

(19)



(11)

**EP 4 682 445 A1**

(12)

**EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**21.01.2026 Bulletin 2026/04**

(21) Application number: **24189443.5**

(22) Date of filing: **18.07.2024**

(51) International Patent Classification (IPC):

**F25B 13/00** <sup>(2006.01)</sup> **F16K 17/00** <sup>(2006.01)</sup>  
**F24F 11/36** <sup>(2018.01)</sup> **F25B 41/20** <sup>(2021.01)</sup>  
**F25B 45/00** <sup>(2006.01)</sup> **F25B 49/00** <sup>(2006.01)</sup>  
**F25B 49/02** <sup>(2006.01)</sup>

(52) Cooperative Patent Classification (CPC):

**F25B 13/00; F24F 11/36; F25B 41/20; F25B 45/00;**  
**F25B 49/005; F25B 49/02; F25B 2345/006;**  
**F25B 2500/22; F25B 2600/2519**

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB**  
**GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL**  
**NO PL PT RO RS SE SI SK SM TR**

Designated Extension States:

**BA**

Designated Validation States:

**GE KH MA MD TN**

(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)**

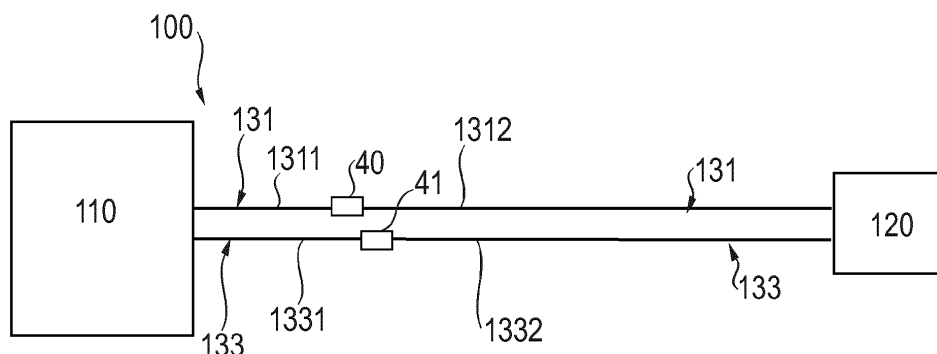
(74) Representative: **Hoffmann Eitle**

**Patent- und Rechtsanwälte PartmbB**  
**Arabellastraße 30**  
**81925 München (DE)**

(54) **RELEASE DEVICE UNIT AND A HEAT PUMP SYSTEM COMPRISING A RELEASE DEVICE**

(57) The disclosure relates to a heat pump system comprising an outdoor unit, an indoor unit, a refrigerant circuit having a first refrigerant pipe and a second refrigerant pipe that connects the outdoor unit and the indoor unit, a first release device for releasing a refrigerant to an outside of the refrigerant circuit, and a control unit configured to control the heat pump system, wherein the control unit is configured to operate the heat pump system 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, wherein in the release operation mode the first release device is operated for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit, wherein the first release device is arranged in the first refrigerant pipe between the outdoor unit and the indoor unit and separates the first refrigerant pipe into a first outdoor refrigerant pipe and a first indoor refrigerant pipe.



**Fig. 2A**

## Description

### TECHNICAL FIELD

[0001] The present disclosure relates to a release device unit and a heat pump system comprising a release device.

### 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 example 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, the release valve is located inside the outdoor unit. As a result, when refrigerant is released from the release valve, components or devices disposed near the release valve may be affected. For example, quick release of the refrigerant via a limited cross section and the associated quick pressure drop may result in a very low temperature. Components or devices may be damaged due to such low temperature.

[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.

[0009] In addition, in JP 5292940 B2, when a refrigerant leak is detected in any of the indoor spaces, a controller is configured to close all the expansion valves and shut-off valves in the indoor units. This means that the refrigerant stored in the indoor heat exchangers is trapped between the expansion valves and the shut-off valves in the indoor unit and is not released to the atmosphere from the release valve. There is, thus, a possibility that the refrigerant trapped in the indoor heat exchanger may further leak into the indoor space.

### SUMMARY OF THE INVENTION

[0010] In view of the above, it is an object of the present disclosure to provide a release device and heat pump system being capable of effectively and inexpensively cope with the problems associated with leaking natural refrigerants.

[0011] Another object of the present disclosure is to provide an improved and safer release device unit and an improved and safer heat pump system, which for example allow for a faster release of refrigerant to the atmosphere and/or prevent components of the heat pump system from being damaged because of the fast release of refrigerant and the associated pressure and eventually temperature drop.

[0012] This object is solved by a release device unit according to claim 1 and a heat pump system according to claim 2. The dependent claims describe optional features and embodiments.

[0013] According to a first aspect of the disclosure, the

release device unit for releasing refrigerant from a refrigerant circuit of a heat pump system to an outside of the heat pump system in case of a leakage in the refrigerant circuit comprises a plurality of ports. Particularly, the ports comprise a first port, a second port and/or a third port, and a fourth port (optionally, particularly in case of a three-pipe heat pump system as described later, a fifth and a sixth port) for connecting the release device unit to the refrigerant circuit of the heat pump system. Thus, for a two-pipe system as described later, the release device has four parts in total (the first to fourth ports). For a three-pipe system as described later, the release device has six ports in total (the first to sixth ports). The release device further comprises a first and second release opening (optionally a third release opening, e.g. in case of a three-pipe system) for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit. The first port and/or the third port (and optionally the fifth port) are connectable to an outdoor unit of the heat pump system (or more particularly components of the refrigerant circuit accommodated in the outdoor unit). In this context, the outdoor unit may have an outdoor unit casing having first and second (optionally third) outdoor service ports to which the first and/or third port (and optionally the fifth port) of the release device unit are connectable. The second port and/or the fourth port are connectable to an indoor unit of the heat pump system (or more particularly to components of the refrigerant circuit accommodated in the indoor unit). In this context, the indoor unit may have an indoor unit casing having first and second indoor service ports to which the second and/or fourth port of the release device unit are connectable. In a three-pipe system (see later), a connection unit may be disposed between the outdoor unit and a plurality of indoor units. In this case, the second port and/or the fourth port and/or the sixth port are connectable to the connection unit. For this purpose, the connection unit has first, second and third connection unit service ports to which the second and/or fourth port and/or the sixth port of the release device unit are connectable.

**[0014]** The release device unit further comprises a first release device and/or a second release device (optionally a third release device) connectable to a control unit of the heat pump system. The first release device is connected to the first port via a first outdoor refrigerant pipe portion and to the second port via a first indoor refrigerant pipe portion. Additionally or alternatively, the second release device - if present - is connected to the third port via a second outdoor refrigerant pipe portion and to the fourth port via a second indoor refrigerant pipe portion. The optional third release device may be connected to the fifth port via a third outdoor refrigerant pipe portion and to the sixth port via a third indoor refrigerant pipe portion.

**[0015]** The first release device is operable by the control unit to communicate at least the second port and the first release opening for releasing refrigerant to the outside of the refrigerant circuit (of the heat pump system),

e.g. to the atmosphere, in case of a leakage in the refrigerant circuit of the heat pump system. Additionally or alternatively, the second release device - if present - is operable by the control unit to communicate at least the fourth port and the second release opening for releasing the refrigerant to the outside of the refrigerant circuit (of the heat pump system), e.g. to the atmosphere, in case of a leakage in the refrigerant circuit of the heat pump system. The optional third release device is operable by the control unit to communicate at least the sixth port and the third release opening for releasing refrigerant to the outside of the refrigerant circuit (of the heat pump system), e.g. to the atmosphere, in case of a leakage in the refrigerant circuit of the heat pump system.

**[0016]** With the release device unit according to the first aspect, it is possible to provide in existing or newly installed heat pump systems a further safety measure, which minimizes the risk of a large mass of refrigerant leaking into the indoor space in which the indoor unit/s is/are located. The first and/or second release devices (and optional third release device) allow/-s refrigerant to be released very quickly to the outside of the heat pump system in case a refrigerant leakage is detected in the refrigerant circuit. Due to the provision of a first release device and/or second release device (and the optional third release device), the heat pump system's overall pressure is effectively reduced and consequently the mass flow rate of refrigerant at the indoor leak is reduced. Thus, the amount of refrigerant leaking into the indoor space can be minimised.

**[0017]** The release device unit may be sold as a separate kit and may be implemented in any existing two-pipe or three-pipe heat pump system. As the release device unit is a unit separate from other components of the refrigerant circuit, any negative effects on and damaging of these components during the release of refrigerant to the outside of the heat pump system can be avoided.

**[0018]** Since the first release device and/or the second release device (and the optional third release device) are integrally configured in the release device unit, workload for connecting the release devices to the first refrigerant pipe and second refrigerant pipe (and the optional third refrigerant pipe) at the installation site is improved.

**[0019]** Any of the first, second and/or third release opening may be integrated into a body of the release device, such as a body of a three-way valve or a blow-off mechanism (see later). In another embodiment, an end of a release pipe comprised by the respective release device forms the release opening. In particular, a first release pipe may branch from the first refrigerant pipe and a second release pipe - if present - may branch from the second refrigerant pipe. (Optionally, a third release pipe may branch from the third refrigerant pipe). The first, second and third refrigerant pipe may respectively be separated into first, second and third outdoor refrigerant pipes and first, second and third indoor refrigerant pipes by the first, second and third release devices (the release

device unit), respectively. Hence, the first, second and third release pipe may respectively branch from the first, second and third outdoor and/or indoor refrigerant pipes. The first release pipe may be part of the first release device. The second release pipe may be part of the second release device. The third release pipe may be part of the third release device. Each of the first port to sixth ports may be directly or indirectly connectable to the outdoor unit and/or indoor unit of the heat pump system.

**[0020]** In the release device unit, a flowed through cross-section of the first port and the second port may be smaller than or may have the same size as a flowed through cross-section of the third port and the fourth port. Due to the different sizes of the ports, it may be possible to distinguish the different ports when the release device unit is installed. Since the first diameter of the first and second ports may be smaller than second diameter of the third and fourth ports, mistakes between the first refrigerant pipe and the second refrigerant pipe connected to the release device unit are reduced.

**[0021]** The release device unit may further comprise a release device casing accommodating the first to sixth ports, the first to third release devices, the first to third release openings and -if present release pipes, the first to third outdoor refrigerant pipe portions, and the first to third indoor refrigerant pipe portions. The release device casing allows that the release device components are protected against the environment. Alternatively, one or more of the first to sixth ports may be located outside the release device casing. The release device casing may further comprise an opening (e.g. one opening per release pipe). The end of a release pipe having the release opening may be directed towards or even protrude from the opening in the release device casing.

**[0022]** The first release device may be operable by the control unit to stop a refrigerant flow between the first port and the second port in case of a leakage in the refrigerant circuit of the heat pump system. The second release device may be operable by the control unit to stop a refrigerant flow between the third port and the fourth port in case of a leakage in the refrigerant circuit of the heat pump system. The optional third release device may be operable by the control unit to stop a refrigerant flow between the fifth port and the sixth port in case of a leakage in the refrigerant circuit of the heat pump system.

**[0023]** Thus, the release device unit allows that refrigerant is sufficiently and fast released to the outside of the refrigerant circuit in case of a leakage in the refrigerant circuit of the two-pipe heat pump system. Due to the stop of the refrigerant flow between the outdoor unit and the indoor unit, an unnecessary release of refrigerant from the outdoor portion of the refrigerant circuit is prevented.

**[0024]** According to a second aspect of the disclosure, a heat pump system comprises an outdoor unit, an indoor unit, a refrigerant circuit having a first refrigerant pipe and a second refrigerant pipe that connects the outdoor unit and the indoor unit.

**[0025]** In this context, the outdoor unit and the indoor

unit may have an outdoor unit casing and an indoor unit casing respectively having first and second outdoor and indoor service ports to which the first and second refrigerant pipe are directly or indirectly connected.

**[0026]** The heat pump system further comprises a first release device for releasing a refrigerant to an outside of the refrigerant circuit. The first release device is arranged in the first refrigerant pipe between the outdoor unit and the indoor unit and separates the first refrigerant pipe into a first outdoor refrigerant pipe and a first indoor refrigerant pipe.

**[0027]** The heat pump system further comprises a control unit configured to control the heat pump system, wherein the control unit is configured to operate the heat pump system 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. In the release operation mode, the first release device is operated for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit (of the heat pump system), e.g. to the atmosphere.

**[0028]** The heat pump system 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 to release the high pressure refrigerant quickly to the outside of the refrigerant circuit. Thus, the release device has a fast response time and offers a more cost-effective solution. A high pressure in the context of the present disclosure is a pressure that is higher than the atmospheric pressure.

