refrigerants requiring specific adaption to existing heat pump systems. In any case, the refrigerant asks for specific safety measures to, in the event of a leakage in an indoor unit, prevent that the mass of refrigerant leaking into the indoor space accommodating the indoor unit exceeds a predetermined value.

[0003] A well-known safety measure is the so-called pump-down operation, in which refrigerant is, in case of leakage in an indoor unit, pumped from the indoor unit towards and into an outdoor unit. Accordingly, the mass of refrigerant leaking into the indoor space can be minimized.

[0004] 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. To the contrary, the use of shut-off valves is not sensible for carbon dioxide because the toxicity limit for carbon dioxide that can be reached in the indoor space in case of leakage is extremely low and it is also reached very fast due to the high leak rate due to the high working pressure.

[0005] A problem with the known inexpensive shut-off valves is that they have a slow closing time, so in the event of a refrigerant leak in an indoor space, too much mass of refrigerant is released into the indoor space. To avoid exceeding the maximum allowable indoor concentration of refrigerant for toxicity, it is essential that the refrigerant mass flow leak rate is minimised very quickly. Shut-off valves having shorter closing times are relatively expensive increasing the overall costs of the heat pump system. Additionally, for installation purposes, the allowed length of piping between the shut-off valves and the indoor unit is relatively long. As a result, a relatively high charge remains in the piping between the indoor unit and the shut-off valves and, consequently in the indoor unit. Depending on the used refrigerant the charge remains in the piping between the indoor unit and the shut-off valves and, consequently in the indoor unit, may already suffice to exceed the maximum allowable limit defined in the respective regulations. This is particularly true if the indoor unit is installed in a relatively small indoor space.

[0006] An alternative safety measure is disclosed in JP 5292940 B2. JP 5292940 B2 discloses to open a release valve and discharge/release the refrigerant in the refrigerant circuit to the atmosphere and, hence, the outside of the refrigerant circuit/heat pump system.

[0007] Yet, in case of JP 5292940, all the refrigerant in the refrigerant circuit is released from the release valve. So, there is a problem that it takes time to release all the refrigerant in the refrigerant circuit to the outside of the refrigerant circuit.

[0008] Further, the release valve of JP 5292940 B2 is in one embodiment located at the bottom of a refrigerant reservoir, so if refrigerant leaks into the indoor space, a pump down operation, pumping the refrigerant into the refrigerant reservoir, is required, which again takes time. Additionally, the release valve is connected to a release pipe branched from the bottom part of the refrigerant reservoir. During the release, the liquid portion of two-phase carbon dioxide (liquid-vapour mixture) in the reservoir may freeze potentially clogging the release pipe.

SUMMARY OF THE INVENTION

[0009] In view of the above, it is an object of the present disclosure to provide a heat pump system and method for releasing refrigerant from the heat pump system being capable of effectively and inexpensively cope with the problems associated with leaking natural refrigerants.

[0010] Another object of the present disclosure is to provide an improved and safer heat pump system and method for releasing refrigerant from the heat pump system, which for example allow for a faster release of refrigerant to the atmosphere.

[0011] This object is solved by a heat pump system according to claim 1 and by a method according to claim 9. The dependent claims describe optional features and embodiments.

[0012] According to a first aspect of the disclosure, the heat pump system comprises a refrigerant circuit connecting a compressor, a heat source heat exchanger, a first expansion valve, and a usage heat exchanger, the refrigerant circuit having an indoor portion and an outdoor portion. The outdoor portion of the refrigerant circuit comprises the compressor, the heat source heat exchanger, and the first expansion valve, and the indoor portion of the refrigerant circuit comprises the usage heat exchanger. The heat pump system further comprises a control unit configured to control the heat pump system, a first release device arranged in the refrigerant circuit, and a second release device arranged in the refrigerant circuit. The first release device and the second release device separate the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit. The control unit is configured to, in a release operation

mode upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system, operate the first release device and the second release device to shut off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit, and to release refrigerant from the indoor portion of the refrigerant circuit to the outside of the refrigerant circuit (atmosphere).

[0013] The heat pump system of the first aspect allows for a quick pressure drop in the refrigerant circuit upon detection of refrigerant leakage so that a high mass flow rate of the refrigerant into the indoor space can be reduced. In case of a refrigerant leakage detection in the refrigerant circuit, the control unit of the heat pump system quickly responds by opening the first release device and the second release device to release the high pressure refrigerant from only the indoor portion of the refrigerant circuit quickly to the outside of the refrigerant circuit. Thus, the first and second release devices have a fast response time and offer a more cost-effective solution. This allows only the refrigerant in the indoor portion of the refrigerant circuit to be released to the outside of the refrigerant circuit in a shorter time.

[0014] In addition, no damage can occur to the components of the outdoor unit by the release of the high pressure refrigerant, as the outdoor portion of the refrigerant circuit is shut off from the indoor portion of the refrigerant circuit. Since the refrigerant may be released from the first and second (optionally third) release devices to the outside of a building (to the atmosphere), nobody is affected by the discharged high pressure refrigerant. Thus, the heat pump system is improved and safer. A high pressure in the context of the present disclosure is a pressure that is higher than the atmospheric pressure.

[0015] Moreover, in the first aspect, the at least one outdoor unit and the at least one indoor unit (or more particularly the components of the refrigerant circuit accommodated in the outdoor unit and the indoor unit, respectively) may be connected forming a refrigerant circuit. The refrigerant circuit has a first refrigerant pipe and a second refrigerant pipe that connect the components of the refrigerant circuit in the outdoor unit with components of the refrigerant circuit in the indoor unit. The refrigerant circuit contains a refrigerant and connects at least the heat source heat exchanger, the first expansion valve, the compressor, and the at least one usage heat exchangers. The components in the outdoor unit may comprise a compressor, a heat source heat exchanger, and a first expansion valve. The components in the indoor unit may comprise a usage heat exchanger.

[0016] The control unit may be configured to operate the components of the heat pump system. The control unit may be configured to operate at least the compressor, an heat source side fan, the expansion valve, and a usage side fan.

[0017] The control unit may be disposed in the outdoor unit and may be connected via a communication line to a PCB in the first and/or second release device (and optional third release device) .

[0018] The normal operation mode is the mode of the heat pump system where heating or cooling with the heat pump system is possible. In particular, during a normal operation mode, the plurality of indoor units can perform heating and cooling simultaneously.

[0019] The control unit may be configured to, in a normal operation mode, operate the first release device and the second release device to allow a refrigerant flow in the first refrigerant pipe and the second refrigerant pipe. In the normal operation mode, no refrigerant is released from the refrigerant circuit via the first release device and the second release device. The first release device and the second release device may be leak tight. Because the first release device and the second release device are leak tight, no refrigerant may escape to the outside of the refrigerant circuit during the normal operation mode.

[0020] The control unit may be further configured to operate the heat pump system in the release operation mode upon a leakage detected by a sensing device configured to detect a leakage in the heat pump system. The sensing device may be a leakage sensor such as a carbon dioxide detector. The sensing device may be located in the indoor space and may or may not be part of the indoor unit. The sensing device may be configured to measure a pressure drop in the refrigerant circuit within the indoor unit instead of detecting refrigerant. The control unit may be configured to receive a signal that a leakage has been detected by a sensing device, to locate the leakage in the heat pump system, and to operate the first release device and/or the second release device in response to the signal.

[0021] In any operation state of the heat pump system, refrigerant may be released without switching the four-way switching valve of the heat pump system. The operation state of the four-way switching valve "not operated" means that the four-way switching valve is not switched and is left unchanged.

[0022] The operation states of the first release device and the second release device means that the first release device is opened for releasing refrigerant or closed for not releasing refrigerant and/or that the second release device is opened for releasing refrigerant or closed for not releasing refrigerant.

[0023] A release device may be a release valve where refrigerant either in the gas state and/or liquid state can be released. The release device is not restricted to the release of gases.

[0024] The heat pump system according to a second aspect is the heat pump system of the first aspect, wherein the first release device comprises a first three-way valve and the second release device comprises a second three-way valve. The first three-way valve is configured to stop a refrigerant flow between the outdoor portion and the indoor portion, and the second three-way valve is configured to stop a refrigerant flow between the outdoor

portion and the indoor portion. Each of the first and second three-way valves is configured to release refrigerant from the usage heat exchanger via the first and the second three-way valves to the outside of the refrigerant circuit.

[0025] The provision of a three-way valve as the release device allows that the release device is opened very quickly to release refrigerant to the outside of the refrigerant circuit. Additionally, the first and second three-way valves allows that the outdoor portion of the refrigerant circuit is sufficiently shut off from the indoor portion of the refrigerant circuit. In this case, releasing the refrigerant from the refrigerant circuit and shutting off the outdoor portion can be realized by one device, the three-way valve.

[0026] The heat pump system according to a third aspect is the heat pump system of the first aspect, wherein the first release device comprises a first two-way valve and a first blow-off mechanism, and the second release device comprises a second two-way valve and a second blow-off mechanism. The first two-way valve is connected to one side of the heat source heat exchanger and to one side of the usage heat exchanger, wherein the refrigerant circuit further connects a first release pipe that branches from the refrigerant circuit between the first two-way valve and the one side of the usage heat exchanger, wherein the first blow-off mechanism is arranged in the first release pipe. The second two-way valve is connected to another side of the usage heat exchanger and to a suction side of the compressor, wherein the refrigerant circuit further connects a second release pipe that branches from the refrigerant circuit between the second two-way valve and the other side of the usage heat exchanger, wherein the second blow-off mechanism is arranged in the second release pipe. Each of the first and second two-way valves are configured to stop a refrigerant flow between the outdoor portion and the indoor portion. Each of the first and second blow-off mechanisms are configured to release refrigerant from the usage heat exchanger to the outside of the refrigerant circuit.

[0027] The blow off mechanism allows that the release device is leak tight in the normal operation mode. The first and second two-way valves allow that the refrigerant flow from the outdoor unit to the indoor unit is stopped upon detection of a refrigerant leakage in the heat pump system. This prevents that refrigerant is released from the outdoor portion of the refrigerant circuit which simultaneously results in a pressure drop in the outdoor refrigerant circuit. This pressure drop in the outdoor refrigerant circuit may damage the components of the outdoor unit due to low temperatures, dry ice formation or oil release. Thus, the heat pump system is further improved and safer.

[0028] The heat pump system may further comprise a manifold pipe connecting the first release pipe and the second release pipe for releasing refrigerant from the refrigerant circuit via the first release device and second release device to the outside of the heat pump system. The manifold pipe may have a release opening located at a release area, which may be outside of a building where the outdoor unit and the indoor unit are installed in.

[0029] In the present disclosure, the release area means an area outside of the room or indoor space. The release area may be outside of the outdoor unit in a machine room of a building (wherein the machine room might have a mechanical ventilation that prevents a too high carbon dioxide or propane concentration). The release area may be outside of a building where the outdoor unit and the indoor unit are installed.

[0030] The heat pump system of a fourth aspect is the heat pump system according to the third aspect, wherein each of the first and second blow-off mechanisms comprises a two-way valve.

[0031] The provision of a two-way valve as a blow-off mechanism is more cost-efficient, but still provides a fast opening time.

[0032] The heat pump system of a fifth aspect is the heat pump system according to the third aspect, wherein each of the first and the second blow-off mechanisms have a sacrificial seal sealing the refrigerant circuit from the outside of the refrigerant circuit, wherein the control unit is further configured to trigger breaking the sacrificial seal.

[0033] Because of the provision of a sacrificial seal in the first and the second blow-off mechanisms, the refrigerant circuit is sealed from the outside of the refrigerant circuit. Thus, it is ensured that the blow-off mechanism is leak tight. Since the control unit is further configured to trigger breaking the sacrificial seal, the sacrificial seal of the first and the second blow-off mechanisms is broken in a controlled way, so that refrigerant leakage during normal operation is prevented. By breaking the sacrificial seal, the response time of the heat pump system in the event of a refrigerant leak is reduced.

[0034] The heat pump system according to a sixth aspect is the heat pump system according to the fifth aspect, wherein the control unit is configured to trigger a change in the properties of the sacrificial seal, whereby the pressure of the refrigerant in the refrigerant circuit breaks the sacrificial seal.

[0035] Since the control unit is configured to trigger only a change in the properties of the sacrificial seal, the sacrificial seal is only fully broken by the pressure of the refrigerant in the refrigerant circuit upon a leakage detection. This ensures that the sacrificial seal is broken in a controlled way and only upon a leakage detection. Thus, the sacrificial seal is leak tight during a normal operation of the heat pump system.

[0036] The heat pump system according to a seventh aspect is the heat pump system according to the fifth or sixth aspect, wherein the blow-off mechanisms further comprise a heater for increasing the temperature of the sacrificial seal, wherein the control unit is further configured to operate the heater to trigger the change in the properties of the sacrificial seal.

[0037] Because the control unit is configured to operate the heater which triggers a change in the properties of the sacrificial seal, the sacrificial seal is only fully broken by the heater upon a leakage detection. This ensures that the sacrificial seal is broken in a controlled way. Thus, the sacrificial seal is leak tight during a normal operation of the heat pump system. In addition, the heater has a quick response time, so that the sacrificial seal is broken very quickly upon a leakage detection.

[0038] The heat pump system according to an eighth aspect is the heat pump system of the fifth aspect, wherein the blow-off mechanisms further comprise a breaking member and the control unit is configured to operate the breaking member to break the sacrificial seal.

[0039] The breaking member allows that the sacrificial seal of the blow-off mechanism is only broken upon detection of a refrigerant leak by the control unit. This allows that the sacrificial seal is leak tight during a normal operation, that the sacrificial seal is only broken if a leakage is detected, and that the control unit controls the breaking member. Thereby, the heat pump system is safer and more reliable.

[0040] A ninth aspect of the disclosure is the method for releasing refrigerant from a heat pump system. The heat pump system comprises a refrigerant circuit connecting a compressor, a heat source heat exchanger, a first expansion valve, and a usage heat exchanger, the refrigerant circuit having an indoor portion and an outdoor portion, wherein the outdoor portion of the refrigerant circuit comprises the compressor, the heat source heat exchanger, and the first expansion valve, and the indoor portion of the refrigerant circuit comprises the usage heat exchanger. The heat pump system further comprises a first release device arranged in the refrigerant circuit and a second release device arranged in the refrigerant circuit, wherein the first release device and the second release device separate the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit. The method comprises the step of starting a refrigerant release operation upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system. In the refrigerant release operation, the method comprises the steps of shutting off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit by the first release device and the second release device and releasing a refrigerant contained in the indoor portion of the refrigerant circuit via the first release device and the second release device to an outside of the heat pump system.

[0041] The method according to the ninth aspect allows for a quick pressure drop in the refrigerant circuit upon detection of refrigerant leakage so that a high mass flow rate of the refrigerant into the indoor space can be reduced. In case of a refrigerant leakage detection in the refrigerant circuit, the heat pump system quickly responds by opening the first and second release devices to release the high pressure refrigerant quickly to the outside of the refrigerant circuit. Thus, the release devices have a fast response time and the method offers a faster solution. This allows only the refrigerant in the indoor portion of the refrigerant circuit to be released to the outside of the refrigerant circuit in a shorter time.

[0042] Thus, the method is improved and safer.

[0043] The method of a tenth aspect is the method of the ninth aspect, wherein the method further comprises the step of, in the refrigerant release operation, operating the first release device and the second release device and not operating a switching device of the refrigerant circuit of the heat pump system. In other words, in any operation state of the heat pump system, refrigerant may be released without switching the four-way switching valve of the heat pump system. The operation state of the four-way switching valve "not operated" means that the four-way switching valve is not switched and is left unchanged in the refrigerant release operation.Since the switching device of the refrigerant circuit of the heat pump system is not operated in the refrigerant release operation, the refrigerant is released more quickly from the refrigerant circuit via the first and second release devices to an outside of the refrigerant circuit. Thus, less refrigerant leaks into the indoor space. The method, hence, improves the safety.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044]

- Fig. 1A shows a schematic piping diagram of a heat pump system according to a first embodiment of the present disclosure.
- Fig. 1B shows a schematic piping diagram of a heat pump system according to a second embodiment of the present disclosure.
- Fig. 2 shows a schematic piping diagram of a heat pump system according to first embodiment of the present disclosure.
- Fig. 3 shows a schematic piping diagram of an example of an outdoor unit of the heat pump system of Fig. 2.
- Fig. 4 shows a schematic piping diagram of a heat pump system according to the second embodiment of the present disclosure.
- Fig. 5 shows a schematic piping diagram of an example of an outdoor unit of the heat pump system of Fig. 4.
- Fig. 6 shows a schematic piping diagram of a first modification of the first embodiment of the heat pump system also applicable to the second embodiment.
- Fig. 7 shows a schematic piping diagram of a second modification of the first embodiment of the heat pump system also applicable to the second embodiment.
- Fig. 8 shows a schematic piping diagram of a fifth modification of the first embodiment of the heat pump system also applicable to the sec-

ond embodiment.

Fig. 9 shows a schematic piping diagram of a sixth modification of the heat pump system of the second embodiment also applicable to the second embodiment.

DESCRIPTION OF EMBODIMENTS

[0045] 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.

[0046] The heat pump system 100 of the disclosure 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, a natural refrigerant with low global warming potential, which can be potentially released to the outside or atmosphere, such as carbon dioxide may be used as refrigerant.

[0047] The heat pump system 100 may be a single-heat pump system, which includes an outdoor unit (which may also be referred to as heat source unit) and an indoor unit (which may also be referred to as usage unit or utilization-side unit). The heat pump system may be a multi-heat pump system, which includes an outdoor unit (which may also be referred to as heat source unit) and a plurality of indoor unit (which may also be referred to as usage units or utilization-side units). The heat source unit may also comprise a plurality of connected outdoor units.

[0048] The heat pump system 100 may have a so-called two-pipe configuration as shown in Fig. 1A, 2, and 3 and as described in the first embodiment, or a so-called three-pipe configuration as shown in Fig. 1B, 4, and 5, and as described in the second embodiment.

First embodiment

[Configuration of the two-pipe heat pump system]

[0049] The heat pump system 100 according to the first embodiment of the present disclosure is a single system with a so-called two-pipe configuration, which includes at least one outdoor unit 110 and at least one indoor unit 120. In an example, as illustrated in Fig. 1A the refrigerant circuit has a first refrigerant pipe 131 and a second refrigerant pipe 133 that connects the outdoor unit 110 and the indoor unit 120. The heat pump system may also be provided with a plurality of indoor units 120 as shown in Fig. 2, wherein a plurality of indoor units 120 are connected to the outdoor unit 110 via the first refrigerant pipe 131 and the second refrigerant pipe 133. Also a plurality of outdoor units are conceivable as described with respect to the modifications shown in Fig. 6 to 8.

[0050] In the two-pipe configuration, the first refrigerant pipe 131 (a liquid pipe), the second refrigerant pipe 133 (a high/low-pressure gas pipe) and the third refrigerant pipe 132 (a low-pressure gas pipe) of a three-pipe configuration (explained later) are limited to the first refrigerant pipe 131 (liquid pipe) and the second refrigerant pipe 133 (a low-pressure gas pipe) (which in a two-pipe system is generally also referred to merely as "gas pipe") as shown in Figs. 1A, 2 and 3. Figs. 1A and 2 show a schematic piping diagram of the two-pipe heat pump system of the first embodiment. Fig. 3 shows a schematic piping diagram of an example of an outdoor unit 110 of the heat pump system of the first embodiment, as shown in Fig. 2.

[0051] The outdoor unit 110 may have an outdoor unit casing having first and second outdoor service ports to which the first and second refrigerant pipe 131, 133 are directly or indirectly connected.

[0052] The outdoor unit 110 in this first embodiment mainly includes a compressor 11 with a motor and a heat source heat exchanger 13 (see for example Fig. 3). In addition, the outdoor unit 110 (heat source unit) includes a switching mechanism 23 (here a four-way valve) 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 (outdoor heat exchanger) functions as an evaporator. The switching mechanism 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 switching mechanism 23 via a discharge pipe 25. The switching mechanism 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. A first expansion valve 14 (outdoor expansion valve), as main expansion valve, is located in the outdoor liquid pipe 27.

[0053] The connection portion (outdoor service port) of the outdoor liquid pipe 27 with respect to the first refrigerant pipe 131 (liquid pipe) is provided with a liquid-side shut-off valve 28.

[0054] The switching mechanism 23 is connected to the second refrigerant pipe 133 (gas pipe) via a second outdoor gas pipe 29. The connection portion (outdoor service port) of the second outdoor gas pipe 29 with respect to the second refrigerant pipe 133 (gas pipe) is provided with a gas side shut-off valve 30. In addition, the outdoor unit 110 further comprises an heat source side fan 19 (outdoor fan) driven by an heat source side fan motor.

[0055] The indoor unit 120 is configured as explained with respect to Fig. 2 below. The indoor unit 120 as shown in Fig. 2 may have an indoor unit casing having first and second indoor service ports to which the first and second refrigerant pipes 131, 133 are directly or indirectly connected. The indoor unit 120 includes a sub-expansion

valve 122 in the liquid pipe (first refrigerant pipe 131) and a usage heat exchanger 123 connected to first and second refrigerant pipes 131, 133. The indoor unit 120 also has a usage side fan 127 (indoor fan) driven by a fan motor.

[0056] Hence, as compared to the three-pipe system, only a first refrigerant pipe 131 (liquid (refrigerant) pipe) and a second refrigerant pipe 133 (low-pressure gas (refrigerant) pipe (gas pipe)) extend out of the outdoor unit 110. The first refrigerant pipe 131 communicates with the heat source heat exchanger 13 and the indoor heat exchangers 123 (usage side heat exchanger). The second refrigerant pipe (gas pipe) 133 communicates with a suction port of the compressor 11 and the indoor heat exchanger 123 (usage side heat exchanger) of the indoor unit 120 or in case of a plurality of indoor units 120 with each of the indoor heat exchangers 123 (usage side heat exchanger).

[0057] It is also conceivable that more than one indoor unit is provided as shown in Fig. 2. In this case, the first refrigerant pipe 131 may branch into a plurality of first liquid refrigerant pipes 141 towards the indoor units 120. The second refrigerant pipe 133 may branch into a plurality of second gas refrigerant pipes 143 towards the indoor units 120. For each of the indoor units 120, the usage heat exchanger 123 may communicate with the corresponding first liquid refrigerant pipe 141 and the second gas refrigerant pipe 143.

[0058] Each of the indoor units 120 includes a sub-expansion valve 122 and a usage heat exchanger 123. Each indoor units 120 also has a usage side fan 127 (indoor fan) driven by a fan motor. The heat pump system 100 according to the first embodiment comprises an outdoor unit 110, and at least one indoor unit 120, a refrigerant circuit having the first refrigerant pipe 131 and the second refrigerant pipe 133 that connects the outdoor unit 110 and the indoor unit 120. As shown in Fig. 2 it is also possible that the heat pump system 100 comprises a plurality of indoor units 120, in particular four indoor units 120. It is also possible that the heat pump system of the first embodiment only comprises one indoor unit 120, as shown in Fig. 1A. It is also possible that the heat pump system of the first embodiment comprises a plurality of outdoor units 110, or a single outdoor unit 110 as shown in Fig. 1A. In addition, the heat pump system of the first embodiment is not restricted to the outdoor unit 110 and/or the indoor unit 120, as described above, and a known outdoor unit and/or indoor unit may be used.

[0059] The refrigerant circuit connects the compressor 11, the heat source heat exchanger 13, hte first expansion valve 14, and the usage heat exchanger 123. The refrigerant circuit having an indoor portion and an outdoor portion, wherein the outdoor portion of the refrigerant circuit comprises the compressor 11, the heat source heat exchanger 13, and the first expansion valve 14. The indoor portion of the refrigerant circuit comprises the usage heat exchanger 123 and the sub-expansion valve 122.