**[0029]** In addition, the first release device may be arranged close to the service ports of the outdoor unit, but not in an outdoor unit casing. Hence, no damage can occur to the components of the indoor unit and the outdoor unit by the release of the high pressure refrigerant. Since the refrigerant may be released from the release device to the outside of a building (to the atmosphere), nobody is affected by the discharged high pressure refrigerant. The refrigerant may also be released from a release pipe but is always discharged to the outside atmosphere. Thus, the heat pump system is improved and safer.

**[0030]** According to a third aspect, the heat pump system of the second aspect further comprises a second release device for releasing the refrigerant to the outside of the refrigerant circuit, wherein the second release device is arranged in the second refrigerant pipe between the outdoor unit and the indoor unit and separates the second refrigerant pipe into a second outdoor refrigerant pipe and a second indoor refrigerant pipe. In the release operation mode, the first release device and/or the second release device are operated for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

**[0031]** The heat pump system according to the third

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 and/or second release device to release the high pressure refrigerant quickly to the outside of the refrigerant circuit. Thus, the release device has a fast response time and offers a more cost-effective solution.

**[0032]** In addition, the second release device may be arranged close to the service ports of the outdoor unit, but not in an outdoor unit casing. Hence, no damage can occur to the components of the indoor unit and the outdoor unit by the release of the high pressure refrigerant. Since the refrigerant may be released from the release device to the outside of a building (to the atmosphere), nobody is affected by the discharged high pressure refrigerant. The refrigerant may also be released from a release pipe but is always discharged to the outside atmosphere. Thus, the heat pump system is improved and safer.

**[0033]** In the second and third 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 connects 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 may connect at least the heat source heat exchanger, the first expansion valve, the compressor, and the at least one usage heat exchanger. 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 and/or a sub-expansion valve.

**[0034]** The refrigerant circuit may comprise a manifold device (branching points) for connecting the outdoor unit to the at least one indoor unit. The manifold device may comprise a liquid pipe and a gas pipe for each of the indoor units. The liquid pipe may correspond to the first refrigerant pipe and the gas pipe may correspond to the second refrigerant pipe.

**[0035]** For example, in a so-called two-pipe heat pump system, a first outdoor refrigerant pipe, which may be a liquid pipe, and a second outdoor refrigerant pipe, which may be a gas pipe, may be connected to the outdoor unit. A plurality of first indoor refrigerant pipes, which may be liquid pipes, and a plurality of second indoor refrigerant pipes, which may be gas pipes may branch of the first outdoor refrigerant pipe and the second outdoor refrigerant pipe, respectively, defining a manifold device or branching points.

**[0036]** Thus, the first indoor refrigerant liquid pipes and the second indoor refrigerant gas pipes form the liquid

pipe and the gas pipe of the respective indoor units.

**[0037]** In a so-called three pipe heat pump system, which is often referred to as three pipe heat recovery system, the refrigerant circuit has a first refrigerant pipe, a second refrigerant pipe and a third refrigerant pipe. In particular, a first outdoor refrigerant pipe, a second outdoor refrigerant pipe, and a third outdoor refrigerant pipe may extend from the outdoor unit. The first outdoor refrigerant pipe may be a heat source liquid pipe, the second outdoor refrigerant pipe may be a heat source high/low-pressure gas pipe, and the third outdoor refrigerant pipe may be a heat source low-pressure gas pipe, all extending from the outdoor unit. The three-pipe system may use one or more connection units. The first outdoor refrigerant pipe, the second outdoor refrigerant pipe and the third outdoor refrigerant pipe extending from the outdoor unit may connect the release devices (release device unit) and the first indoor refrigerant pipe, the second indoor refrigerant pipe and the third indoor refrigerant pipe extending from the release devices (release device unit) may connect to the connection unit. In the connection unit a plurality of first indoor refrigerant pipes, which may be usage liquid pipes, may branch of the first outdoor refrigerant pipe. The first indoor refrigerant pipes, may form the liquid pipe of the respective indoor units. Additionally, a plurality of second indoor refrigerant pipes, which may be usage high/low-pressure gas pipes may branch of the second outdoor refrigerant pipe. A plurality of third indoor refrigerant pipes, which may be usage low-pressure gas pipes may branch of the third outdoor refrigerant pipe. The second indoor refrigerant pipe and the third indoor refrigerant pipe may merge into an indoor gas pipe, respectively. The merging may be realized within the connection unit or connection unit casing. The indoor gas pipes respectively may form the gas pipe of the respective indoor unit.

**[0038]** In either case, the indoor liquid and gas pipes may at least in part be arranged in the connection unit or connection unit casing.

**[0039]** The release device unit according to the first aspect may be implemented in the heat pump system according to any of the second aspect, the third aspect and the subsequent aspects.

**[0040]** The control unit may be configured to, in a normal operation mode, operate the first release device and/or 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/or the second release device. The first release device and/or the second release device may be leak tight. Because the first release device and/or the second release device are leak tight, no refrigerant may escape to the outside of the refrigerant circuit during the normal operation mode.

**[0041]** The control unit may be further configured to, in a release operation mode, open the sub-expansion

valve/-s of the indoor unit/-s. The control unit may be configured to, in a release operation mode, open all expansion valves in the indoor unit/-s and - if present - the connection unit. Due to the opening of the expansion valves, all refrigerant from the indoor refrigerant circuit can flow to the release device unit and is sufficiently released to the outside of the refrigerant circuit in case a refrigerant leakage is detected in the refrigerant circuit of the heat pump system. Further, the opening of the expansion valves has the advantage of limiting the formation of dry ice and decrease the chance of blockage (in case of carbon dioxide as refrigerant) during the release due to small cross sectional areas that can be formed in the valves, and make the fluid redistribute to allow even faster release.

**[0042]** 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 outdoor fan, the expansion valve, the sub expansion valve/-s and/or a usage side fan/-s. The control unit may be disposed in the outdoor unit and may be connected via a communication line to a PCB (Printed Circuit Board) in the first and/or second release device. The control unit and the PCB may be connected by one communication cable. Thus, it is unnecessary to connect the control unit with the first and/or second release device by a separate communication cable. Thereby, the workload is improved.

**[0043]** The normal operation mode is the mode of the heat pump system where heating or cooling the target space/indoor space by the heat pump system is possible. In particular, during a normal operation mode, the plurality of indoor units can perform heating and cooling simultaneously.

**[0044]** The operation states of the first release device and the second release device means that the first release device is opened or closed for releasing refrigerant and/or that the second release device is opened or closed for releasing refrigerant (and that the optional third release device is opened or closed for releasing refrigerant). The operation state of the four-way switching valve "not operated" means that the four-way valve is not switched and is left unchanged. In any operation state, refrigerant may be released without switching a four-way switching valve of the heat pump system.

**[0045]** 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 leak may also be detected using ultrasonic. 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 (optionally the third release device) in response to the signal.

**[0046]** 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.

**[0047]** The heat pump system according to a fourth aspect is the heat pump system according to the second or third aspect, wherein the first release device is a first three-way valve. In addition, if a second release device is present, the second release device is a second three-way valve. The first and/or the second three-way valves are configured to release the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit via the first indoor refrigerant pipe and/or the second indoor refrigerant pipe and to stop a refrigerant flow between the first outdoor refrigerant pipe and the first indoor refrigerant pipe and/or between the second outdoor refrigerant pipe and the second indoor refrigerant pipe.

**[0048]** The release device unit according to a fourth aspect is the release device unit according to the first aspect, wherein the first release device is a first three-way valve and the second release device is a second three-way valve. The first and/or the second three-way valves are configured to release the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit. The first and/or the second three-way valves may be configured to release refrigerant from the refrigerant circuit via the first indoor refrigerant pipe and/or the second indoor refrigerant pipe and to stop a refrigerant flow between the first outdoor refrigerant pipe and the first indoor refrigerant pipe and/or between the second outdoor refrigerant pipe and the second indoor refrigerant pipe, when connected to a heat pump system.

**[0049]** The provision of a three-way valve as the release device allows that the release device can be opened very quickly to release refrigerant to the outside of the refrigerant circuit. In case that only a first three-way valve is provided, no release pipe in the second refrigerant pipe is necessary. In case that a first and second three-way valves are provided, the outdoor portion of the refrigerant circuit is sufficiently shut off. 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.

**[0050]** The heat pump system according to a fifth aspect is the heat pump system according to the second or third aspect, wherein the first release device comprises a first blow-off mechanism. In addition, if a second release device is present, the second release device comprises a second blow-off mechanism. A first release pipe branches from the first refrigerant pipe and the first blow-off mechanism is arranged in the first release pipe, and/or a second release pipe branches from the second refrigerant pipe and the second blow-off mechanism is arranged in the second release pipe, and the first blow-off mechanism is configured to release the refrigerant from

the refrigerant circuit via the first indoor refrigerant pipe and the first release pipe to the outside of the refrigerant circuit. Additionally or alternatively, the second blow-off mechanism is configured to release the refrigerant from the refrigerant circuit via the second refrigerant pipe and the second release pipe to the outside of the refrigerant circuit. As previously explained, the first and second refrigerant pipe may respectively be separated into first and second outdoor refrigerant pipes and first and second indoor refrigerant pipes by the first and second release devices (the release device unit), respectively. Hence, the first and second release pipe may respectively branch from the first and second indoor and/or outdoor refrigerant pipes. Consequently, the first and second blow-off mechanism may be configured to release the refrigerant from the refrigerant circuit via the first and/or second indoor and outdoor refrigerant pipe and the first and second release pipe to the outside of the refrigerant circuit, respectively.

**[0051]** The release device unit according to a fifth aspect is the release device unit according to the first aspect or fourth aspect, wherein the first release device comprises a first blow-off mechanism and the second release device comprises a second blow-off mechanism (optionally the third release device comprises a third blow-off mechanism). The first blow-off mechanism is arranged in the first release pipe, and the second blow-off mechanism is arranged in the second release pipe (optionally the third blow-off mechanism is arranged in the third release pipe). The first blow-off mechanism is configured to release the refrigerant from the refrigerant circuit via the first indoor refrigerant pipe and the first release pipe to the outside of the refrigerant circuit and the second blow-off mechanism is configured to release the refrigerant from the refrigerant circuit via the second indoor refrigerant pipe and the second release pipe to the outside of the refrigerant circuit. Optionally, the third blow-off mechanism is configured to release the refrigerant from the refrigerant circuit via the third indoor refrigerant pipe and the third release pipe to the outside of the refrigerant circuit.

**[0052]** The heat pump system or the release device unit may further comprise a manifold pipe connecting the first release pipe and the second release pipe (and optionally the third release pipe) for releasing refrigerant from the refrigerant circuit via the first release device and second release device (optionally third release device) to the outside of the heat pump system. The manifold pipe may have only one release opening (combining the previously mentioned first to third release openings) located at a release area, which may be outside of a building where the outdoor unit and the indoor unit are installed in. 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 concentration). The release area may be outside of

a building where the outdoor unit and the indoor unit are installed.

**[0053]** The blow off mechanism allows that the release device is leak tight in the normal operation mode, which provides an improved and safer release device unit and heat pump system.

**[0054]** The heat pump system according to the sixth aspect is the heat pump system of the fifth aspect, wherein the first and/or the second blow-off mechanisms comprise a two-way valve. The release device unit according to a sixth aspect is the release device unit according to the first, fourth or fifth aspect, wherein the first and the second blow-off mechanisms (optionally third blow-off mechanism) comprise a two-way valve.

**[0055]** The provision of a two-way valve as a blow-off mechanism is more cost-efficient, but still provides a fast opening time.

**[0056]** The heat pump system according to a seventh aspect is the heat pump system according to the fifth aspect, wherein the first and/or 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. In this context, the sacrificial seal is exclusively broken upon being triggered by the control unit and cannot be broken by e.g. an overpressure in the refrigerant circuit. The release device unit according to a seventh aspect is the release device unit according to the first, fourth, fifth, or sixth aspect, wherein the first and/or the second blow-off mechanisms (and optionally the third blow-off mechanism) 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.

**[0057]** The blow-off mechanism may be a sacrificial release device. A sacrificial release device may be a safety device, a pressure relief device, a bursting disc, a one-time use safety component, or a fusible plug.

**[0058]** Because of the provision of a sacrificial seal in the first and/or 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/or 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.