[0060] The refrigerant contained in the refrigerant circuit is in this example carbon dioxide.

[0061] The heat pump system 100 according to the first embodiment further comprises a first release device 40 for releasing a refrigerant to an outside of the refrigerant circuit. The first release device 40 is arranged in the first refrigerant pipe 131 between the outdoor unit 110 and the indoor unit 120 and separates the first refrigerant pipe 131 into a first outdoor refrigerant pipe 1311 and a first indoor refrigerant pipe 1312 (see for example Fig. 1A). The first release device 40 is arranged in the refrigerant circuit.

[0062] The heat pump system further comprises a second release device 41 for releasing the refrigerant to the outside of the refrigerant circuit. The second release device 41 is arranged in the second refrigerant pipe 133 between the outdoor unit 110 and the indoor unit 120 and separates the second refrigerant pipe 133 into a second outdoor refrigerant pipe 1331 and a second indoor refrigerant pipe 1332. In the release operation mode, the first release device 40 and the second release device 41 are operated for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit. The second release device 41 is arranged in the refrigerant circuit.

[0063] The first release device 40 and the second release device 41 separate the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit.

[0064] The heat pump system further comprises a control unit 300 configured to control the heat pump system 100. The control unit 300 is configured to operate the heat pump system 100 in a release operation mode upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system 100. In the release operation mode, the first release device 40 and the second release device 41 are operated for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit. The control unit 300 may be configured to, in a release operation mode upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system 100, operate the first release device 40 and the second release device 41 to shut off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit, and to release refrigerant from the indoor portion of the refrigerant circuit to the outside of the refrigerant circuit.

[0065] The control unit 300 may be configured to, in a normal operation mode, operate the first release device 40 and the second release device 41 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 via the first release device 40 and the second release device 41.

First modification of the first embodiment

[0066] The heat pump system 100 in a first modification of the first embodiment of the present disclosure is the heat pump system of the first embodiment wherein the first release device 40 is a first three-way valve 71 and the second release device 41 is a second three-way valve 72.

[0067] The first three-way valve 71 and the second three-way valve 72 are configured to release the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit via a first release pipe 61 and/or a second release pipe 62 and to stop a refrigerant flow between the first outdoor refrigerant pipe 1311 and the first indoor refrigerant pipe 1312 and between the second outdoor refrigerant pipe 1331 and the second indoor refrigerant pipe 1332.

[0068] Fig. 6 shows a schematic piping diagram of the first modification of the heat pump system of the first embodiment.

[0069] The first three-way valve 71 is configured to stop a refrigerant flow between the outdoor portion and the indoor portion. The second three-way valve 72 is configured to stop a refrigerant flow between the outdoor portion and the indoor portion. Each of the first and second three-way valves 71, 72 is configured to release refrigerant from the usage heat exchanger 123 via the first and the second three-way valves 71, 72 to the outside of the refrigerant circuit. Each of the first and second three-way valves 71, 72 may be configured to release refrigerant from the usage heat exchanger 123 via the first and the second three-way valves 71, 72 and the first and second release pipes 61, 62 to the outside of the refrigerant circuit. The first release pipe 61 may be connected to the first three-way valve 71 and the second release pipe 62 may be connected to the second three-way valve 72.

[0070] The control unit 300 may configured to, in a release operation mode upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system 100, operate the first and second three-way valves 71, 72 to shut off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit, and to release refrigerant from the indoor portion of the refrigerant circuit to the outside of the refrigerant circuit.

[0071] The control unit 300 may be configured to, in a normal operation mode, operate the first and second three-way valves 71, 72 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 via the first and second three-way valves 71, 72.

[0072] As shown in Fig. 6, two outdoor units 110 are connected by a refrigerant circuit with three indoor units 120. Fig. 6 further shows that the first release device 40 and the second release device 41 may be arranged in a release device casing 44. The heat pump system of the first modification of the first embodiment is not restricted to the use of two outdoor units 110 and may be compatible with a single outdoor unit or with a plurality of outdoor units. The heat pump system of the first modification of the first embodiment is not restricted to the use of three indoor units 120 and may be compatible with a single indoor unit or with a plurality of indoor units. The release device casing 44 may also not be present in the heat pump system of the first modification of the first embodiment.

[0073] The heat pump system of the first modification of the first embodiment is further not restricted to the use of two outdoor units 110 and may be compatible with a single outdoor unit 110 or with a plurality of outdoor units.

[0074] The heat pump system of the first modification of the first embodiment is not restricted to the use of three indoor units 120 and may be compatible with a single indoor unit 120 or with a plurality of indoor units 120. The release device casing 44 may also not be present in the heat pump system of the first modification of the first embodiment.

[0075] In a system with multiple outdoor units and/or multiple indoor units connected, the first and second release devices are arranged on a main liquid pipe and a main gas pipe between the multiple outdoor units and/or multiple indoor units. The main liquid pipe is a pipe that a plurality of liquid pipes 131 extending from a plurality of the outdoor units 110 towards the indoor unit(s) 120 are merged into. The main gas pipe is one pipe that a plurality of gas pipes 133 extending from a plurality of the outdoor units 110 towards the indoor unit(s) 120 are merged into. The main liquid pipe also is one pipe that a plurality of liquid pipes 131 extending from a plurality of the indoor units 120 towards the outdoor unit(s) 110 are merged into. The main gas pipe also is one pipe that a plurality of gas pipes 133 extending from a plurality of the indoor units 120 towards the outdoor unit(s) 110 are merged into. This configuration improves workability because it eliminates the need to connect multiple release device units to the system. The workloads required to connect multiple release device units to the system can be reduced.

Second modification of the first embodiment

[0076] In a second modification of the first embodiment of the present disclosure, the heat pump system is the heat pump system of the first embodiment wherein the first release device 40 comprises a first blow-off mechanism 81. Fig. 7 shows a schematic piping diagram of the second modification of the first embodiment of the heat pump system.

[0077] A first release pipe 61 branches from the first refrigerant pipe 131 and the first blow-off mechanism 81 is arranged in the first release pipe 61. The first blow-off mechanism 81 is configured to release the refrigerant from the refrigerant circuit via the first indoor refrigerant pipe 1312 and the first release pipe 61 to the outside of the refrigerant circuit.

[0078] The second release device 41 comprises a

second blow-off mechanism 82. A second release pipe 62 branches from the second refrigerant pipe 133 and the second blow-off mechanism 82 is arranged in the second release pipe 62. The second blow-off mechanism 82 is configured to release the refrigerant from the refrigerant circuit via the second indoor refrigerant pipe 1332 and the second release pipe 62 to the outside of the refrigerant circuit.

[0079] Each of the first and second blow-off mechanisms 81, 82 are configured to release refrigerant from the usage heat exchanger 123 to the outside of the refrigerant circuit. The first release device 40 may comprise the first release pipe 61 and the first blow-off mechanism 81. The second release device 41 may comprise the second release pipe 62 and the second blow-off mechanism 82.

[0080] The control unit 300 may configured to, in a release operation mode upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system 100, operate the first and second blow-off mechanisms 81, 82 to release refrigerant from the indoor portion of the refrigerant circuit to the outside of the refrigerant circuit.

[0081] The control unit 300 may be configured to, in a normal operation mode, operate the first and second blow-off mechanisms 81, 82 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 via the first and second blow-off mechanisms 81, 82.

[0082] As shown in Fig. 7, the heat pump system may comprise a plurality of outdoor units 110, in particular two outdoor units 110. The heat pump system may comprise a plurality of indoor unit 120. As shown in Fig. 7, the heat pump system may comprise three indoor units 120. Fig. 7 further shows that the first release device 40 and the second release device 41 may be arranged in a release device casing 44. The heat pump system of the second modification of the first embodiment is not restricted to the use of two outdoor units 110 and may be compatible with a single outdoor unit or with a plurality of outdoor units. The heat pump system of the second modification of the first embodiment is not restricted to the use of three indoor units 120 and may be compatible with a single indoor unit or with a plurality of indoor units. The the release device casing 44 may also not be present in the heat pump system of the second modification of the first embodiment.

Third modification of the first embodiment

[0083] In a third modification of the first embodiment of the present disclosure, the heat pump system is the heat pump system of the second modification of the first embodiment wherein the first blow-off mechanism 81 and the second blow-off mechanism 82 comprise a two-way valve. In other words, the heat pump system of the third modification of the first embodiment is the heat pump system of the second modification of the first embodiment wherein each of the first and second blow-off mechanisms 81, 82 comprise a two-way valve. The two-way valve is configured to stop a refrigerant flow between the refrigerant circuit and the outside of the refrigerant circuit. The two-way valve is further configured to release refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

[0084] In the release operation mode, the first blow-off mechanism 81 is operated by the control unit 300 for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit. In the release operation mode, the second blow-off mechanism 82 is operated by the control unit 300 for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

[0085] The control unit 300 may be configured to, in a normal operation mode, operate the first blow-off mechanism 81 and the second blow-off mechanism 82 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 via the first blow-off mechanism 81 and the second blow-off mechanism 82.

Fourth modification of the first embodiment

[0086] The heat pump system in a fourth modification of the first embodiment of the present disclosure is a heat pump system of the second modification of the first embodiment wherein the first blow-off mechanism 81 and the second blow-off mechanism 82 of this fourth modification have a sacrificial seal sealing the refrigerant circuit from the outside of the refrigerant circuit, wherein the control unit 300 is further configured to trigger breaking the sacrificial seal.

[0087] The control unit 300 is configured to trigger a change in the properties of the sacrificial seal. In an example the sacrificial seal can be weakened in its mechanical strength so that the pressure of the refrigerant in the refrigerant circuit breaks the sacrificial seal. In other words, the control unit 300 may trigger that the pressure resistance of the sacrificial seal is lowered, so that the pressure of the refrigerant circuit is sufficient to break the sacrificial seal. For example, the control unit may trigger that the sacrificial seal is thinned out (for example by stretching), so that the pressure of the refrigerant in the refrigerant circuit can break the sacrificial seal. The blow-off mechanism 81, 82 may further comprise a heater for increasing the temperature of the sacrificial seal, wherein the control unit 300 is further configured to operate the heater to trigger the change in the properties of the sacrificial seal. The heater may melt the sacrificial seal due to a temperature increase, so that the refrigerant can be released from the refrigerant circuit. Alternatively to the heater, the blow-off mechanism 81, 82 may further comprise a breaking member and the control unit 300 is configured to operate the breaking member to break the sacrificial seal. An example of a breaking member is a metal pin which destroys the sacrificial seal which is for

example made of a glass material, so that due to the mechanical impact of the metal pin the glass sacrificial seal breaks and refrigerant can be released form the refrigerant circuit. Alternatively, the breaking member may be a pyrotechnic element which breaks the sacrificial seal due to an explosion.

[0088] In the release operation mode, the first blow-off mechanism 81 may be operated by the control unit 300 to break a sacrificial seal for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit. In the release operation mode, the second blow-off mechanism 82 may be operated by the control unit 300 to break the sacrificial seal for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

[0089] The control unit 300 may be configured to, in a normal operation mode, control the first blow-off mechanism 81 and the second blow-off mechanism 82 not to break the sacrificial seal 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 via the first blow-off mechanism 81 and the second blow-off mechanism 82.

Fifth modification of the first embodiment

[0090] The heat pump system in a fifth modification of the first embodiment of the present disclosure is the heat pump system of according to the second, third, and/or fourth modification of the first embodiment. In other word, the heat pump system of the fifth modification of the first embodiment is compatible with the second, third, and/or fourth modification of the first embodiment. Fig. 8 shows a schematic piping diagram of the fifth modification of the heat pump system of the first embodiment.

[0091] The first release device 40 further comprises a first two-way valve 91. The first two-way valve 91 is arranged in the first outdoor refrigerant pipe 1311. The first two-way valve 91 is connected to one side of the heat source heat exchanger 13 and to one side of the usage heat exchanger 123. The first two-way valve 91 is configured to stop a refrigerant flow between the first outdoor refrigerant pipe 1311 and the first indoor refrigerant pipe 1312.

[0092] The second release device 41 further comprises a second two-way valve 92. The second two-way valve 92 is arranged in the second outdoor refrigerant pipe 1331. The second two-way valve 92 is connected to another side of the usage heat exchanger 123 and to a suction side of the compressor 11. The second two-way valve 92 is configured to stop a refrigerant flow between the second outdoor refrigerant pipe 1331 and the second indoor refrigerant pipe 1332.

[0093] Each of the first and second two-way valves 91, 92 are configured to stop a refrigerant flow between the outdoor portion and the indoor portion.

[0094] In the release operation mode, the first and second two-way valves 91, 92 are operated by the control unit 300 to stop a refrigerant flow from the outdoor unit 110 to the indoor unit 120.

[0095] The control unit 300 may be configured to, in a normal operation mode, operate the first and second two-way valves 91, 92 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.

[0096] As shown in Fig. 8, two outdoor units 110 are connected by a refrigerant circuit with three indoor units 120. The refrigerant circuit of Fig. 8 further comprises a connection unit 200. Fig. 8 further shows that the first release device 40 and the second release device 41 may be arranged in a release device casing 44. The heat pump system of the fifth modification of the first embodiment is not restricted to the use of two outdoor units 110 and may be compatible with a single outdoor unit or with a plurality of outdoor units. The heat pump system of the fifth modification of the first embodiment is not restricted to the use of three indoor units 120 and may be compatible with a single indoor unit or with a plurality of indoor units. The release device casing 44 may also not be present in the heat pump system of the fifth modification of the first embodiment.

Sixth modification of the second embodiment

[0097] The heat pump system in a sixth modification of the first embodiment of the present disclosure is the heat pump system of according to the second, third, fourth and/or fifth modification of the first embodiment. In other word, the heat pump system of the sixth modification of the first embodiment is compatible with the second, third, fourth and/or fifth modification of the first embodiment. Fig. 9 shows a schematic piping diagram of the sixth modification of the heat pump system of the first embodiment.

[0098] In the sixth modification of the heat pump system of the first embodiment, the second blow-off mechanism 82 as well as second release pipe 62 are omitted and substituted by a bypass pipe 45 and a two-way valve 46 provided in the bypass pipe 45. The bypass pipe 45 is at one and connected to a pipe (the first release pipe 61) connecting the refrigerant pipe 131 and the first blow off mechanism 81 and at the other end to the gas line 133 between the second two - way valve 92 and the indoor units 120. The bypass valve 46 is required in the bypass pipe 45 to prevent a direct connection between a liquid-side and gas-side of the refrigerant circuit 130.

[0099] In a further modification (not shown), the second release device 41 may comprise a three-way valve instead of the second two-way valve 92 and the bypass valve 46, of which a first connection port is connected the second outdoor refrigerant pipe 1331, a second connection port is connected to the second indoor refrigerant pipe 1332 and a third connection port is connected to the bypass pipe 45. In such a modification, a dedicated bypass-valve is not required or in other words, the bypass

valve is integrated into the three-way valve.

[0100] Even though not illustrated, in the sixth modification it is alternatively possible to interchange the first and second release device so that the bypass valve and the bypass pipe becomes part of the first release device 40 and the second release device 41 is configured as shown in figure 8.

Second embodiment

[Configuration of the three-pipe heat pump system]

[0101] All components and modifications described for the first embodiment can be implemented in the second embodiment. The second embodiment differs from the first embodiment in that a third refrigerant pipe 132 with a third release device 42 are provided.

[0102] The heat pump system 100 according to the second embodiment of the present disclosure is a multi-heat pump system with a so-called three-pipe configuration, which includes an outdoor unit 110 and a plurality of indoor units 120.

[0103] Figs. 1B and 4 show a schematic piping diagram of the three-pipe heat pump system of the second embodiment. Fig. 5 shows a schematic piping diagram of an example of an outdoor unit 110 of the heat pump system of the second embodiment, as shown in Fig. 4.

[0104] As shown in Fig. 4, the heat pump system 100 comprises an outdoor unit 110, and a plurality of indoor units 120 connected to the outdoor unit 110 via pipes defining a refrigerant circuit and with a connection unit 200 interposed between the outdoor unit 110 and the plurality of indoor units 120.. The refrigerant circuit contains a natural refrigerant, such as carbon dioxide.

[0105] The outdoor unit 110 may be installed in an outside space, such as outside of a building. The outdoor unit 110 may for example be configured as shown in Fig. 5.

[0106] In particular, the outdoor unit 110 defines an outdoor refrigerant circuit that constitutes part of the refrigerant circuit. The outdoor refrigerant circuit includes a compressor 11, a three-way switching valve 12, a heat source heat exchanger 13 (outdoor heat exchanger), a first expansion valve 14 (outdoor expansion valve) as main expansion valve, an accumulator 15, a liquid side closing valve 16, a suction gas side closing valve 17, a discharge gas side closing valve 18 and an outdoor fan 19 driven by an outdoor fan motor.

[0107] In this second embodiment, the three-way switching valve 12 and a high pressure shut-off valve 22 are used as a mechanism for switching between a condensation operation state (cooling operation/mode), in which the heat source heat exchanger 13 functions as a condenser, and an evaporation operation state (heating operation/mode), in which the heat source heat exchanger 13 functions as an evaporator. However, a four-way switching valve or a plurality of switching valves may be used instead of a three-way switching valve 12 and the high pressure shut-off valve 22.

[0108] The three-way switching valve 12 connects the discharge side of the compressor 11 and the gas side of the heat source heat exchanger 13 when the heat source heat exchanger 13 functions as a condenser (hereinafter referred to as cooling operation/mode). When the heat source heat exchanger 13 functions as an evaporator (hereinafter referred to as heating operation/mode), the suction side of the compressor 11 and the gas side of the heat source heat exchanger 13 are connected. Thus, the heat source heat exchanger 13 has a gas side connected to the three-way switching valve 12 and a liquid side connected to the outdoor expansion valve 14 and the liquid side closing valve 16.

[0109] A first refrigerant pipe 131 (which may also be referred to as liquid (refrigerant) pipe) connects to the liquid side closing valve 16. In the second embodiment, the first expansion valve 14 is configured to adjust the pressure of the refrigerant flowing in the outdoor refrigerant circuit in heating operation. The first expansion valve 14 may be an electric expansion valve (connected to the liquid side of the heat source heat exchanger 13 in this embodiment) disposed downstream of the heat source heat exchanger 13 and upstream of the liquid side closing valve 16.

[0110] A second refrigerant pipe 133 (a low-pressure gas (refrigerant) pipe) is connected to the suction side of the compressor 11 (here upstream of the accumulator 15) via an intake gas side closing valve 17. As a result, low-pressure gas refrigerant returning from the indoor units 120 can be returned to the suction side of the compressor 11 regardless of the switching operation of the three-way switching valve 12.

[0111] The outdoor unit 110 may have an outdoor unit casing having first to third outdoor service ports.

[0112] A third refrigerant pipe 132 (a high/low-pressure gas (refrigerant) pipe) connects between the discharge side of the compressor 11 and the three-way switching valve 12 via a discharge gas side closing valve 18. Thereby, the high-pressure gas refrigerant compressed and discharged in the compressor 11 can be supplied to the indoor units 120 regardless of the switching operation of the three-way switching valve 12.

[0113] A low pressure communication pipe 20 communicates with a pipe that connects to the second refrigerant pipe 133 (low pressure gas pipe) and a pipe that connects to the third refrigerant pipe 132 (high/low-pressure gas pipe). A low pressure communication valve 21 is arranged in the low pressure communication pipe 20 that can block the passage of refrigerant by closing the low pressure communication valve 21. As a result, the second refrigerant pipe 133 and the third refrigerant pipe 132 can be brought into communication with each other as necessary.

[0114] The high-pressure shut-off valve 22 is provided in the third refrigerant pipe 132. The high-pressure gas refrigerant discharged from the compressor 11 can, thus, be blocked from being sent to the third refrigerant pipe

132 by closing the high-pressure shut-off valve 22.

[0115] In heating operation, the high-pressure shut-off valve 22 will be opened and the low pressure communication valve 21 will be closed to send high pressure gas through the third refrigerant pipe 132, which in this case is a high pressure gas pipe. In cooling operation, the high-pressure shut-off valve 22 will be closed and the low pressure communication valve 21 will be opened to allow low pressure gas to be send to the suction side of the compressor via the second refrigerant pipe 133 and the second refrigerant pipe 132, which in this case is a low pressure gas pipe.

[0116] The indoor units are basically configured as explained with respect to Fig. 2 above. Each of the indoor units 120 (usage units) includes a sub-expansion valve 122 and a usage heat exchanger 123. The indoor units 120 may have an indoor unit casing respectively having first and second indoor service ports.

[0117] The liquid (refrigerant) pipe 131, the high/low-pressure gas (refrigerant) pipe 132, and the low-pressure gas (refrigerant) pipe 133 extend out of the outdoor unit 110.

[0118] The first refrigerant pipe 131 (liquid pipe) communicates with each of the heat source heat exchanger 13 and the usage heat exchangers 123. The third refrigerant pipe 132 (high/low-pressure gas pipe) communicates with a discharge port of the compressor 11. The second refrigerant pipe 133 (low-pressure gas pipe) communicates with a suction port of the compressor 11.

[0119] The first refrigerant pipe 131 branches into a plurality of first liquid refrigerant pipes 141 towards the indoor units 120. The third refrigerant pipe 132 (high/low-pressure gas pipe) branches into a plurality of third high/-low-pressure gas refrigerant pipes 142 towards the connection unit 200. The second gas refrigerant pipe 133 branches into a plurality of second gas refrigerant pipes 143 towards the indoor units 120.

[0120] In the heat pump system 100, a liquid refrigerant piping and a gas refrigerant piping extends between the outdoor unit 110 and the indoor units 120, to form the refrigerant circuit. Thereby, it is possible to supply hot/-cold heat from the outdoor unit 110 to each of the indoor units 120 by circulating refrigerant. The first release device 40 is arranged in the first refrigerant pipe 131. A second release device 41 is arranged in the second refrigerant pipe 133. A third release device 42 is arranged in the third refrigerant pipe 132.

[0121] The heat pump system 100 may further include at least one connection unit 200, as shown in Fig. 4. A manifold device 201 including the branching points towards the corresponding indoor units 120 may be disposed in the corresponding connection unit 200. The connection unit may have a connection unit casing having first to third connection unit service ports.

[0122] The heat pump system 100 according to the second embodiment is the heat pump system of the first embodiment, wherein the refrigerant circuit further comprises a connection unit 200 interposed between the outdoor unit 110 and the indoor unit 120 and a third refrigerant pipe 132 connecting the outdoor unit 110 to the connection unit 200.. The first to third refrigerant pipes 131 to 133 are connected to the first to third outdoor service ports of the outdoor unit 110 and are connected to the first to third connection unit service ports of the connection unit 200. In particular, the first to third outdoor refrigerant pipes 1311, 1321 and 1331 are connected to the first to third outdoor service ports of the outdoor unit 110 and the first to third indoor refrigerant pipes 1312, 1322 and 1332 are connected to the first to third connection unit service ports of the connection unit 200.

The heat pump system 100 according to the second embodiment further comprises a third release device 42 for releasing the refrigerant to the outside of the refrigerant circuit, wherein the third release device 42 is arranged in the third refrigerant pipe 132 between the outdoor unit 110 and the connection unit 200 and separates the third refrigerant pipe 132 into a third outdoor refrigerant pipe 1321 and a third indoor refrigerant pipe 1322 (see for example Fig. 1B). The third release device 42 further separates the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit. In the release operation mode, the third release device 42 is operated by the control unit 300 for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

[0123] The control unit 300 may configured to, in a release operation mode upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system 100, operate the first release device 40, the second release device 41, and additionally the third release device 42 to shut off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit, and to release refrigerant from the indoor portion of the refrigerant circuit to the outside of the refrigerant circuit.