**[0059]** The heat pump according to an eighth aspect is the heat pump system according to any one of the fifth to seventh aspects, wherein the first release device further comprises a first two-way valve. If the second release device is present, the second release device further comprises a second two-way valve. The first two-way valve is arranged in the first outdoor refrigerant pipe, and/or the second two-way valve is arranged in the second outdoor refrigerant pipe, and wherein the first

two-way valve is configured to stop a refrigerant flow between the first outdoor refrigerant pipe and the first indoor refrigerant pipe and/or the second two-way valve is configured to stop a refrigerant flow between the second outdoor refrigerant pipe and the second indoor refrigerant pipe. The release device unit according to an eighth aspect is the release device unit according to the first, fourth, fifth, sixth or seventh aspect, wherein the first release device further comprises a first two-way valve and the second release device further comprises a second two-way valve (optionally the third release device further comprises a third two-way valve). The first two-way valve is arranged in the first outdoor refrigerant pipe, in particular in the first outdoor refrigerant pipe portion, and/or the second two-way valve is arranged in the second outdoor refrigerant pipe, in particular in the second outdoor refrigerant pipe portion, and wherein the first two-way valve is configured to stop a refrigerant flow between the first outdoor refrigerant pipe and the first indoor refrigerant pipe and/or the second two-way valve is configured to stop a refrigerant flow between the second outdoor refrigerant pipe and the second indoor refrigerant pipe. The optional third two-way valve is arranged in the third outdoor refrigerant pipe, in particular in the third outdoor refrigerant pipe portion, and wherein the third two-way valve is configured to stop a refrigerant flow between the third outdoor refrigerant pipe and the third indoor refrigerant pipe. The refrigerant circuit may further connect the 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 refrigerant circuit may further connect the 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.

**[0060]** The first and second two-way valves (optionally third two-way valve) in the refrigerant pipes allows 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 (in case carbon dioxide is used) or oil release. Thus, the heat pump system is further improved and safer.

**[0061]** The heat pump system according to a ninth aspect is the heat pump system according to any one of the third to eighth aspects, wherein the refrigerant circuit further comprises a connection unit interposed between the outdoor unit and the indoor unit and connected to the first and the second indoor refrigerant pipes, and a third refrigerant pipe that connects the outdoor unit to the connection unit. The heat pump system further

comprises a third release device for releasing the refrigerant to the outside of the refrigerant circuit, wherein the third release device is arranged in the third refrigerant pipe between the outdoor unit and the connection unit and separates the third refrigerant pipe into a third outdoor refrigerant pipe and a third indoor refrigerant pipe, and wherein in the release operation mode the third release device is operated for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

**[0062]** The heat pump system according to the ninth aspect allows that a high mass flow rate of the refrigerant in a three-pipe heat pump system due is minimized in the indoor space, where a refrigerant leakage may be detected. 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 to third release devices to release the high pressure refrigerant quickly to the outside of the refrigerant circuit. Due to the opening of the three release devices, the refrigerant is quickly discharged to the outside of the refrigerant circuit. Thus, the release device has a fast response time and offers a more cost-effective solution. In addition, no damage can occur to the components of the indoor unit and the outdoor unit by the release of the high pressure refrigerant to the outside. Thus, the heat pump system is further improved and safer.

**[0063]** The heat pump system according to a tenth aspect is the heat pump system according to the ninth aspect, wherein the third release device is a third three-way valve, and wherein 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 and to stop a refrigerant flow between the third outdoor refrigerant pipe and the third indoor refrigerant pipe.

**[0064]** The provision of a third three-way valve as the third release device allows that the third release device can be opened very quickly to release refrigerant to the outside of the refrigerant circuit.

**[0065]** The heat pump system according to a eleventh aspect is the heat pump system according to the ninth aspect, wherein the third release device comprises a third blow-off mechanism, wherein a third release pipe branches from the third refrigerant pipe and the third blow-off mechanism is arranged in the third release pipe, and wherein the third blow-off mechanism is configured to release the refrigerant from the refrigerant circuit via the third three-way valve to the outside of the refrigerant circuit.

**[0066]** The third blow off mechanism allows that the third release device is leak tight in the normal operation mode, which provides a further improved and safer heat pump system.

**[0067]** The heat pump system according to a twelfth aspect is the heat pump system according to the eleventh aspect, wherein the third blow-off mechanism comprises a two-way valve. The provision of a two-way valve as a

blow-off mechanism is more cost-efficient, but still has a fast opening time.

**[0068]** The heat pump system according to a thirteenth aspect is the heat pump system according to the eleventh aspect, wherein the third blow-off mechanism has a sacrificial seal sealing the refrigerant circuit from the outside of the refrigerant circuit, and wherein the control unit is further configured to trigger breaking the sacrificial seal.

**[0069]** Because of the provision of a sacrificial seal in the third blow-off mechanism, 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 third blow-off mechanism 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 further reduced.

**[0070]** The heat pump system according to a fourteenth aspect is the heat pump system according to any one of the eleventh to thirteenth aspects, wherein the third release device further comprises a third two-way valve, wherein the third two-way valve is arranged in the third outdoor refrigerant pipe, and wherein the third two-way valve is configured to stop a refrigerant flow between the third outdoor refrigerant pipe and the third indoor refrigerant pipe.

**[0071]** The third two-way valve in the third refrigerant pipe allows 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 (in case carbon dioxide is used) or oil release. Thus, the heat pump system is further improved and safer.

**[0072]** The release device unit according to a fifteenth aspect is the release device unit according to a first aspect, wherein the refrigerant contained in the refrigerant circuit is natural refrigerant, particularly carbon dioxide. The heat pump system according to the fifteenth aspect is the heat pump system according to any one of the second to fourteenth aspects, wherein the refrigerant contained in the refrigerant circuit is carbon dioxide.

**[0073]** The use of carbon dioxide as refrigerants allows that the refrigerant may be released to the outside of the refrigerant circuit, in particular to the atmosphere, and that the released refrigerant must not be collected. Even if carbon dioxide refrigerant leaks in an indoor unit, since at least the first release device is opened, the amount of carbon dioxide leaking into the indoor space can be reduced.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0074]

- 5 Fig. 1A shows a schematic piping diagram of a release device unit in a two-pipe heat pump system according to a first embodiment of the present disclosure.
- Fig. 1B shows a schematic piping diagram of a release device unit in a three-pipe heat pump system according to a first modification of the first embodiment of the present disclosure.
- 10 Fig. 2A shows a schematic piping diagram of a heat pump system according to a second embodiment of the present disclosure.
- Fig. 2B shows a schematic piping diagram of a heat pump system according to a third embodiment of the present disclosure.
- 15 Fig. 3 shows a schematic piping diagram of a heat pump system according to second embodiment of the present disclosure.
- 20 Fig. 4 shows a schematic piping diagram of an example of an outdoor unit of the heat pump system of Fig. 3.
- 25 Fig. 5 shows a schematic piping diagram of a heat pump system according to the third embodiment of the present disclosure.
- Fig. 6 shows a schematic piping diagram of an example of an outdoor unit of the heat pump system of Fig. 5.
- 30 Fig. 7 shows a schematic piping diagram of a first modification of the heat pump system of the second embodiment also applicable to the third embodiment.
- 35 Fig. 8 shows a schematic piping diagram of a second modification of the heat pump system of the second embodiment also applicable to the third embodiment.
- Fig. 9 shows a schematic piping diagram of a fifth modification of the heat pump system of the second embodiment also applicable to the third embodiment.
- 40 Fig. 10 shows a schematic piping diagram of a sixth modification of the heat pump system of the second embodiment also applicable to the third embodiment.
- 45

## DESCRIPTION OF EMBODIMENTS

- 50 **[0075]** 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.
- 55

[0076] 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..

[0077] 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.

[0078] The heat pump system 100 may have a so-called two-pipe configuration as shown in Fig. 1A, 2A, 3, and 4 or a so-called three-pipe configuration as shown in Fig. 1B, 2B, 5, and 6.

### First embodiment

#### [Configuration of the Release Device Unit]

[0079] A release device unit 50 according to a first embodiment of the present disclosure is a release device unit 50 for releasing refrigerant from a refrigerant circuit of a heat pump system 100 to an outside of the heat pump system 100 in case of a leakage in the refrigerant circuit. The release device unit 50 according to a first embodiment is shown in Fig. 1A.

[0080] The release device unit 50 is connectable to a heat pump system 100 with a two-pipe configuration (as described in more detail later). The heat pump system 100 may comprise an outdoor unit 110, an indoor unit 120 (or a plurality of indoor units as described with respect to Fig. 3), and a refrigerant circuit. The refrigerant circuit may have a first refrigerant pipe 131 and a second refrigerant pipe 133 that connects the outdoor unit 110 and the indoor unit 120. The release device unit 50 is arranged in the first refrigerant pipe 131 and/or the second refrigerant pipe 133 and separates the first refrigerant pipe 131 into a first outdoor refrigerant pipe 1311 and a first indoor refrigerant pipe 1312, and/or the second refrigerant pipe 133 into a second outdoor refrigerant pipe 1331 and a second indoor refrigerant pipe 1332.

[0081] The release device unit 50 comprises a first port 51, a second port 52, and/or a third port 53 and a fourth port 54 for connecting the release device unit 50 to the refrigerant circuit of the heat pump system 100. Additionally, the release device unit 50 comprises a first release opening 55 and/or a second release opening 56 for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit. The first port 51 and/or the third port 53 are connectable to an outdoor

unit 110 of the heat pump system 100, and the second port 52 and/or the fourth port 54 are connectable to an indoor unit 120 of the heat pump system 100.

[0082] The release device unit 50 further comprises a first release device 40 connectable to a control unit 300 of the heat pump system (not illustrated in Fig. 1A). The first release device 40 is connected to the first port 51 via a first outdoor refrigerant pipe portion 1311A and to the second port 52 via a first indoor refrigerant pipe portion 1312A. The first release opening 55 is located at an end of a first release pipe 61. The first release device 40 is operable by the control unit 300 to communicate at least the second port 52 and the first release opening 55 for releasing refrigerant via the first release opening 55 to the outside of the refrigerant circuit in case of a leakage in the refrigerant circuit of the heat pump system 100.

[0083] The first release pipe 61 branches from the first refrigerant pipe 131, particularly between first outdoor refrigerant pipe 1311 and the first indoor refrigerant pipe 1312, and more particularly between the first outdoor refrigerant pipe portion 1311A and the first indoor refrigerant pipe portion 1312A of the release device unit 50. The first release pipe 61 may be connected to or be part of the first release device 40. The first release opening 55 for releasing the refrigerant from the refrigerant circuit may be connected to the first release pipe 61 on one side and may open to the outside of the refrigerant circuit at another side. Alternatively, the first release opening 55 may also be integrated into the first release device 40 without the need of the first release pipe 61. The first release device 40 may be configured as discussed below, particularly with respect to the second and third embodiment and its modifications.

[0084] Additionally or alternatively, the release device unit 50 further comprises a second release device 41 connectable to a control unit 300 of the heat pump system. The second release device 41 is connected to the third port 53 via a second outdoor refrigerant pipe portion 1331A and to the fourth port 54 via a second indoor refrigerant pipe portion 1332A. The second release opening 56 is located at an end of a second release pipe 62. The second release device 41 is operable by the control unit 300 to communicate at least the fourth port 54 and the second release opening 56 for releasing the refrigerant via second release opening 56 to the outside of the refrigerant circuit in case of a leakage in the refrigerant circuit of the heat pump system 100.

[0085] The second release pipe 62 branches from the second refrigerant pipe 133, particularly between the second outdoor refrigerant pipe 1331 and the second indoor refrigerant pipe 1332, and more particularly between the second outdoor refrigerant pipe portion 1331A and the second indoor refrigerant pipe portion 1332A of the release device unit 50. The second release pipe 62 may be connected to or be part of the second release device 41. The second release opening 56 for releasing the refrigerant from the refrigerant circuit may be connected to the second release pipe 62 on one side and

may open to the outside of the refrigerant circuit at another side. Alternatively, the second release opening 56 may also be integrated into the second release device 41 without the need of the second release pipe 62. The second release device 41 may be configured as discussed below, particularly with respect to the second and third embodiment and its modifications.

**[0086]** The refrigerant contained in the refrigerant circuit may be carbon dioxide.

**[0087]** In the release device unit 50 a flow through cross-section of the first port 51 and a flow through cross-section of the second port 52 may be smaller than or may have the same size as a flow through cross-section of the first release opening 55. Alternatively or additionally a flow through cross-section of the third port 53 and a flow through cross-section of the fourth port 54 may be smaller than or may have the same size as a flow through cross-section of the second release opening 56. A flow through cross-section of the first port 51 and a flow through cross-section of the second port 52 may be smaller than or may have the same size as a flow through cross-section of the third port 53 and a flow through cross-section of the fourth port 54. Due to the different sizes of the ports, it is possible to distinguish the different ports when the release device unit is installed.

**[0088]** The release device unit 50 may further comprise a release device casing 44 accommodating the first to fourth ports 51 - 54, the first and second release devices 40 - 41, the first and second release pipes 61 - 62 including the first and second release openings 55 - 56, the first and second outdoor refrigerant pipe portions 1311A - 1331A, and the first and second indoor refrigerant pipe portions 1312A - 1332A. The release device casing 44 is indicated in Fig. 1A by the dotted line and may also be omitted.