[0124] The control unit 300 may be configured to, in a normal operation mode, operate the first release device 40, the second release device 41, and additionally the third release device 42 to allow a refrigerant flow in the first refrigerant pipe 131, the second refrigerant pipe 133, and the third refrigerant pipe 132. In the normal operation mode, no refrigerant is released from the refrigerant circuit via the first release device 40, the second release device 41, and the third release device 42.

[0125] The refrigerant contained in the refrigerant circuit is carbon dioxide or propane.

First modification of the second embodiment

[0126] The heat pump system 100 in a first modification of the second embodiment of the present disclosure is similar to the first modification of the first embodiment shown in Fig. 6 but applied to a three pipe system. In the heat pump system of the second embodiment, the third release device 42 is a third three-way valve. Thus, the first modification of the second embodiment differs from

the second embodiment in that the third release device 42 is a third three-way valve. The first modification of the second embodiment differs from the first modification of the first embodiment in that a third release device 42 is present in a third refrigerant pipe 132.

[0127] The third three-way valve is configured to release the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit via the third indoor refrigerant pipe 1322 and to stop a refrigerant flow between the third outdoor refrigerant pipe 1321 and the third indoor refrigerant pipe 1322.

[0128] The third three-way valve is configured to stop a refrigerant flow between the outdoor portion and the indoor portion. The third three-way valve is configured to release refrigerant from the usage heat exchanger 123 via the third three-way valve to the outside of the refrigerant circuit. The third three-way valve may be configured to release refrigerant from the usage heat exchanger 123 via the third three-way valve and the third release pipe 63 to the outside of the refrigerant circuit. The third release pipe 63 may be connected to the third three-way valve 73.

[0129] The control unit 300 may configured to, in a release operation mode upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system 100, operate the first to third three-way valves to shut off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit, and to release refrigerant from the indoor portion of the refrigerant circuit to the outside of the refrigerant circuit.

[0130] The control unit 300 may be configured to, in a normal operation mode, operate the first to third three-way valves to allow a refrigerant flow in the first refrigerant pipe 131, the second refrigerant pipe 133, and the third refrigerant pipe 132. In the normal operation mode, no refrigerant is released from the refrigerant circuit via the first to third three-way valves.

Second modification of the second embodiment

[0131] The heat pump system 100 in a second modification of the second embodiment of the present disclosure is similar to the second modification of the first embodiment shown in Fig. 7 but applied to a three pipe system. In the heat pump system 100 of the second embodiment, the third release device 42 comprises a third blow-off mechanism. The heat pump system 100 in a second modification of the second embodiment of the present disclosure is the heat pump system 100 of the second modification of the first embodiment wherein a third release device 42 comprising a third blow-off mechanism is provided in addition to a third refrigerant pipe 132.

[0132] A third release pipe branches from the third indoor refrigerant pipe 1322 and the third blow-off mechanism is arranged in the third release pipe 132. The third blow-off mechanism is configured to release the refrigerant from the refrigerant circuit via the third three-way valves to the outside of the refrigerant circuit.

[0133] The third blow-off mechanism may be configured to release refrigerant from the usage heat exchanger 123 to the outside of the refrigerant circuit. The third release device 42 may comprise the third release pipe and the third blow-off mechanism.

[0134] The control unit 300 may configured to, in a release operation mode upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system 100, operate the first to third blow-off mechanisms to release refrigerant from the indoor portion of the refrigerant circuit to the outside of the refrigerant circuit.

[0135] The control unit 300 may be configured to, in a normal operation mode, operate the first to third blow-off mechanisms to allow a refrigerant flow in the first refrigerant pipe 131, the second refrigerant pipe 133, and the third refrigerant pipe 132. In the normal operation mode, no refrigerant is released from the refrigerant circuit via the first to third blow-off mechanisms.

Third modification of the second embodiment

[0136] The heat pump system 100 in a third modification of the second embodiment of the present disclosure is the heat pump system 100 of the second modification of the second embodiment wherein the third blow-off mechanism comprises a two-way valve. The heat pump system 100 in a third modification of the second embodiment of the present disclosure is the heat pump system 100 of the third modification of the first embodiment wherein a third release device is provided comprising the third blow-off mechanism, and that the third blow-off mechanism comprises a two-way valve.

[0137] The two-way valve is configured to stop a refrigerant flow between the refrigerant circuit and the outside of the refrigerant circuit. The two-way valve is further configured to release refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

[0138] In the release operation mode, the third blow-off mechanism may be operated by the control unit 300 for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

[0139] The control unit 300 may be configured to, in a normal operation mode, operate the third blow-off mechanism to allow a refrigerant flow in the third refrigerant pipe 132. In the normal operation mode, no refrigerant is released from the refrigerant circuit via the third blow-off mechanism.

Fourth modification of the second embodiment

[0140] The heat pump system 100 in a fourth modification of the second embodiment of the present disclosure is the heat pump system 100 of the second modification of the second embodiment wherein the third blow-off mechanism has a sacrificial seal sealing the refrigerant circuit from the outside of the refrigerant circuit, wherein the control unit 300 is further configured to trigger break-

ing the sacrificial seal.

[0141] The heat pump system 100 in the fourth modification of the second embodiment of the present disclosure is the heat pump system 100 of the fourth modification of the first embodiment wherein a third release device 42 in a third refrigerant pipe 132 comprising the third blow-off mechanism is provided. The third blow-off mechanism further has a sacrificial seal sealing the refrigerant circuit from the outside of the refrigerant circuit, wherein the control unit 300 is further configured to trigger breaking the sacrificial seal.

[0142] The control unit 300 is configured to trigger a change in the properties of the sacrificial seal, whereby the pressure of the refrigerant in the refrigerant circuit breaks the sacrificial seal. In other words, the control unit 300 may trigger that the pressure resistance of the sacrificial seal is lowered, so that the pressure of the refrigerant circuit is sufficient to break the sacrificial seal. For example, the control unit may trigger that the sacrificial seal is thinned out (for example by stretching), so that the pressure of the refrigerant in the refrigerant circuit can break the sacrificial seal. The blow-off mechanisms may further comprise a heater for increasing the temperature of the sacrificial seal, wherein the control unit 300 is further configured to operate the heater to trigger the change in the properties of the sacrificial seal. The heater may melt the sacrificial seal due to a temperature increase, so that the refrigerant can be released from the refrigerant circuit. Alternatively to the heater, the blow-off mechanism may further comprise a breaking member and the control unit 300 is configured to operate the breaking member to break the sacrificial seal. An example of a breaking member is a metal pin which destroys the sacrificial seal which is for example made of a glass material, so that due to the mechanical impact of the metal pin the glass sacrificial seal breaks and refrigerant can be released form the refrigerant circuit. Alternatively, the breaking member may be a pyrotechnic element which breaks the sacrificial seal due to an explosion. The function of the sacrificial seal of the third blow-off mechanism may be the same as of the first and second blow-off mechanisms, as described for the fourth modification of the first embodiment.

[0143] In the release operation mode, the third blow-off mechanism may be operated by the control unit 300 to break a sacrificial seal for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

[0144] The control unit 300 may be configured to, in a normal operation mode, control the third blow-off mechanism not to break the sacrificial seal to allow a refrigerant flow in the third refrigerant pipe 132. In the normal operation mode, no refrigerant is released from the refrigerant circuit via the third blow-off mechanism.

Fifth modification of the second embodiment

[0145] In a fifth modification of the second embodiment of the present disclosure is similar to the fifth modification of the first embodiment shown in Fig. 8 but applied to a three pipe system. The fifth modification of the second embodiment of the present disclosure is a heat pump system 100 of according to the second, third, and/or fourth modification of the second embodiment. The fifth modification of the second embodiment of the present disclosure is a heat pump system 100 according to the fifth modification of the first embodiment wherein a third refrigerant pipe 132 with the third release device 42 comprising a third blow-off mechanism and a third two-way valve is provided.

[0146] The third release device 42 further comprises a third two-way valve. The third two-way valve is arranged in the third outdoor refrigerant pipe 1321. The third two-way valve is configured to stop a refrigerant flow between between the third outdoor refrigerant pipe 1321 and the third indoor refrigerant pipe 1322.

[0147] The third two-way valve may be connected to another side of the usage heat exchanger 123 and to a discharge side of the compressor 11. The third two-way valve may be configured to stop a refrigerant flow between the third outdoor refrigerant pipe 1321 and the third indoor refrigerant pipe 1322.

[0148] The third two-way valve may be configured to stop a refrigerant flow between the outdoor portion and the indoor portion.

[0149] In the release operation mode, the third two-way valve may be operated by the control unit 300 to stop a refrigerant flow from the outdoor unit 110 to the indoor unit 120. In the release operation mode, the third two-way valve may be operated by the control unit 300 to stop a refrigerant flow from the outdoor portion of the refrigerant circuit to an indoor portion of the refrigerant circuit.

[0150] The control unit 300 may be configured to, in a normal operation mode, operate the third two-way valve to allow a refrigerant flow in the third refrigerant pipe 132. In the normal operation mode, no refrigerant is released from the refrigerant circuit.

Sixth modification of the second embodiment

[0151] The heat pump system in a sixth modification of the second embodiment of the present disclosure is similar to the sixth modification of the first embodiment shown in Fig. 9 but applied to a three pipe system. In other word, the heat pump system of the sixth modification of the second embodiment is compatible with the second, third, and/or fourth modification of the second embodiment.

[0152] In the sixth modification of the heat pump system of the second embodiment, the second blow-off mechanism as well as the second release pipe and the third blow-off mechanism as well as third release pipe are omitted. The second blow-off mechanism is, as in the sixth modification of the first embodiment, substituted by a first bypass pipe and a first two-way valve provided in the first bypass pipe. In addition, the third blow-off me-

chanism is substituted by a second bypass pipe and a second two-way valve provided in the second bypass pipe. The second bypass pipe is at one and connected to a pipe (the first release pipe) connecting the first refrigerant pipe and the first blow off mechanism and at the other end to the second refrigerant pipe between the third two - way valve and the connection unit.

[0153] In a further modification (not shown), the third release device may comprise a three-way valve instead of the third two-way valve and the second bypass valve, of which a first connection port is connected the second outdoor refrigerant pipe 1321, a second connection port is connected to the second indoor refrigerant pipe 1322 and a third connection port is connected to the second bypass pipe. In such a modification, a dedicated bypass-valve is not required or in other words, the bypass valve is integrated into the three-way valve.

[0154] Even though not illustrated, in the sixth modification it is alternatively possible to interchange the first, second and third release devices so that the bypass valve and the bypass pipe becomes part of the first release device and the second or third release device is configured as shown in figure 9.

Third embodiment

[0155] The method for releasing refrigerant from a heat pump system is according to a third embodiment of the present disclosure.

[0156] The method of the third embodiment is performed in a heat pump system 100 according to the first or second embodiment including all modifications.

[0157] The heat pump system 100 comprises a refrigerant circuit connecting a compressor 11, a heat source heat exchanger 13, a first expansion valve 14, and a usage heat exchanger 123. The refrigerant circuit has an indoor portion and an outdoor portion, wherein the outdoor portion of the refrigerant circuit comprises the compressor 11, the heat source heat exchanger 13, and the first expansion valve 14, and the indoor portion of the refrigerant circuit comprises the usage heat exchanger 123. The heat pump system 100 further comprises a first release device 40 arranged in the refrigerant circuit and a second release device 41 arranged in the refrigerant circuit. The first release device 40 and the second release device 41 separate the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit. The method comprises the step of starting a refrigerant release operation upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system 100. In the refrigerant release operation, the method comprises the steps of shutting off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit by the first release device 40 and the second release device 41, and releasing a refrigerant contained in the indoor portion of the refrigerant circuit via the first release device 40 and the second release device 41 to an outside of the heat pump system 100.