**[0089]** The first release device 40 may be operable by the control unit 300 to stop a refrigerant flow between the first port 51 and the second port 52 in case of a leakage in the refrigerant circuit of the heat pump system 100. The second release device 41 may be operable by the control unit 300 to stop a refrigerant flow between the third port 53 and the fourth port 54 in case of a leakage in the refrigerant circuit of the heat pump system 100.

**[0090]** Thus, the release device unit 50 allows that refrigerant is sufficiently and fast released to the outside of the refrigerant circuit in case of a leakage in the refrigerant circuit of the two-pipe heat pump system 100.

#### First modification of the first embodiment

**[0091]** The release device unit 50 in a first modification of the first embodiment of the present disclosure is a release device unit 50 of the first embodiment wherein the release device unit 50 is connectable to a heat pump system 100 with a three-pipe configuration (described in more detail later) instead of a two-pipe configuration. Further, a plurality of indoor units 120 are provided. A

release device unit 50 according to the first modification of the first embodiment is shown in Fig. 1B. Thus, in the first modification of the first embodiment it is possible to additionally connect the release device unit 50 to a third refrigerant pipe 132 that is connected to the outdoor unit 110.

**[0092]** The release device unit 50 is connectable to a heat pump system 100 with a three-pipe configuration. The heat pump system 100 comprises an outdoor unit 110, a connection unit 200, a plurality of indoor units 120, and a refrigerant circuit. The refrigerant circuit has a first refrigerant pipe 131, a second refrigerant pipe 133, and the third refrigerant pipe 132. The connection unit 200 is disposed between the outdoor unit 110 and the indoor units 120, and the refrigerant circuit may have the first refrigerant pipe 131, the second refrigerant pipe 133 and the third refrigerant pipe 132 that connect the outdoor unit 110 and the connection unit 200. The release device unit 50 is arranged in the first refrigerant pipe 131, the second refrigerant pipe 133, and the third refrigerant pipe 132, and separates the first refrigerant pipe 131 into a first outdoor refrigerant pipe 1311 and a first indoor refrigerant pipe 1312, the second refrigerant pipe 133 into a second outdoor refrigerant pipe 1331 and a second indoor refrigerant pipe 1332, and the third refrigerant pipe 132 into a third outdoor refrigerant pipe 1321 and a third indoor refrigerant pipe 1322. The first to third outdoor refrigerant pipes 1311, 1331 and 1321 are connected to the outdoor unit 110. The first to third indoor refrigerant pipes 1312, 1332 and 1322 are connected to the connection unit 200. The indoor units 120 are respectively connected to the connection unit 200 as explained in more detail with respect to Figure 5 below.

**[0093]** The release device unit 50 further comprises a fifth port 57 and a sixth port 58 for connecting the release device unit 50 to the refrigerant circuit of the heat pump system 100. Additionally, the release device unit 50 further comprises a third release opening 59 for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit. The fifth port 57, as the first and third port 51, 53, is connectable to the outdoor unit 110 of the heat pump system 100, and the sixth port 58, as the second and fourth port 52, 54, is connectable to the connection unit 200 of the heat pump system 100.

**[0094]** The release device unit 50 further comprises a third release device 42 connectable to a control unit 300 of the heat pump system (not illustrated in Fig. 1B). The third release device 42 is connected to the fifth port 57 via a third outdoor refrigerant pipe portion 1321A and to the sixth port 58 via a third indoor refrigerant pipe portion 1322A. The third release opening 59 is located at an end of a third release pipe 63. The third release device 42 is operable by the control unit 300 to communicate at least the sixth port 58 and the third release opening 59 for releasing refrigerant via the third release opening 59 to the outside of the refrigerant circuit in case of a leakage in the refrigerant circuit of the heat pump system 100. The third release device 42 may be further operable by the

control unit 300 to stop a refrigerant flow between the fifth port 57 and the sixth port 58 in case of a leakage in the refrigerant circuit of the heat pump system 100.

**[0095]** The third release pipe 63 branches from the third refrigerant pipe 132, particularly between the third outdoor refrigerant pipe 1321 and the third indoor refrigerant pipe 1322, and more particularly between the third outdoor refrigerant pipe portion 1321A and the third indoor refrigerant pipe portion 1322A of the release device unit 50. The third release pipe 63 may be connected to or be part of the third release device 42. The third release opening 59 for releasing the refrigerant from the refrigerant circuit may be connected to the third release pipe 63 on one side and may open to the outside of the refrigerant circuit at another side. Alternatively, the third release opening 59 may also be integrated into the third release device 43 without the need of the third release pipe 63. The third release device 42 may be configured as discussed below, particularly described with respect to the second and third embodiment and its modifications and similar to the first and second release device 40, 41.

**[0096]** A flowed through cross-section of the fifth port and the sixth port may be smaller than or may have the same size as a flowed through cross-section of the third release opening 59.

**[0097]** The release device unit 50 may further comprise a release device casing 44 accommodating the first to sixth ports 51 - 54, 57, 58, the first to third release devices 40 - 42, the first to third release pipes 61 - 63 including the first to third release openings 55 - 56, 59, the first to third outdoor refrigerant pipe portions 1311A - 1331A, and the first to third indoor refrigerant pipe portions 1312A - 1332A. The release device casing 44 is indicated in Fig. 1B by the dotted line and may also be omitted.

**[0098]** Thus, the release device unit 50 allows that refrigerant is sufficiently and fast released to the outside of the refrigerant circuit in case of a leakage in the refrigerant circuit of a three-pipe heat pump system 100.

## Second embodiment

[Configuration of the two-pipe heat pump system]

**[0099]** The heat pump system 100 according to the second 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. 2A, 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. 3, 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. 7 to 9.

**[0100]** 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, 2A, 3 and 4. Figs. 2A and 3 show a schematic piping diagram of the two-pipe heat pump system of the second embodiment. Fig. 4 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. 3.

**[0101]** 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.

**[0102]** The outdoor unit 110 in this second embodiment mainly includes a compressor 11 with a motor and a heat source heat exchanger 13 (see for example Fig. 4). 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.

**[0103]** 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.

**[0104]** 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 outdoor fan 19 driven by an outdoor fan motor.

**[0105]** The indoor unit 120 is configured as explained with respect to Fig. 3 below. The indoor unit 120 as shown in Fig. 3 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.

**[0106]** 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) or in case of a plurality of indoor units 120 with each of 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).

**[0107]** It is also conceivable that more than one indoor unit is provided as shown in Fig. 4. 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.

**[0108]** The release device unit 50 according to the first embodiment may be implemented in the heat pump system 100 according to the second embodiment.

**[0109]** The heat pump system 100 according to the second 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. 3 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 second embodiment only comprises one indoor unit 120, as shown in Fig. 2A. In addition, the heat pump system of the second 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.

**[0110]** The refrigerant circuit connects the compressor 11, the heat source heat exchanger 13, the 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.

**[0111]** The refrigerant contained in the refrigerant circuit is in this example carbon dioxide.

**[0112]** The heat pump system 100 according to the second 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. 2A). The first release device 40 is arranged in the refrigerant circuit.

**[0113]** 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/or 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.

**[0114]** 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.

**[0115]** 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 is 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.

**[0116]** 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/or the second release device 41. The control unit 300 may be further configured to, in a release operation mode, open the sub-expansion valve 122. The control unit 300 may be configured to, in a release operation mode, open all expansion valves in the indoor portion (portion between the release devices and the indoor unit(-s)) refrigerant circuit. The control unit

300 may not operate or switch the four-way valve 23 in a release operation mode.

[0117] The refrigerant contained in the refrigerant circuit is carbon dioxide.

[0118] The first and second release devices 40, 41 are integrated into the first and second refrigerant pipe 131, 133 in the second embodiment. However, the first and second release devices 40, 41 may be comprised by a release device unit as shown in Fig. 1A. Such release device unit can be retrofitted to existing systems and/or be incorporated only if the heat pump system due its implementation in a building requires the release devices as safety measures.

#### First modification of the second embodiment

[0119] The heat pump system 100 in a first modification of the second embodiment of the present disclosure is the heat pump system of the second embodiment wherein the first release device 40 is a first three-way valve 71. If a second release device 41 is present, the second release device 41 is a second three-way valve 72.

[0120] The first three-way valve 71 and/or 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/or between the second outdoor refrigerant pipe 1331 and the second indoor refrigerant pipe 1332.

[0121] Fig. 7 shows a schematic piping diagram of the first modification of the heat pump system of the second embodiment.

[0122] 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/or the second release pipe 62 may be connected to the second three-way valve 72.

[0123] As shown in Fig. 7, two outdoor units 110 are connected by a refrigerant circuit with 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 first modification of the second 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 second 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 second embodiment.

[0124] Fig. 7 further shows that the first release device 40 and the second release device 41 may optionally be arranged in a release device casing 44 as explained with respect to Figure 1A forming a release device until 50. The release device casing 44 may also not be present in the heat pump system of the first modification of the second embodiment.

[0125] The heat pump system of the first modification of the second 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.

[0126] The heat pump system of the first modification of the second 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 second embodiment.

[0127] 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 second embodiment

[0128] In a second modification of the second embodiment of the present disclosure, the heat pump system is the heat pump system of the second embodiment wherein the first release device 40 comprises a first blow-off mechanism 81. Fig. 8 shows a schematic piping diagram of the second modification of the second embodiment of the heat pump system.

**[0129]** 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, the first outdoor refrigerant pipe 1311 and the first release pipe 61 to the outside of the refrigerant circuit.

**[0130]** If a second release device 41 is present, 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, the second outdoor refrigerant pipe 1331 and the second release pipe 62 to the outside of the refrigerant circuit.

**[0131]** Each of the first and second blow-off mechanisms 81, 82 are configured to release refrigerant from the usage heat exchanger 123 and the heat source heat exchanger 13 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.

**[0132]** As shown in Fig. 8, 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. 8, the heat pump system may comprise three indoor units 120. 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 second modification of the second 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 second 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 second modification of the second embodiment.

### Third modification of the second embodiment

**[0133]** In a third modification of the second embodiment of the present disclosure, the heat pump system is the heat pump system of the second modification of the second embodiment wherein the first blow-off mechanism 81 and/or the second blow-off mechanism 82 comprise a two-way valve. In other words, the heat pump system of the third modification of the second embodiment is the heat pump system of the second modification of the second 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.

**[0134]** 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.

**[0135]** The control unit 300 may be configured to, in a normal operation mode, operate the first blow-off mechanism 81 and/or the second blow-off mechanism 82 to allow a refrigerant flow in the first refrigerant pipe 131 and the second refrigerant pipe 133 and not to release refrigerant from the first and second blow-off mechanisms 81, 82. In the normal operation mode, no refrigerant is released from the refrigerant circuit via the first blow-off mechanism 81 and/or the second blow-off mechanism 82.

### Fourth modification of the second embodiment

**[0136]** The heat pump system in a fourth modification of the second embodiment of the present disclosure is a heat pump system of the second modification of the second embodiment wherein the first blow-off mechanism 81 and/or 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.

**[0137]** 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. 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. 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.

**[0138]** 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.

**[0139]** The control unit 300 may be configured to, in a normal operation mode, control the first blow-off mechanism 81 and/or 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/or the second blow-off mechanism 82.

#### Fifth modification of the second embodiment

[0140] The heat pump system in a fifth modification of the second embodiment of the present disclosure is the heat pump system of according to the second, third, and/or fourth modification of the second embodiment. In other word, the heat pump system of the fifth modification of the second embodiment is compatible with the second, third, and/or fourth modification of the second embodiment. Fig. 9 shows a schematic piping diagram of the fifth modification of the heat pump system of the second embodiment.

[0141] 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.

[0142] If a second release device 41 is present, 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.

[0143] 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. 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.

[0144] 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.

[0145] As shown in Fig. 9, two outdoor units 110 are connected by a refrigerant circuit with three indoor units 120. Fig. 9 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 second 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 second 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 second embodiment.

#### Sixth modification of the second embodiment

[0146] The heat pump system in a sixth modification of the second embodiment of the present disclosure is the heat pump system of according to the second, third, fourth and/or fifth modification of the second embodiment. In other word, the heat pump system of the sixth modification of the second embodiment is compatible with the second, third, fourth and/or fifth modification of the second embodiment. Fig. 10 shows a schematic piping diagram of the sixth modification of the heat pump system of the second embodiment.

[0147] In the sixth modification of the heat pump system of the second 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 end 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.

[0148] 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.

[0149] 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 9.

#### Third embodiment

[Configuration of the three-pipe heat pump system]

[0150] The release device unit 50 according to the first embodiment and as shown in Fig. 1B can be implemented in the heat pump system 100 according to the third embodiment. All components and modifications described for the second embodiment can be implemented

in the third embodiment. The third embodiment differs from the second embodiment in that a third refrigerant pipe 132 with a third release device 42 are provided.