[0158] The method further comprises in the refrigerant release operation the step of operating the first release device 40 and the second release device 41 and not operating a four way valve 23 of the refrigerant circuit of the heat pump system 100. In any operation state of the heat pump system, refrigerant may be released without switching the four-way switching valve of the heat pump system. The operation state of the four-way switching valve "not operated" means that the four-way switching valve is not switched and is left unchanged in the refrigerant release operation Since the switching device of the refrigerant circuit of the heat pump system is not operated in the refrigerant release operation, the refrigerant is released more quickly from the refrigerant circuit via the first and second release devices to an outside of the refrigerant circuit. Thus, less refrigerant leaks into the indoor space. The method, hence, improves the safety.

[0159] The heat pump system 100 may further comprise a third release device 42 arranged in the refrigerant circuit. The third release device 42 separates the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit. In the refrigerant release operation, the method may further comprise the steps of shutting off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit by the third release device 42, and releasing a refrigerant contained in the indoor portion of the refrigerant circuit via the third release device 42 to an outside of the heat pump system 100. In the refrigerant release operation, the method further comprises the step of operating the first release device 40, the second release device 41, and the third release device 42 and not operating a switching device 12 of the refrigerant circuit of the heat pump system 100. In any operation state of the heat pump system, refrigerant may be released without switching the four-way switching valve of the heat pump system. The operation state of the four-way switching valve "not operated" means that the four-way switching valve is not switched and is left unchanged in the refrigerant release operation Since the switching device of the refrigerant circuit of the heat pump system is not operated in the refrigerant release operation, the refrigerant is released more quickly from the refrigerant circuit via the first and second release devices to an outside of the refrigerant circuit. Thus, less refrigerant leaks into the indoor space. The method, hence, improves the safety.

REFERENCE LIST

[0160]

100	heat pump system
110	outdoor unit
11	compressor
12	three-way switching valve
13	heat source heat exchanger

14	first expansion valve (main expansion valve)
15	accumulator
16	liquid side closing valve
17	suction gas side closing valve
18	discharge gas side closing valve
19	outdoor fan with motor
20	low pressure communication pipe
21	low pressure communication valve
22	high pressure shut-off valve
23	four-way valve
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	first release device
41	second release device
42	third release device
44	release device casing
45	bypass pipe
46	bypass valve
61	first release pipe
62	second release pipe
63	third release pipe
71	first three-way valve
72	second three-way valve
81	first blow-off mechanism
82	second blow-off mechanism
91	first two-way valve
92	second two-way valve
120	indoor unit (usage side unit)
122	sub-expansion valve
123	usage heat exchanger
127	usage side fan
131	first refrigerant pipe (liquid pipe)
1311	first outdoor refrigerant pipe
1312	first indoor refrigerant pipe
132	third refrigerant pipe (high/low-pressure gas pipe)
1321	third outdoor refrigerant pipe
1322	third indoor refrigerant pipe
133	second refrigerant pipe (low-pressure gas pipe (only "gas
pipe"	in two-pipe configuration)
1331	second outdoor refrigerant pipe
1332	second indoor refrigerant pipe
141	first liquid refrigerant pipe
142	third high/low-pressure gas refrigerant pipe
143	second gas refrigerant pipe
151	usage side liquid pipe
152	usage side gas pipe
200	connection unit
201	manifold device
300	control unit

Claims

1. A heat pump system (100) comprising:

a refrigerant circuit connecting a compressor (11), a heat source heat exchanger (13), a first expansion valve (14), and a usage heat exchanger (123), the refrigerant circuit having an indoor portion and an outdoor portion, wherein the outdoor portion of the refrigerant circuit comprises the compressor (11), the heat source heat exchanger (13), and the first expansion valve (14), and the indoor portion of the refrigerant circuit comprises the usage heat exchanger (123),
a control unit (300) configured to control the heat pump system (100),
a first release device (40) arranged in the refrigerant circuit, and
a second release device (41) arranged in the refrigerant circuit, wherein the first release device (40) and the second release device (41) separate the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit,
wherein the control unit (300) is configured to, in a release operation mode upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system (100), operate the first release device (40) and the second release device (41) to shut off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit, and to release refrigerant from the indoor portion of the refrigerant circuit to the outside of the refrigerant circuit.

2. The heat pump system according to claim 1,

wherein the first release device (40) comprises a first three-way valve (71) and the second release device (41) comprises a second three-way valve (72),
wherein the first three-way valve (71) is configured to stop a refrigerant flow between the outdoor portion and the indoor portion, and the second three-way valve (72) is configured to stop a refrigerant flow between the outdoor portion and the indoor portion, and
wherein each of the first and second three-way valves (71, 72) is configured to release refrigerant from the usage heat exchanger (123) via the first and the second three-way valves (71, 72) to the outside of the refrigerant circuit.

3. The heat pump system according to claim 1,

wherein the first release device (40) comprises a first two-way valve (91) and a first blow-off me-

chanism (81),
wherein the second release device (41) comprises a second two-way valve (92) and a second blow-off mechanism (82),
wherein the first two-way valve (91) is connected to one side of the heat source heat exchanger (13) and to one side of the usage heat exchanger (123), wherein the refrigerant circuit further connects a first release pipe (61) that branches from the refrigerant circuit between the first two-way valve (91) and the one side of the usage heat exchanger (123), wherein the first blow-off mechanism (81) is arranged in the first release pipe (61),
wherein the second two-way valve (92) is connected to another side of the usage heat exchanger (123) and to a suction side of the compressor (11), wherein the refrigerant circuit further connects a second release pipe (62) that branches from the refrigerant circuit between the second two-way valve (92) and the other side of the usage heat exchanger (123), wherein the second blow-off mechanism (82) is arranged in the second release pipe (62),
wherein each of the first and second two-way valves (91, 92) are configured to stop a refrigerant flow between the outdoor portion and the indoor portion, and
wherein each of the first and second blow-off mechanisms (81, 82) are configured to release refrigerant from the usage heat exchanger (123) to the outside of the refrigerant circuit.

4. The heat pump system according to claim 3, wherein each of the first and second blow-off mechanisms (81, 82) comprises a two-way valve.

5. The heat pump system according to claim 3, wherein each of the first and the second blow-off mechanisms (81, 82) having a sacrificial seal sealing the refrigerant circuit from the outside of the refrigerant circuit, wherein the control unit (300) is further configured to trigger breaking the sacrificial seal.

6. The heat pump system according to claim 5, wherein the control unit (300) is configured to trigger a change in the properties of the sacrificial seal, whereby the pressure of the refrigerant in the refrigerant circuit breaks the sacrificial seal.

7. The heat pump system according to claim 5 or 6, wherein the blow-off mechanisms (81, 82) further comprise a heater for increasing the temperature of the sacrificial seal, wherein the control unit (300) is further configured to operate the heater to trigger the change in the properties of the sacrificial seal.

8. The heat pump system according to claim 5, wherein the blow-off mechanisms (81, 82) further comprise a breaking member and the control unit (300) is configured to operate the breaking member to break the sacrificial seal.

9. A method for releasing refrigerant from a heat pump system (100), the heat pump system comprising:

a refrigerant circuit connecting a compressor (11), a heat source heat exchanger (13), a first expansion valve (14), and a usage heat exchanger (123), the refrigerant circuit having an indoor portion and an outdoor portion, wherein the outdoor portion of the refrigerant circuit comprises the compressor (11), the heat source heat exchanger (13), and the first expansion valve (14), and the indoor portion of the refrigerant circuit comprises the usage heat exchanger (123);
a first release device (40) arranged in the refrigerant circuit and a second release device (41) arranged in the refrigerant circuit, wherein the first release device (40) and the second release device (41) separate the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit,
wherein the method comprises the step of:

starting a refrigerant release operation upon receipt of a signal that a refrigerant leakage is detected in the refrigerant circuit of the heat pump system (100),
in the refrigerant release operation:

shutting off the indoor portion of the refrigerant circuit from the outdoor portion of the refrigerant circuit by the first release device (40) and the second release device (41),
releasing a refrigerant contained in the indoor portion of the refrigerant circuit via the first release device (40) and the second release device (41) to an outside of the heat pump system (100).

10. The method of claim 9, wherein the method further comprises the step of:
in the refrigerant release operation:
operating the first release device (40) and the second release device (41) and not operating a switching device (12) of the refrigerant circuit of the heat pump system (100).

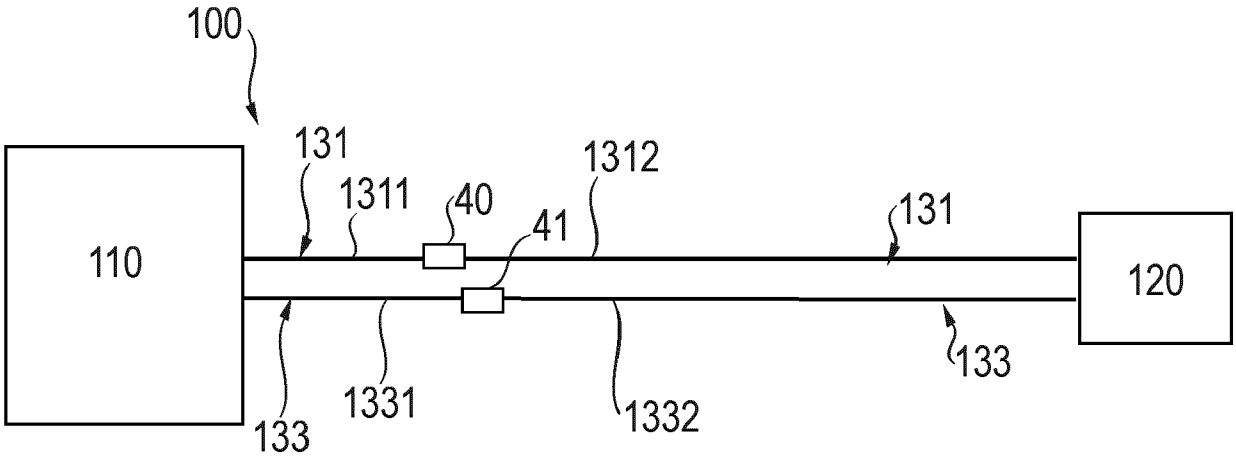
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Fig. 1A

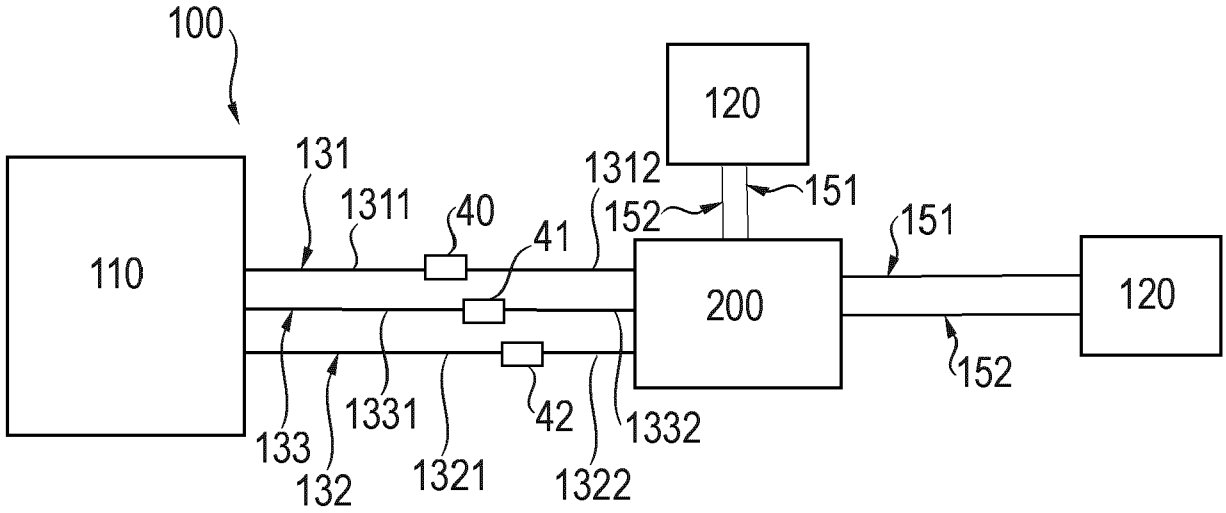
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Fig. 1B

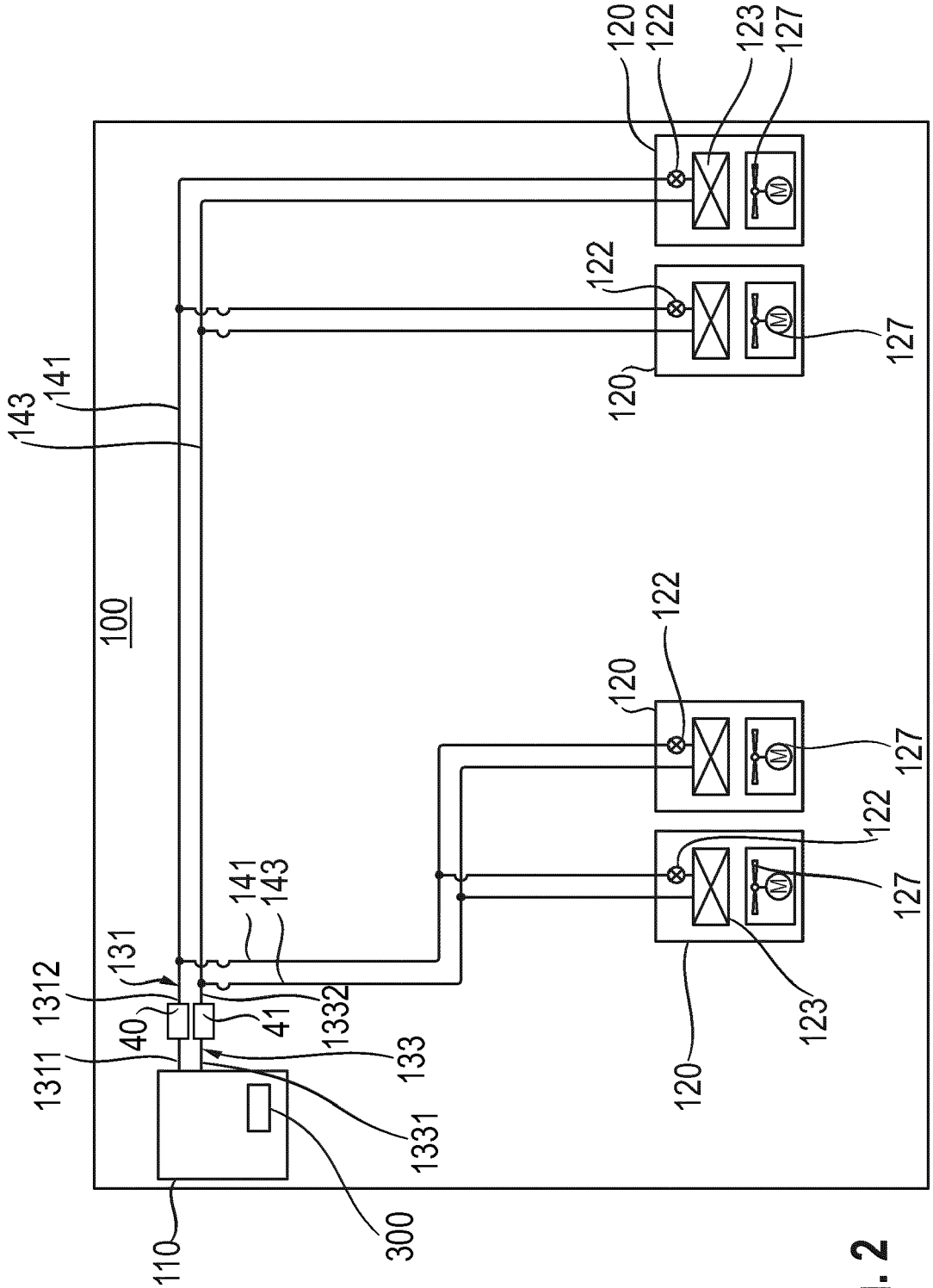
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Fig. 2

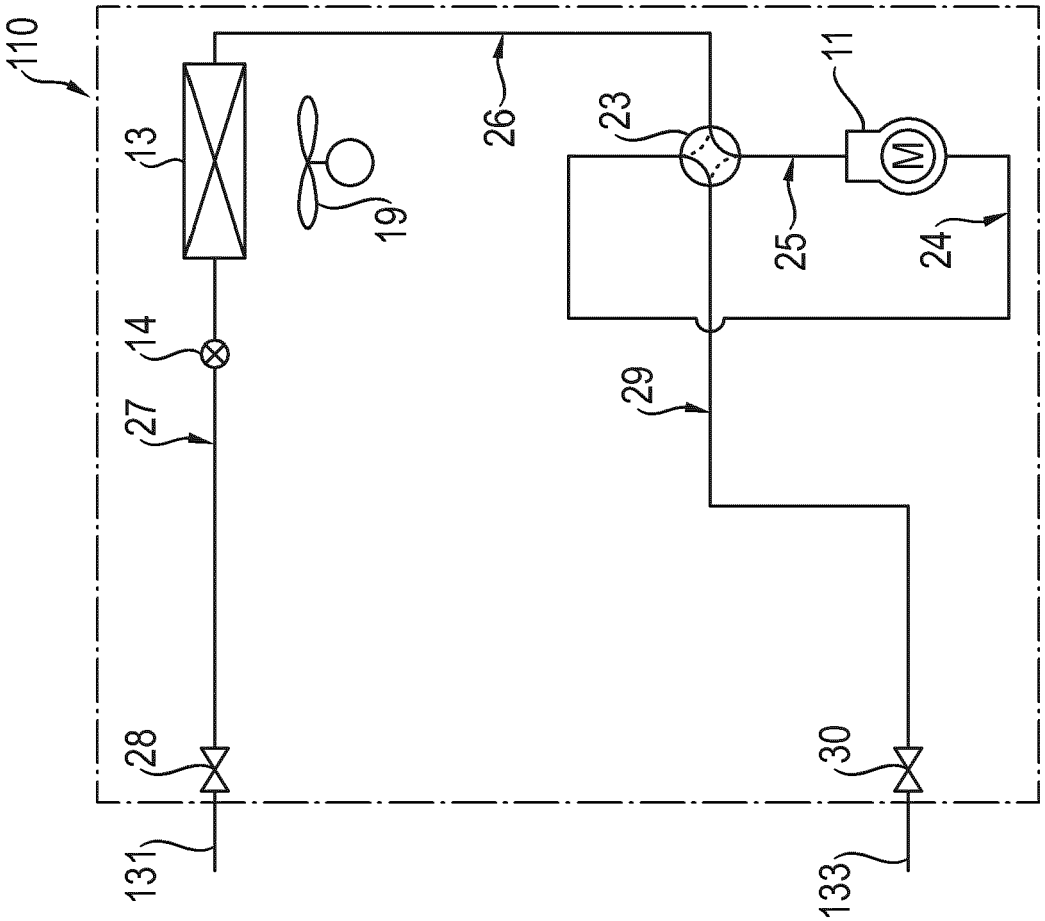

Fig. 3

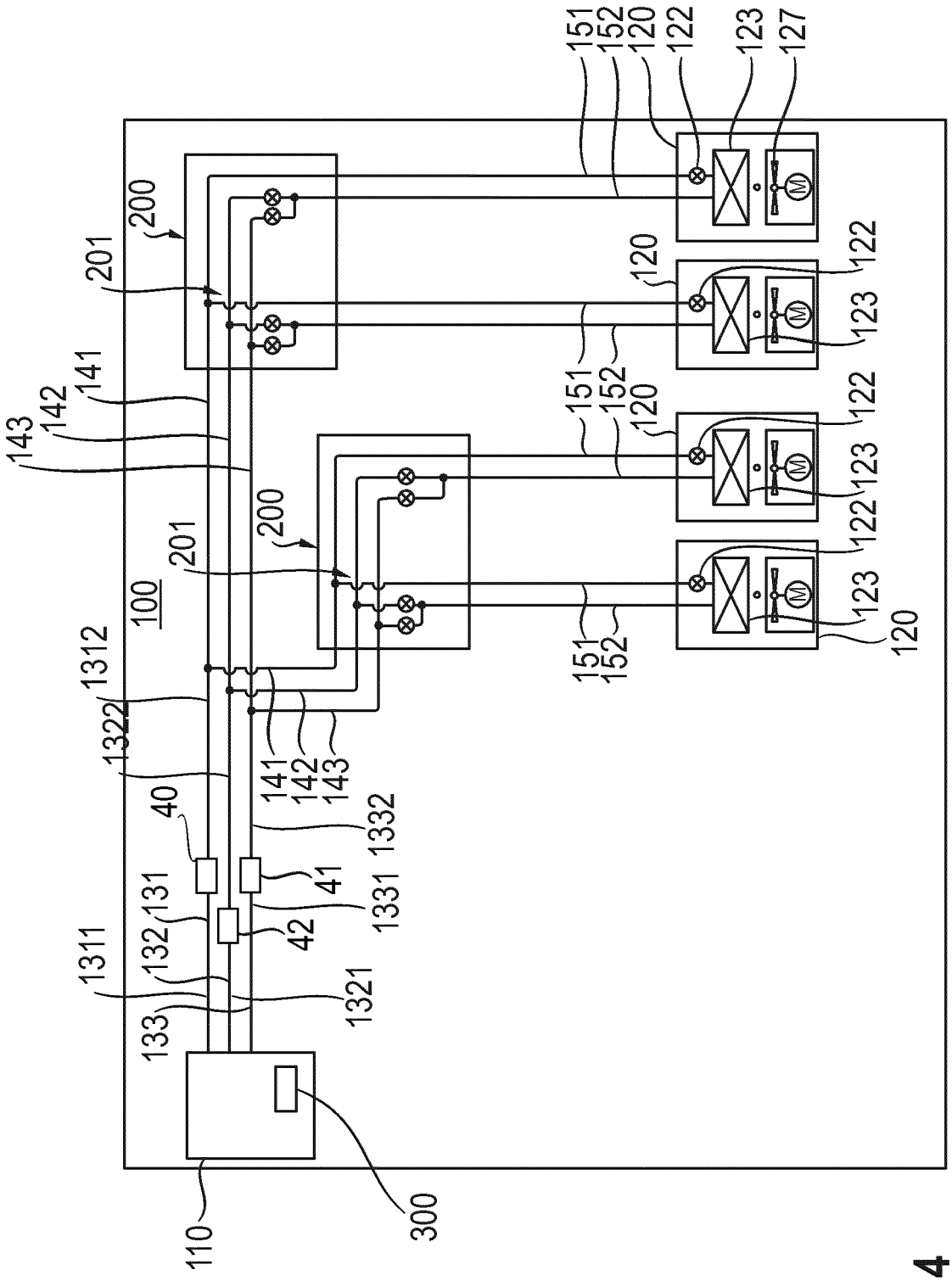
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Fig. 4