**[0151]** The heat pump system 100 according to the third 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. In an example as illustrated in Fig. 2B, a connection unit 200 may be disposed between the outdoor unit 110 and the plurality of indoor units 120.

**[0152]** Figs. 2B and 5 show a schematic piping diagram of the three-pipe heat pump system of the third embodiment. Fig. 6 shows a schematic piping diagram of an example of an outdoor unit 110 of the heat pump system of the third embodiment, as shown in Fig. 5.

**[0153]** As shown in Fig. 5, 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.

**[0154]** 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. 6.

**[0155]** 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.

**[0156]** In this third 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.

**[0157]** 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.

**[0158]** 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 third embodiment, the first expansion valve 14 is configured to adjust the pressure and flow rate 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.

**[0159]** 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.

**[0160]** 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.

**[0161]** The outdoor unit 110 may have an outdoor unit casing having first to third outdoor service ports.

**[0162]** 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.

**[0163]** 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.

**[0164]** 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 sent 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.

**[0165]** The indoor units are basically configured as explained with respect to Fig. 3 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.

**[0166]** 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.

**[0167]** 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.

**[0168]** 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.

**[0169]** 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.

**[0170]** The heat pump system 100 may further include at least one connection unit 200, as shown in Fig. 5. 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.

**[0171]** The heat pump system 100 according to the third embodiment is the heat pump system of the second embodiment, wherein the refrigerant circuit further comprises a connection unit 200 interposed between the outdoor unit 110 and the indoor unit 120. 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 third 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 Figs. 2B and 5). 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.

**[0172]** 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, 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.

**[0173]** 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/or the third release device 42.

#### 25 First modification of the third embodiment

**[0174]** The heat pump system 100 in a first modification of the third embodiment of the present disclosure is similar to the first modification of the second embodiment shown in Fig. 7 but applied to a three pipe system. In the heat pump system of the third embodiment, the third release device 42 is a third three-way valve. Thus, the first modification of the third embodiment differs from the third embodiment in that the third release device 42 is a third three-way valve. The first modification of the third embodiment differs from the first modification of the second embodiment in that a third release device 42 with a third three-way valve is present in a third refrigerant pipe 132.

**[0175]** 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.

**[0176]** 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.

### Second modification of the third embodiment

[0177] The heat pump system 100 in a second modification of the third embodiment of the present disclosure is similar to the second modification of the second embodiment shown in Fig. 8 but applied to a three pipe system. In the heat pump system 100 of the third embodiment the third release device 42 comprises a third blow-off mechanism. The heat pump system 100 in a second modification of the third embodiment of the present disclosure is the heat pump system 100 of the second modification of the second embodiment wherein a third release device 42 comprising a third blow-off mechanism is provided in addition to a third refrigerant pipe 132.

[0178] 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.

[0179] The third blow-off mechanism may be configured to release refrigerant from the usage heat exchanger 123 and the heat source heat exchanger 13 to the outside of the refrigerant circuit. The third release device 42 may comprise the third release pipe and the third blow-off mechanism.

### Third modification of the third embodiment

[0180] The heat pump system 100 in a third modification of the third embodiment of the present disclosure is the heat pump system 100 of the second modification of the third embodiment wherein the third blow-off mechanism comprises a two-way valve. The heat pump system 100 in a third modification of the third embodiment of the present disclosure is the heat pump system 100 of the third modification of the second 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.

[0181] 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.

[0182] 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.

[0183] 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 third embodiment

[0184] The heat pump system 100 in a fourth modification of the third embodiment of the present disclosure is the heat pump system 100 of the second modification of the third 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 breaking the sacrificial seal.

[0185] The heat pump system 100 in the fourth modification of the third embodiment of the present disclosure is the heat pump system 100 of the fourth modification of the second 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.

[0186] 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. The third blow-off mechanism 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. Alternatively to the heater, the third 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.

[0187] 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.

[0188] 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 third embodiment

[0189] In a fifth modification of the third embodiment of the present disclosure is similar to the fifth modification of the second embodiment shown in Fig. 9 but applied to a three pipe system. The modification of the third embodiment of the present disclosure is a heat pump system 100 according to the second, third, and/or fourth modification of the third embodiment. The fifth modification of the third embodiment of the present disclosure is a heat pump system 100 according to the fifth modification of the second 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 are pro-

vided.

**[0190]** 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 the third outdoor refrigerant pipe 1321 and the third indoor refrigerant pipe 1322.

**[0191]** 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.

**[0192]** The third two-way valve may be configured to stop a refrigerant flow between the outdoor portion and the indoor portion.

**[0193]** 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.

**[0194]** 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 third embodiment

**[0195]** The heat pump system in a sixth modification of the third embodiment of the present disclosure is similar to the sixth modification of the second embodiment shown on Fig. 10 but applied to a three pipe system. In other word, the heat pump system of the sixth modification of the third embodiment is compatible with the second, third, and/or fourth modification of the third embodiment.

**[0196]** In the sixth modification of the heat pump system of the third 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 second 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 mechanism 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.

**[0197]** 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.

**[0198]** 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.

#### REFERENCE LIST

##### [0199]

- |    |                                                 |
|----|-------------------------------------------------|
| 15 | 100 heat pump system                            |
|    | 110 outdoor unit                                |
|    | 11 compressor                                   |
|    | 12 three-way switching valve                    |
|    | 13 heat source heat exchanger                   |
| 20 | 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             |
| 25 | 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                               |
| 30 | 24 suction pipe                                 |
|    | 25 discharge pipe                               |
|    | 26 first outdoor gas pipe                       |
|    | 27 outdoor liquid pipe                          |
| 35 | 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                         |
| 40 | 44 release device casing                        |
|    | 45 bypass pipe                                  |
|    | 46 bypass valve                                 |
|    | 50 release device unit                          |
|    | 51 first port                                   |
| 45 | 52 second port                                  |
|    | 53 third port                                   |
|    | 54 fourth port                                  |
|    | 55 first release opening                        |
|    | 56 second release opening                       |
| 50 | 57 fifth port                                   |
|    | 58 sixth port                                   |
|    | 59 third release opening                        |
|    | 61 first release pipe                           |
|    | 62 second release pipe                          |
| 55 | 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                                                                         | 5  |
| 123 usage heat exchanger                                                                        |    |
| 127 usage side fan                                                                              |    |
| 131 first refrigerant pipe (liquid pipe)                                                        |    |
| 1311 first outdoor refrigerant pipe                                                             |    |
| 1312 first indoor refrigerant pipe                                                              | 10 |
| 1311A first outdoor refrigerant pipe portion                                                    |    |
| 1312A first indoor refrigerant pipe portion                                                     |    |
| 132 third refrigerant pipe (high/low-pressure gas pipe)                                         |    |
| 1321 third outdoor refrigerant pipe                                                             | 15 |
| 1322 third indoor refrigerant pipe                                                              |    |
| 1321A third outdoor refrigerant pipe portion                                                    |    |
| 1322A third indoor refrigerant pipe portion                                                     |    |
| 133 second refrigerant pipe (low-pressure gas pipe (only "gas pipe" in two-pipe configuration)) | 20 |
| 1331 second outdoor refrigerant pipe                                                            |    |
| 1332 second indoor refrigerant pipe                                                             |    |
| 1331A second outdoor refrigerant pipe portion                                                   |    |
| 1332A second indoor refrigerant pipe portion                                                    |    |
| 141 first liquid refrigerant pipe                                                               | 25 |
| 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                                                                             | 30 |
| 201 manifold device                                                                             |    |
| 300 control unit                                                                                |    |

## Claims

1. A release device unit (50) for releasing refrigerant from a refrigerant circuit of a heat pump system (100) to an outside of the heat pump system in case of a leakage in the refrigerant circuit comprising:

(A) a first port (51) and a second port (52) for connecting the release device unit to the refrigerant circuit of the heat pump system,

wherein the first port (51) is connectable to an outdoor unit (110) of the heat pump system,

wherein the second port (52) is connectable to an indoor unit (120) of the heat pump system,

a first release device (40) connectable to a control unit (300) of the heat pump system, wherein the first release device (40) is connected to the first port (51) via a first outdoor refrigerant pipe portion (1311A) and to the second port (52) via a first indoor refrigerant pipe portion (1312A), and comprises a first

release opening for releasing refrigerant to the outside of the refrigerant circuit, wherein the first release device (40) is operable by the control unit (300) to communicate at least the second port (52) and the first release opening for releasing refrigerant to the outside of the refrigerant circuit in case of a leakage in the refrigerant circuit of the heat pump system,

and/or

(B) a third port (53) and a fourth port (54) for connecting the release device unit to the refrigerant circuit of the heat pump system,

wherein the third port (53) is connectable to the outdoor unit (110) of the heat pump system,

wherein the fourth port (54) is connectable to the indoor unit (120) of the heat pump system,

a second release device (41) connectable to the control unit (300) of the heat pump system,

wherein the second release device (41) is connected to the third port (53) via a second outdoor refrigerant pipe portion (1331A) and to the fourth port (54) via a second indoor refrigerant pipe portion (1332A), and comprises a second release opening for releasing refrigerant to the outside of the refrigerant circuit,

wherein the second release device (41) is operable by the control unit (300) to communicate at least the fourth port (54) and the second release opening for releasing the refrigerant to the outside of the refrigerant circuit in case of a leakage in the refrigerant circuit of the heat pump system.

2. A heat pump system (100) comprising:

an outdoor unit (110),

an indoor unit (120),

a refrigerant circuit having a first refrigerant pipe (131) and a second refrigerant pipe (133) that connects the outdoor unit (110) and the indoor unit (120),

a first release device (40) for releasing a refrigerant to an outside of the refrigerant circuit, and a control unit (300) configured to control the heat pump system (100), wherein the control unit (300) is configured to operate the heat pump system 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,

wherein in the release operation mode the first

release device (40) is operated for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit, wherein 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).

3. The heat pump system according to claim 2, further comprising:

a second release device (41) for releasing the refrigerant to the outside of the refrigerant circuit, wherein 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), wherein in the release operation mode the first release device (40) and/or the second release device (41) are operated for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

4. The release device unit according to claim 1 or the heat pump system according to claim 2 or 3, wherein the first release device (40) is a first three-way valve (71), and/or the second release device (41) is a second three-way valve (72), wherein the first and/or the second three-way valves (71, 72) are configured to release the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit via the first indoor refrigerant pipe (1312) and/or the second indoor refrigerant pipe (1332) and to stop a refrigerant flow between the first outdoor refrigerant pipe (1311) and the first indoor refrigerant pipe (1312) and/or between the second outdoor refrigerant pipe (1331) and the second indoor refrigerant pipe (1332).

5. The release device unit according to claim 1 or 4, or the heat pump system according to claim 2 or 3, wherein the first release device (40) comprises a first blow-off mechanism (81), and/or the second release device (41) comprises a second blow-off mechanism (82),

wherein 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), and/or wherein 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), and wherein the first blow-off mechanism (81) is configured to release the refrigerant from the refrigerant circuit via the first refrigerant pipe (131) and the first release pipe (61) to the outside of the refrigerant circuit and/or the second blow-off mechanism (82) is configured to release the refrigerant from the refrigerant circuit via the second refrigerant pipe (133) and the second release pipe (62) to the outside of the refrigerant circuit.

6. The release device unit according to claim 1, 4 or 5, or the heat pump system according to claim 5, wherein the first and/or the second blow-off mechanisms (81, 82) comprise a two-way valve.
7. The release device unit according to claim 1, 4, 5, or 6, or the heat pump system according to claim 5, wherein the first and/or 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.
8. The release device unit according to claim 1, 4, 5, 6 or 7, or the heat pump system according to any one of claims 5 to 7,

wherein the first release device (40) further comprises a first two-way valve (91), and/or the second release device (41) further comprises a second two-way valve (92), wherein the first two-way valve (91) is arranged in the first outdoor refrigerant pipe (1311), and/or the second two-way valve (92) is arranged in the second outdoor refrigerant pipe (1331), and wherein 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) and/or 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).

9. The heat pump system according to any one of claims 3 to 8, wherein the refrigerant circuit further comprises:

a connection unit (200) interposed between the outdoor unit (110) and the indoor unit (120) and connected to the first and the second refrigerant pipes (131, 133), and a third refrigerant pipe (132) that connects the outdoor unit (110) to the connection unit (200), wherein the heat pump system (100) 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), and wherein in the release operation mode the third release device (42) is operated for releasing the refrigerant from the refrigerant circuit to the outside of the refrigerant circuit.

10. The heat pump system according to claim 9, 15

wherein the third release device (42) is a third three-way valve, and wherein 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). 20 25

11. The heat pump system according to claim 9,

wherein the third release device (42) comprises a third blow-off mechanism, wherein a third release pipe (63) branches from the third refrigerant pipe (132) and the third blow-off mechanism is arranged in the third release pipe (63), and wherein the third blow-off mechanism is configured to release the refrigerant from the refrigerant circuit via the third three-way valve to the outside of the refrigerant circuit. 30 35

12. The heat pump system according to claim 11, wherein the third blow-off mechanism comprises a two-way valve. 40

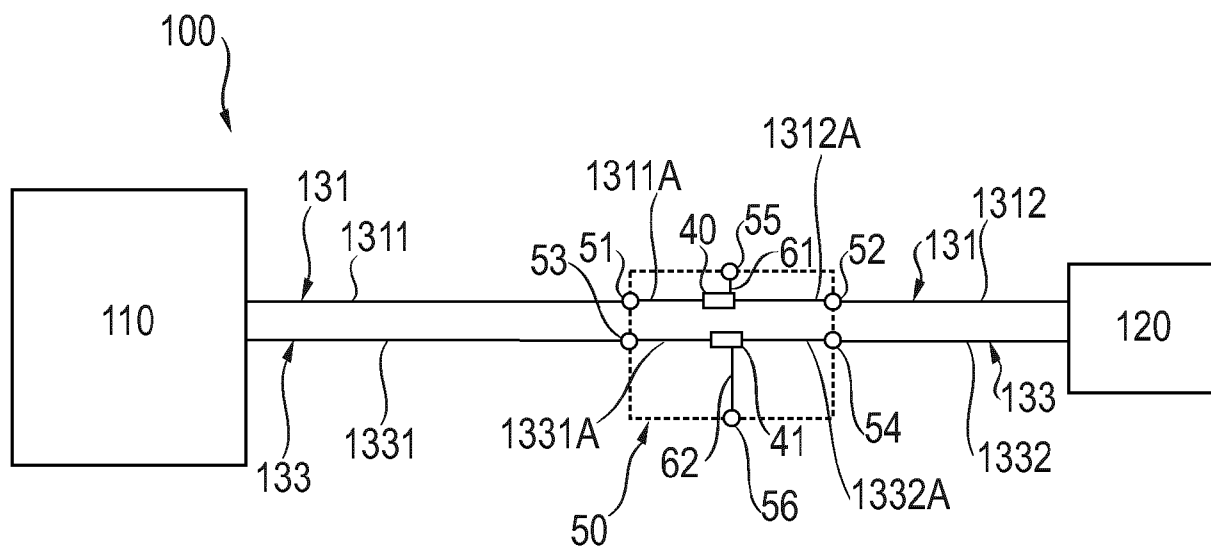
13. The heat pump system according to claim 11, wherein the third blow-off mechanism having a sacrificial seal sealing the refrigerant circuit from the outside of the refrigerant circuit, wherein the control unit (300) is further configured to trigger breaking the sacrificial seal. 45 50

14. The heat pump system according to any one of claims 11 to 13,

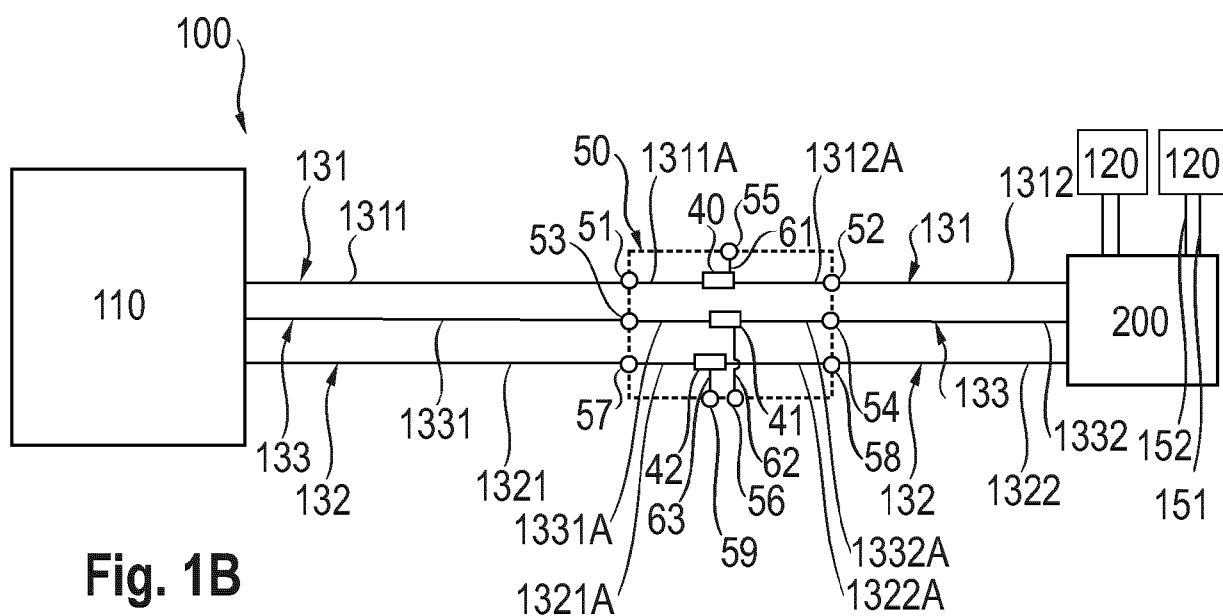
wherein the third release device (42) further comprises a third two-way valve, wherein the third two-way valve is arranged in the third outdoor refrigerant pipe (1321), and wherein the third two-way valve is configured to 55

stop a refrigerant flow between between the third outdoor refrigerant pipe (1321) and the third indoor refrigerant pipe (1322) .

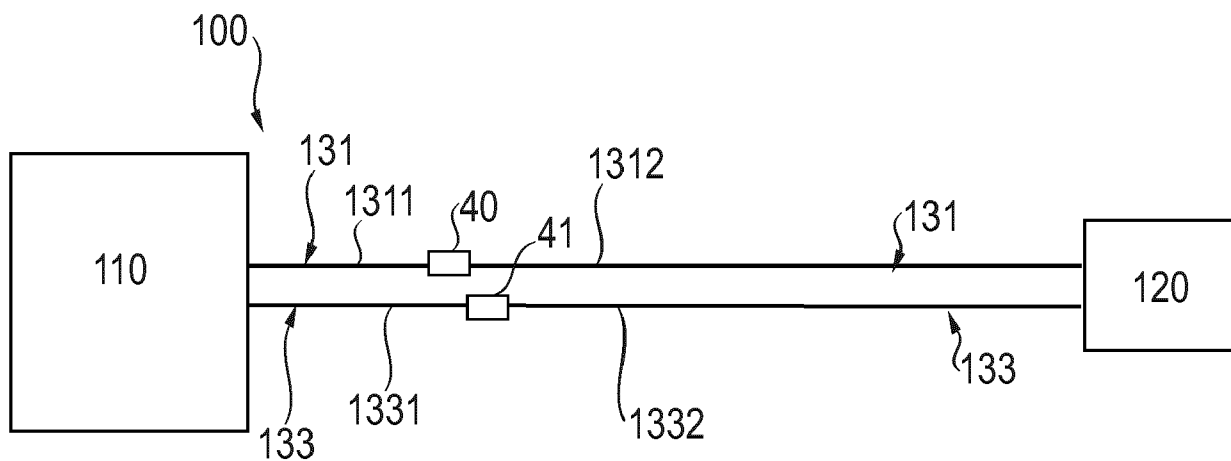
15. The release device unit according to claim 1 or the heat pump system according to any one of claims 2 to 14, wherein the refrigerant contained in the refrigerant circuit is a natural refrigerant, particularly carbon dioxide.