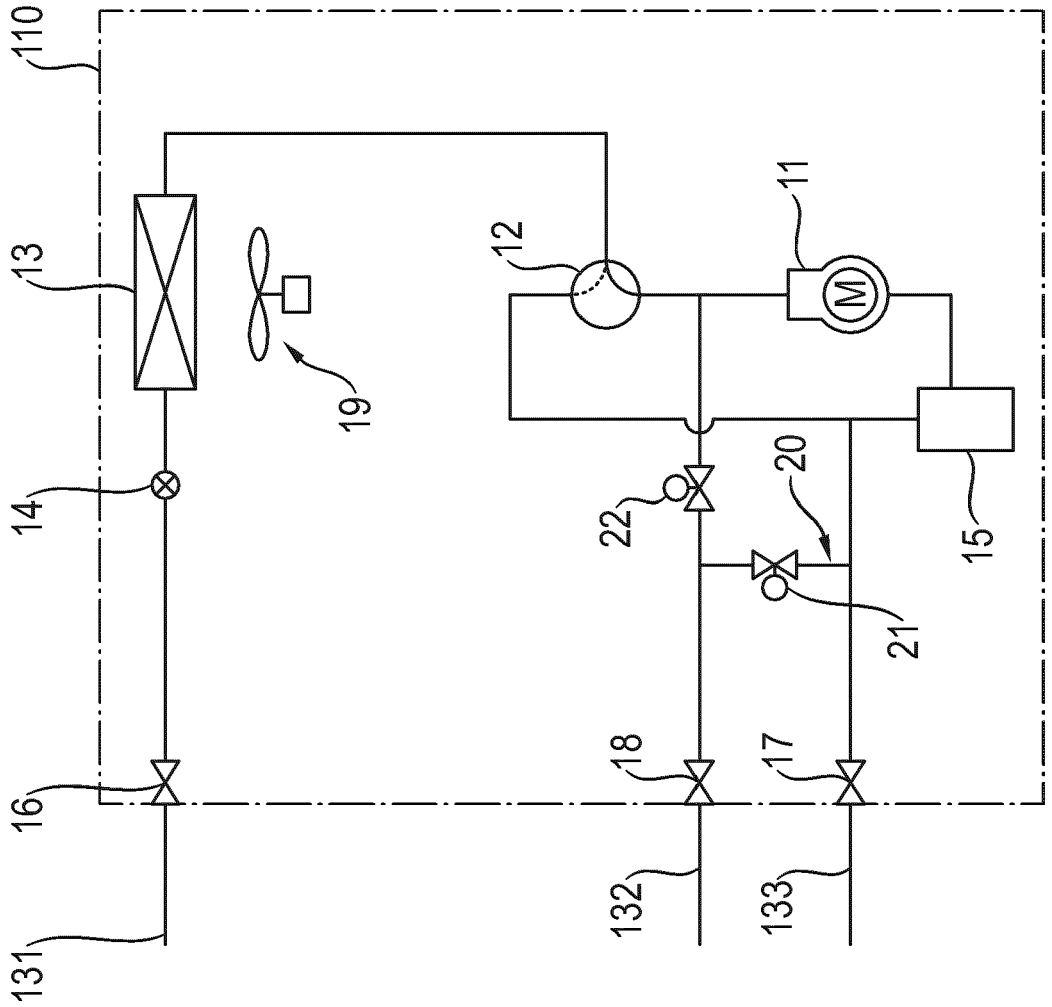

Fig. 5

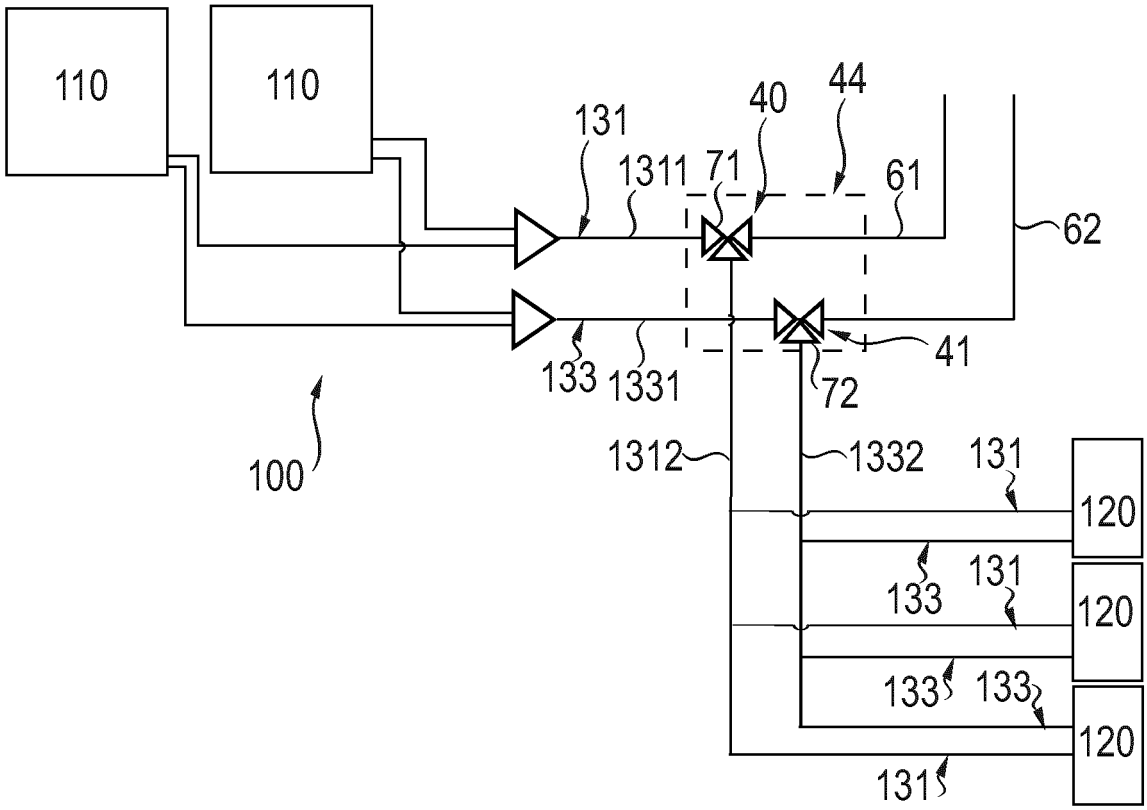
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Fig. 6

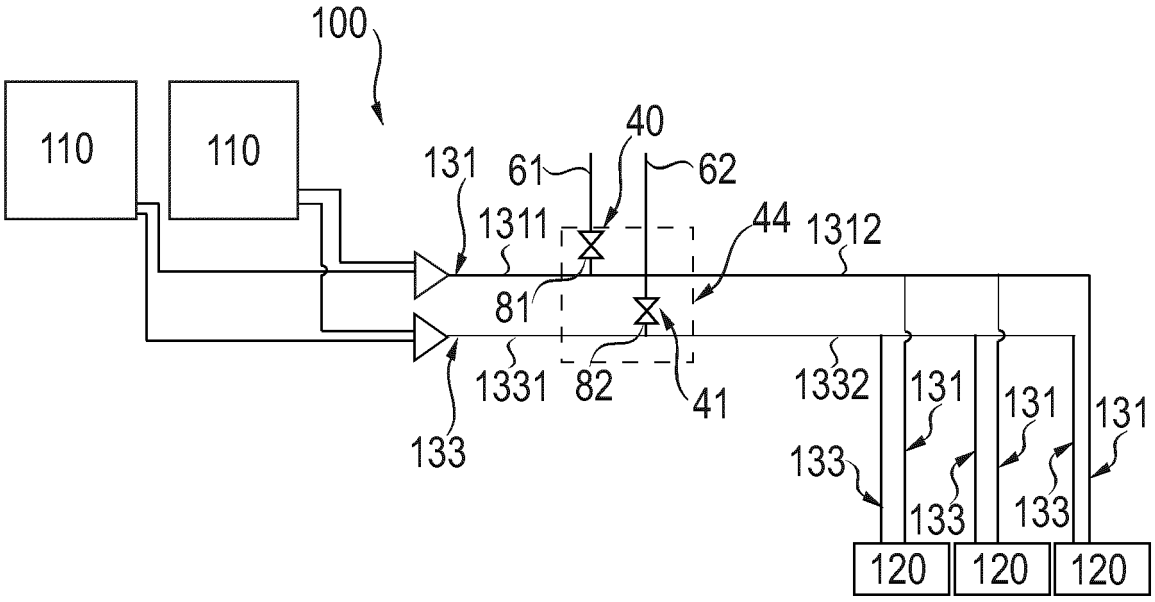
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Fig. 7

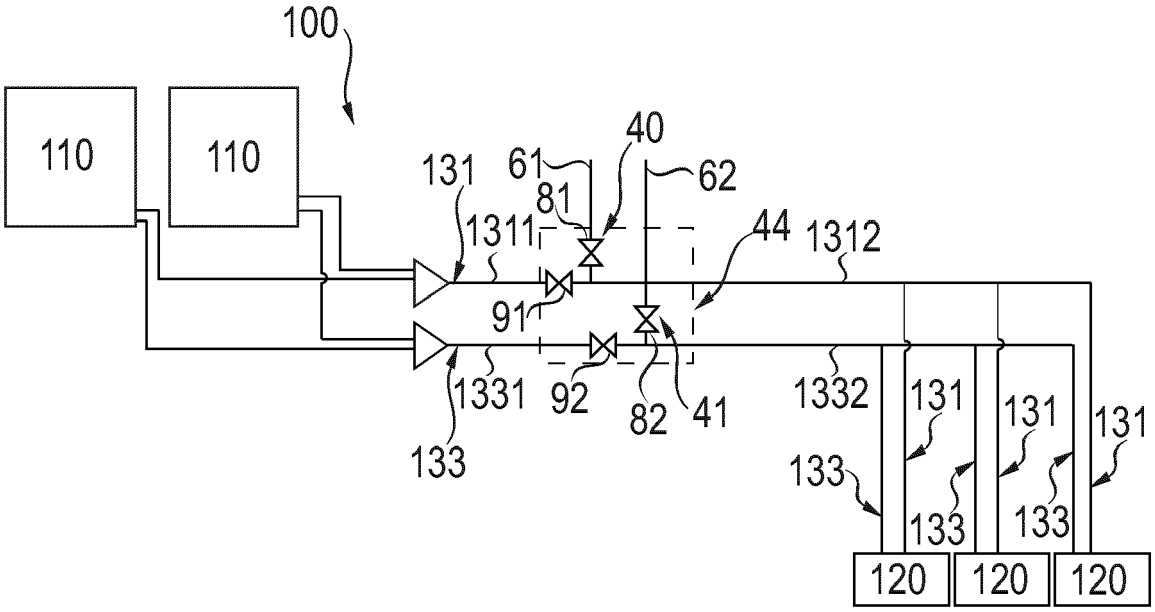
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Fig. 8

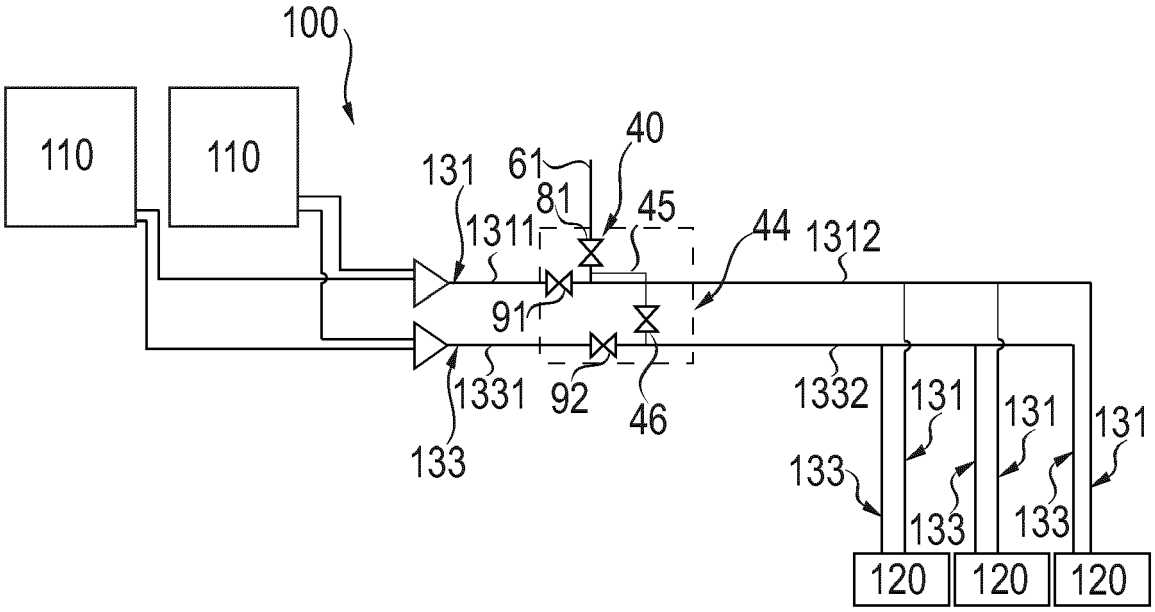
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Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 24 18 9442

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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
Munich	4 December 2024	Lepers, Joachim

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