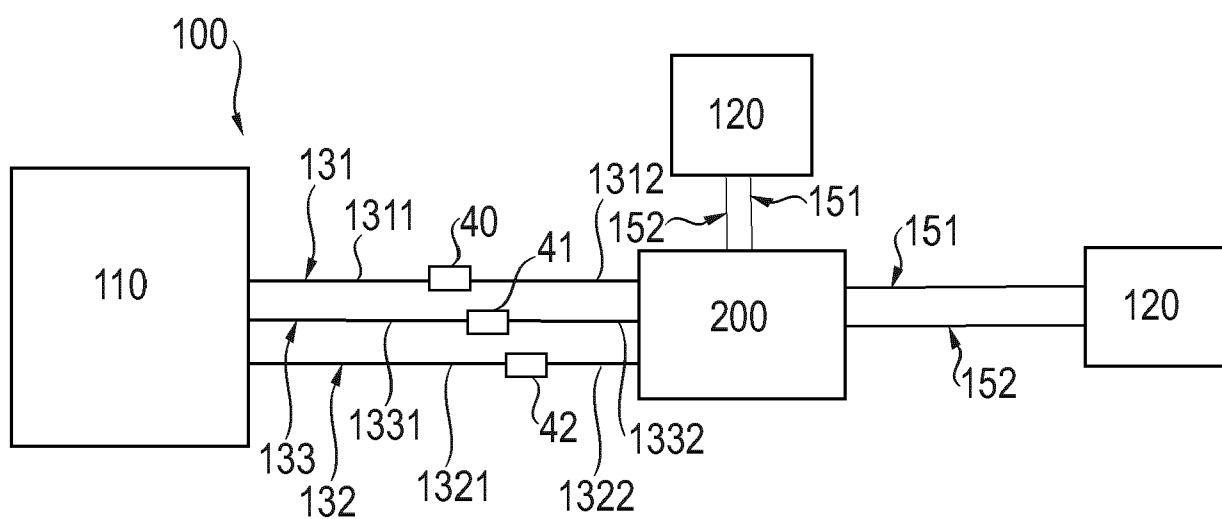
**Fig. 1A**



**Fig. 1B**



**Fig. 2A**



**Fig. 2B**

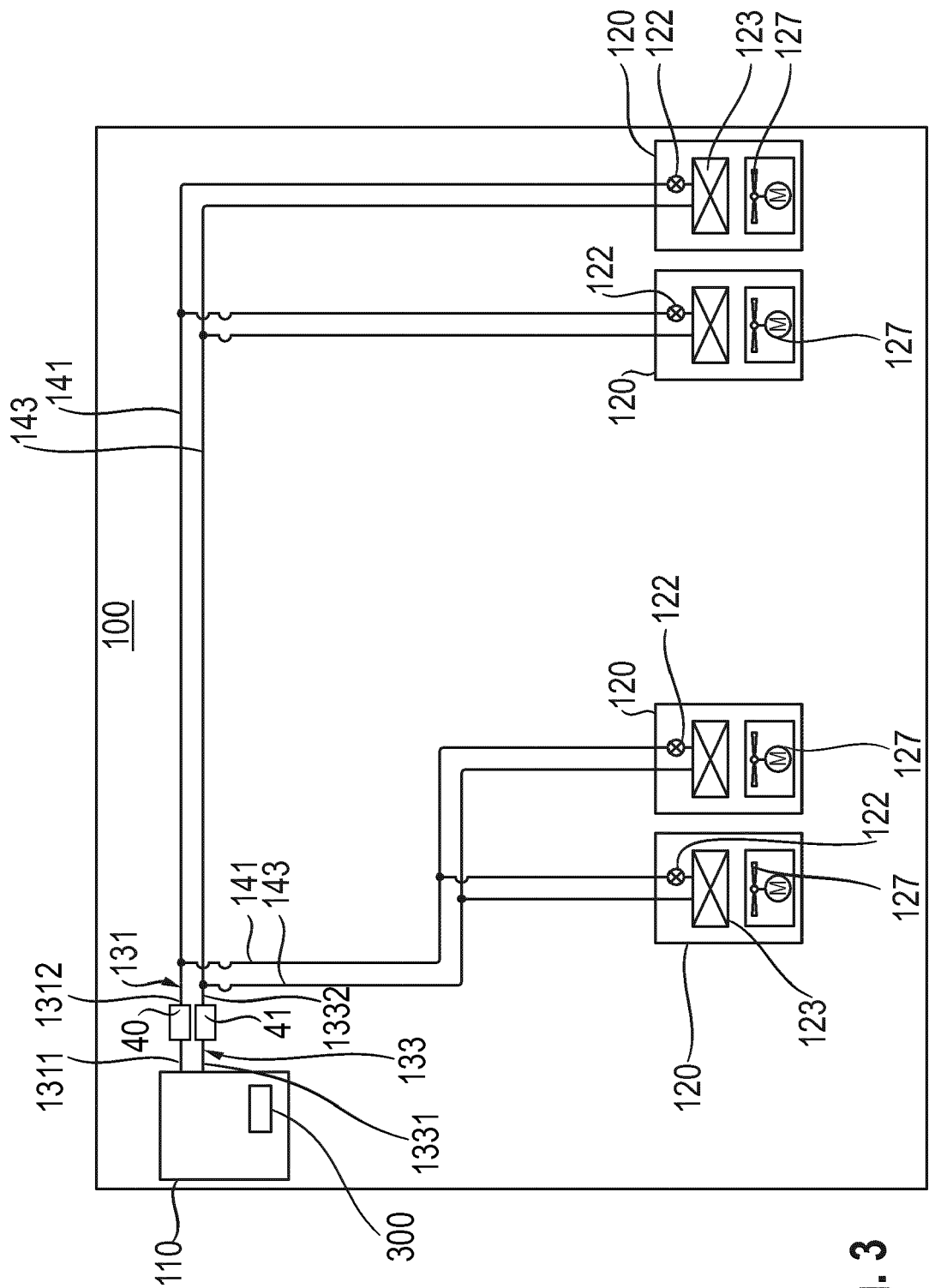


Fig. 3

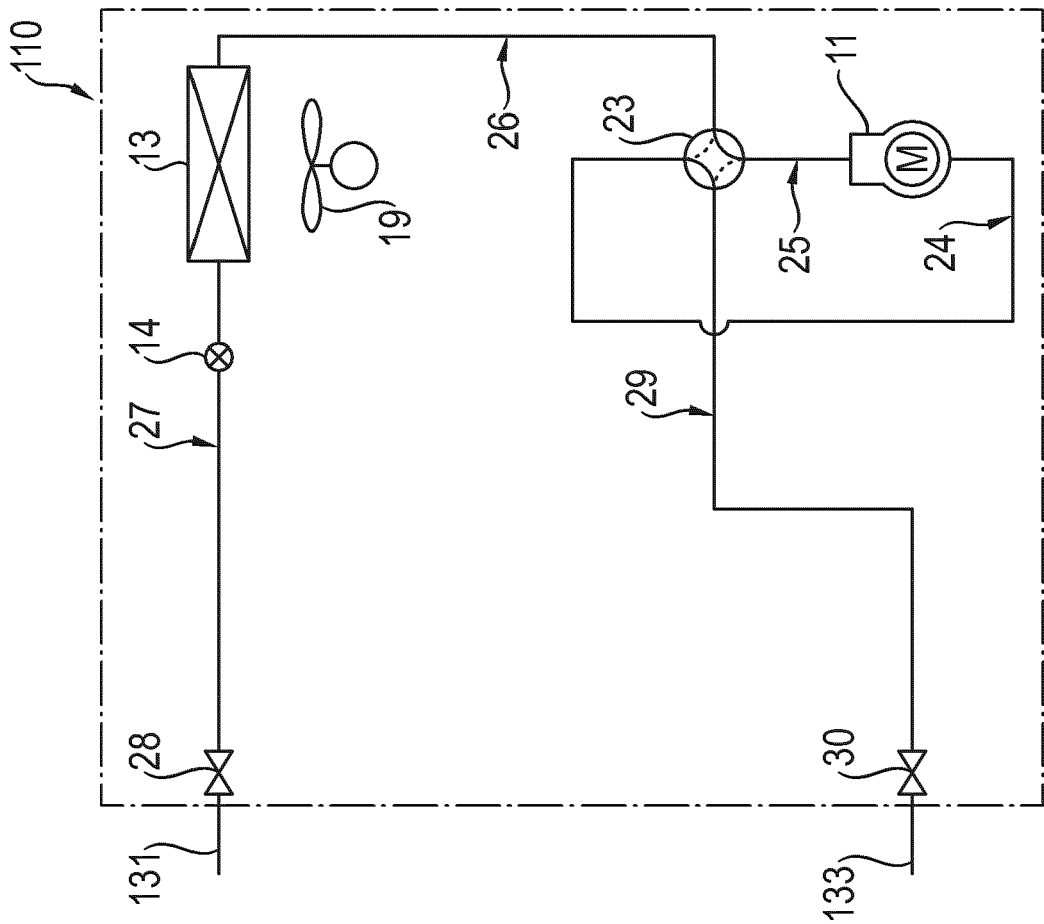


Fig. 4

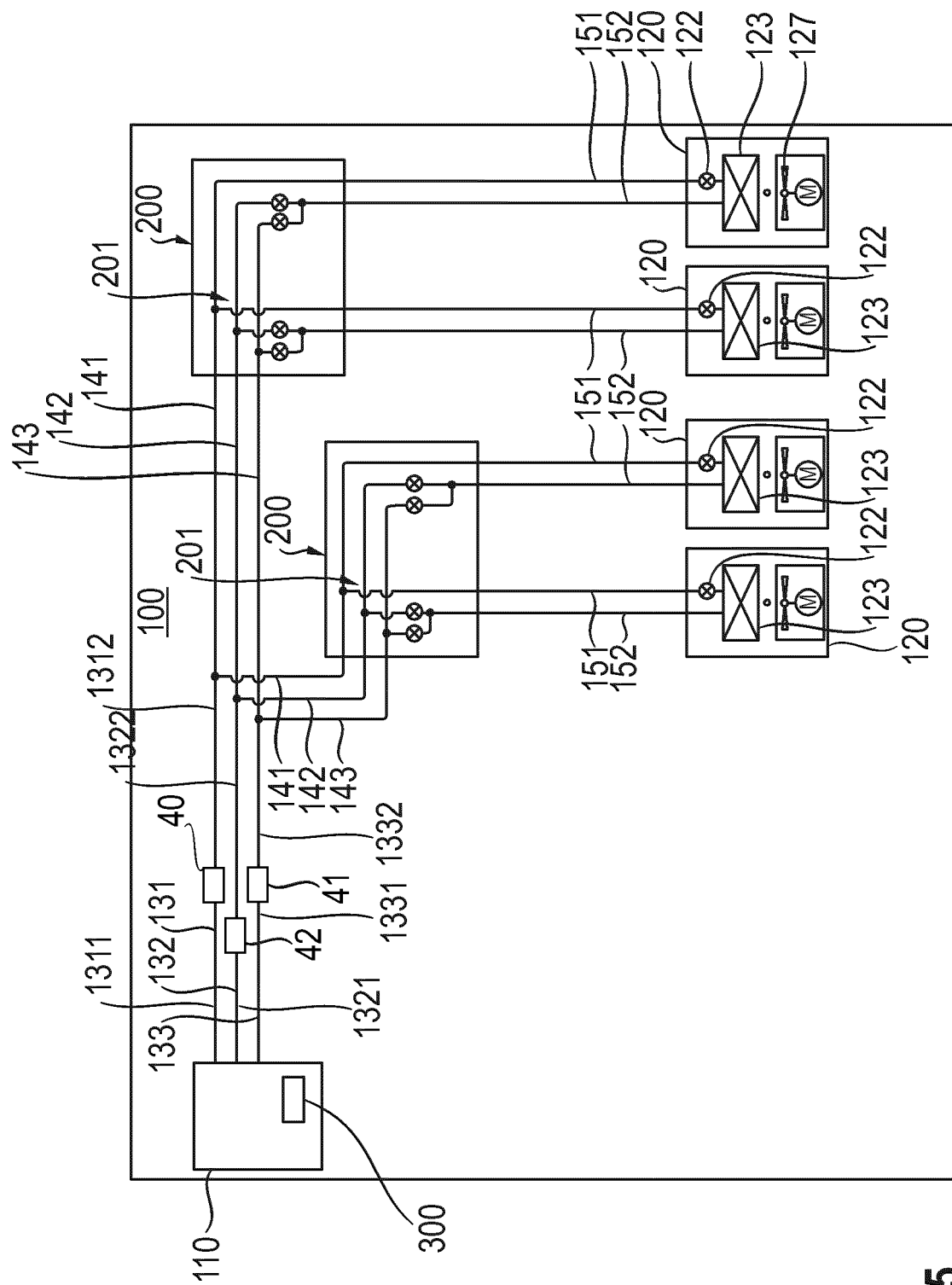


Fig. 5

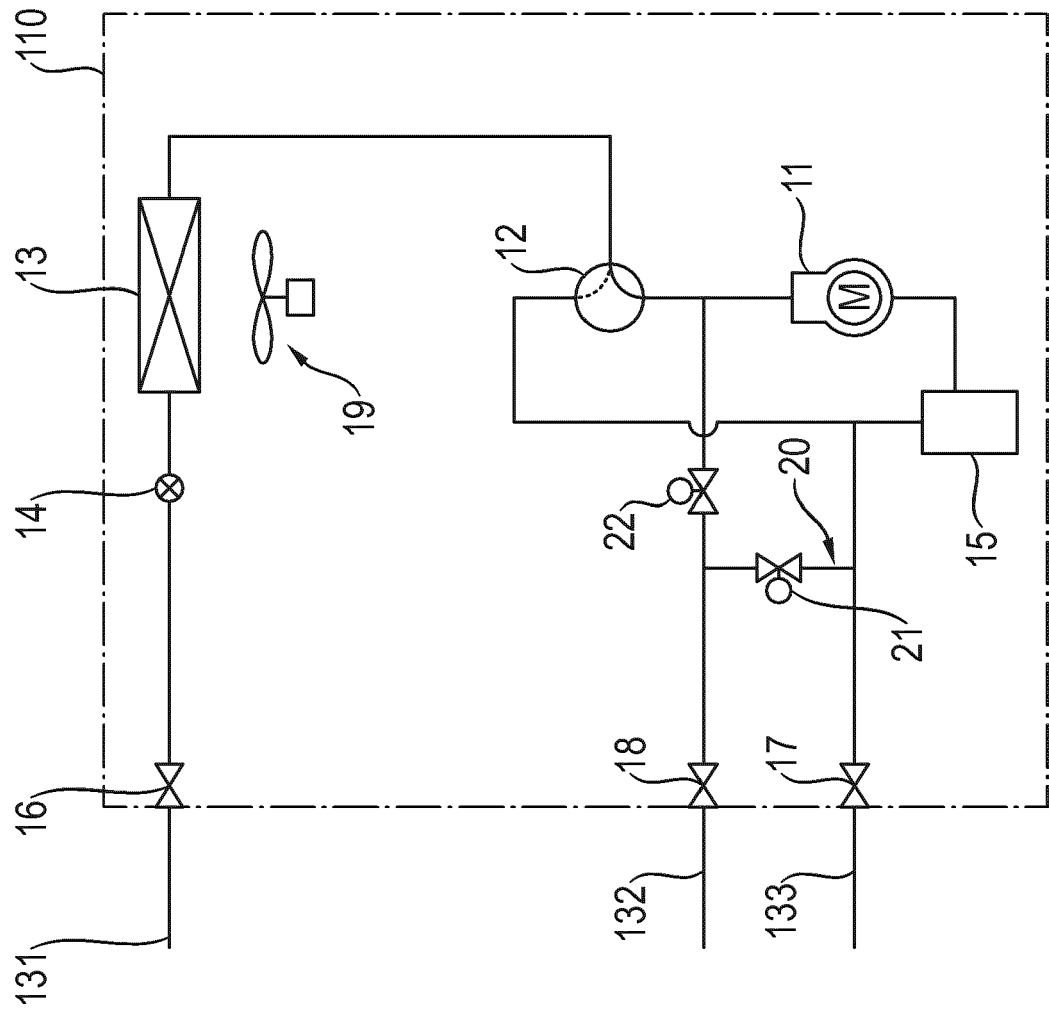


Fig. 6

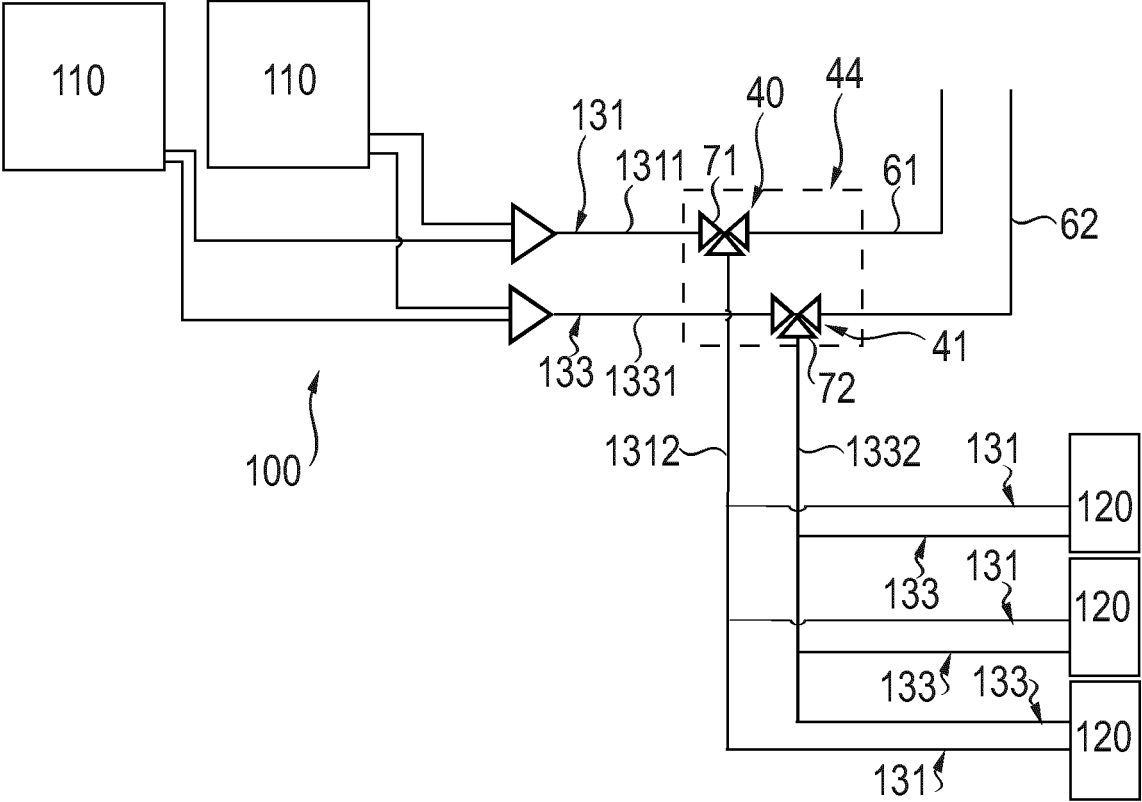


Fig. 7

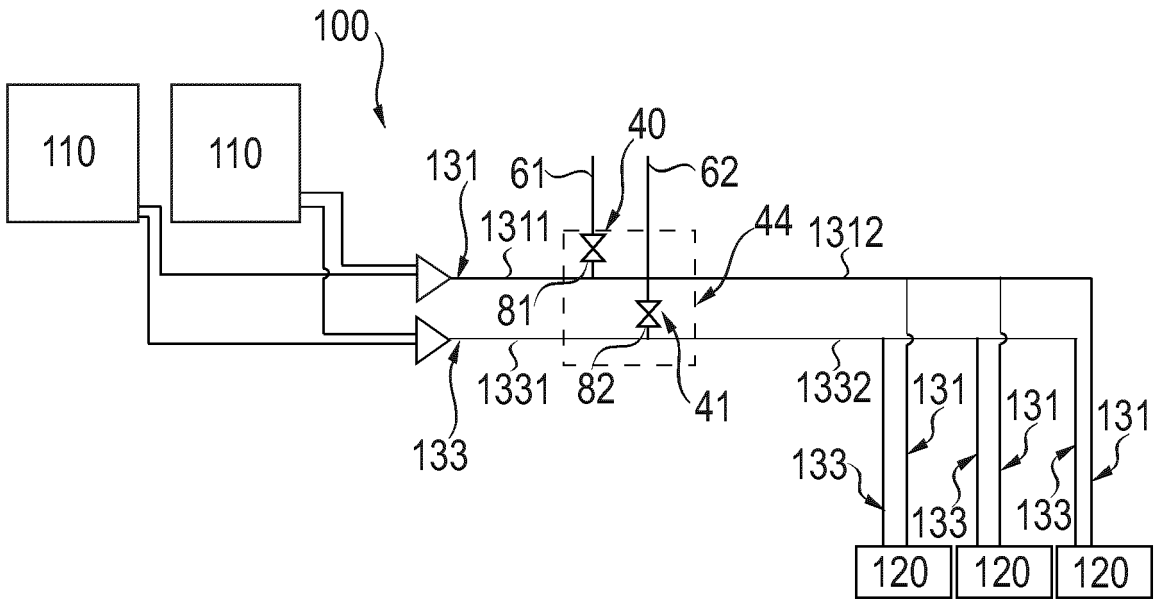


Fig. 8

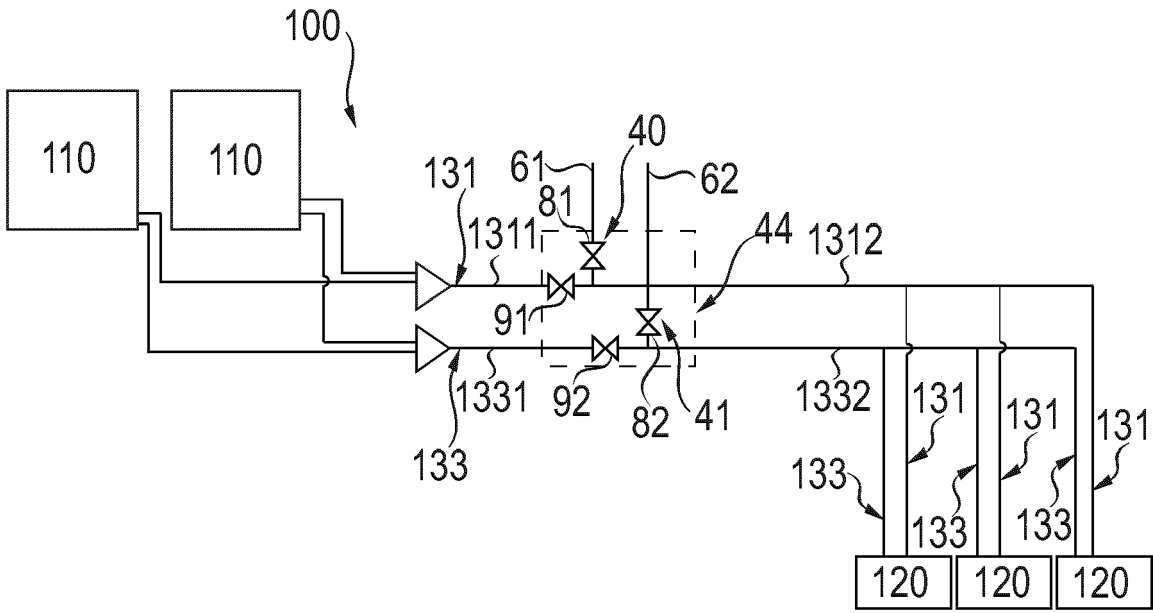


Fig. 9

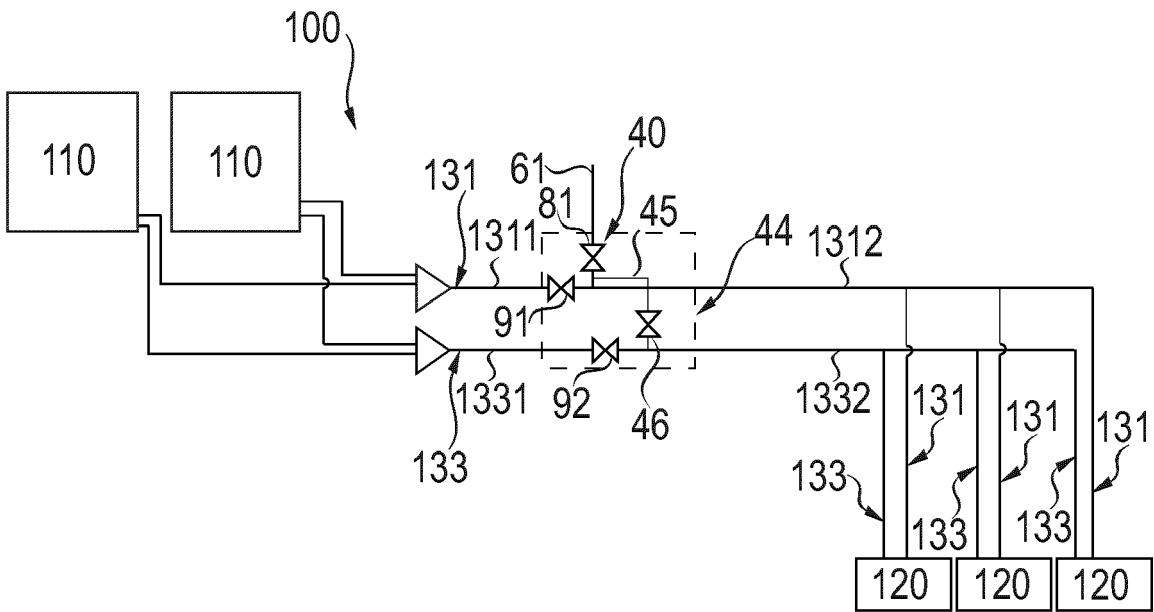


Fig. 10



## EUROPEAN SEARCH REPORT

Application Number

EP 24 18 9443

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                            | Relevant to claim                                                                                                                                                                                                                                                                     | CLASSIFICATION OF THE APPLICATION (IPC)                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| X                                                                                                                                                                                                                                                      | CN 112 032 965 A (TCL AIR CONDITIONER ZHONGSHAN CO LTD)<br>4 December 2020 (2020-12-04)                                  | 1,2,5,6,8,15                                                                                                                                                                                                                                                                          | INV.<br>F25B13/00<br>F16K17/00                          |
| Y                                                                                                                                                                                                                                                      | * enclosed English translation;<br>claims 1,7-9; figures 1-2 *                                                           | 4                                                                                                                                                                                                                                                                                     | F24F11/36<br>F25B41/20<br>F25B45/00                     |
| X                                                                                                                                                                                                                                                      | US 11 274 866 B2 (DAIKIN IND LTD [JP])<br>15 March 2022 (2022-03-15)                                                     | 2,3,5,6,15                                                                                                                                                                                                                                                                            | F25B49/00<br>F25B49/02                                  |
| Y                                                                                                                                                                                                                                                      | * columns 13-14; figures 1, 3 *                                                                                          | 4                                                                                                                                                                                                                                                                                     |                                                         |
| A                                                                                                                                                                                                                                                      |                                                                                                                          | 9-14                                                                                                                                                                                                                                                                                  |                                                         |
| X                                                                                                                                                                                                                                                      | US 11 280 523 B2 (DAIKIN IND LTD [JP])<br>22 March 2022 (2022-03-22)                                                     | 1,2,5-7,15                                                                                                                                                                                                                                                                            |                                                         |
| Y                                                                                                                                                                                                                                                      | * figures 9, 13,15 *                                                                                                     | 4                                                                                                                                                                                                                                                                                     |                                                         |
| A                                                                                                                                                                                                                                                      |                                                                                                                          | 9-14                                                                                                                                                                                                                                                                                  |                                                         |
| Y                                                                                                                                                                                                                                                      | CN 110 553 341 A (GREE ELECTRIC APPLIANCES INC ZHUHAI) 10 December 2019 (2019-12-10)<br>* enclosed English translation * | 4                                                                                                                                                                                                                                                                                     |                                                         |
| Y                                                                                                                                                                                                                                                      | JP 2000 088403 A (MATSUSHITA REFRIGERATION) 31 March 2000 (2000-03-31)<br>* figures 9-12 *                               | 4                                                                                                                                                                                                                                                                                     | TECHNICAL FIELDS SEARCHED (IPC)<br>F25B<br>F24F<br>F16K |
| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                                          |                                                                                                                                                                                                                                                                                       |                                                         |
| Place of search<br><b>Munich</b>                                                                                                                                                                                                                       |                                                                                                                          | Date of completion of the search<br><b>5 December 2024</b>                                                                                                                                                                                                                            | Examiner<br><b>Lepers, Joachim</b>                      |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                          | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |                                                         |

EPO FORM 1503 03.82 (P34C01)

# **ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.**

EP 24 18 9443

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

05-12-2024

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date           |
|-------------------------------------------|---------------------|----------------------------|-------------------------------|
| CN 112032965                              | A                   | 04-12-2020                 | NONE                          |
| US 11274866                               | B2                  | 15-03-2022                 | AU 2018310045 A1 16-01-2020   |
|                                           |                     |                            | CN 110730893 A 24-01-2020     |
|                                           |                     |                            | EP 3663681 A1 10-06-2020      |
|                                           |                     |                            | ES 2953351 T3 10-11-2023      |
|                                           |                     |                            | JP 7032667 B2 09-03-2022      |
|                                           |                     |                            | JP WO2019027050 A1 02-07-2020 |
|                                           |                     |                            | US 2021148620 A1 20-05-2021   |
|                                           |                     |                            | WO 2019027050 A1 07-02-2019   |
| US 11280523                               | B2                  | 22-03-2022                 | CN 110291349 A 27-09-2019     |
|                                           |                     |                            | EP 3584521 A1 25-12-2019      |
|                                           |                     |                            | JP 6380696 B2 29-08-2018      |
|                                           |                     |                            | JP 2018132292 A 23-08-2018    |
|                                           |                     |                            | US 2019390877 A1 26-12-2019   |
|                                           |                     |                            | WO 2018151178 A1 23-08-2018   |
| CN 110553341                              | A                   | 10-12-2019                 | NONE                          |
| JP 2000088403                             | A                   | 31-03-2000                 | NONE                          |

**REFERENCES CITED IN THE DESCRIPTION**

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

**Patent documents cited in the description**

- JP 5292940 B [0006] [0008] [0009]