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(54) **HEAT PUMP**

(57) The present disclosure relates to a heat pump. The heat pump (1) comprises a refrigerant circuit (10) having a compressor (11), a heat source heat exchanger (12), an expansion valve (13), and an intermediate heat exchanger (20), and a heat medium circuit (30) having the intermediate heat exchanger (20) and a gas-liquid separator (31). The intermediate heat exchanger (20) has a first side wall (21), a second side wall (22) opposing the first side wall (21), a front wall (23) extending between the first side wall (21) and the second side wall (22), a top wall (24) being connected to upper ends of the first side wall (21), the second side wall (22), and the front wall (23), a rear wall (25) opposing the front wall (23) in a front-rear direction, and a bottom wall (26) opposing the top wall (24) in an up-down direction, wherein the intermediate heat exchanger (20) has a first inlet opening (27) and a first outlet opening (28) for a heat medium, the first inlet opening (27) and the first outlet opening (28) being provided in the front wall (23). The gas-liquid separator (31) has a second inlet opening (311) and a second outlet opening (312) for the heat medium, wherein a heat medium connection pipe (32) is provided between the first outlet opening (28) and the second inlet opening (311) for allowing the heat medium to flow from the intermediate heat exchanger (20) to the gas-liquid separator (31). A majority of the gas-liquid separator (31) is located in an arrangement region (AR) next to the intermediate heat exchanger (20), the arrangement region (AR) extending in the up-down direction from the top wall (24) to the bottom wall (26) of the intermediate heat exchanger (20) and in the front-rear direction from the rear wall (25) of the intermediate heat exchanger (20) to a frontmost point of the heat medium connection pipe (32).

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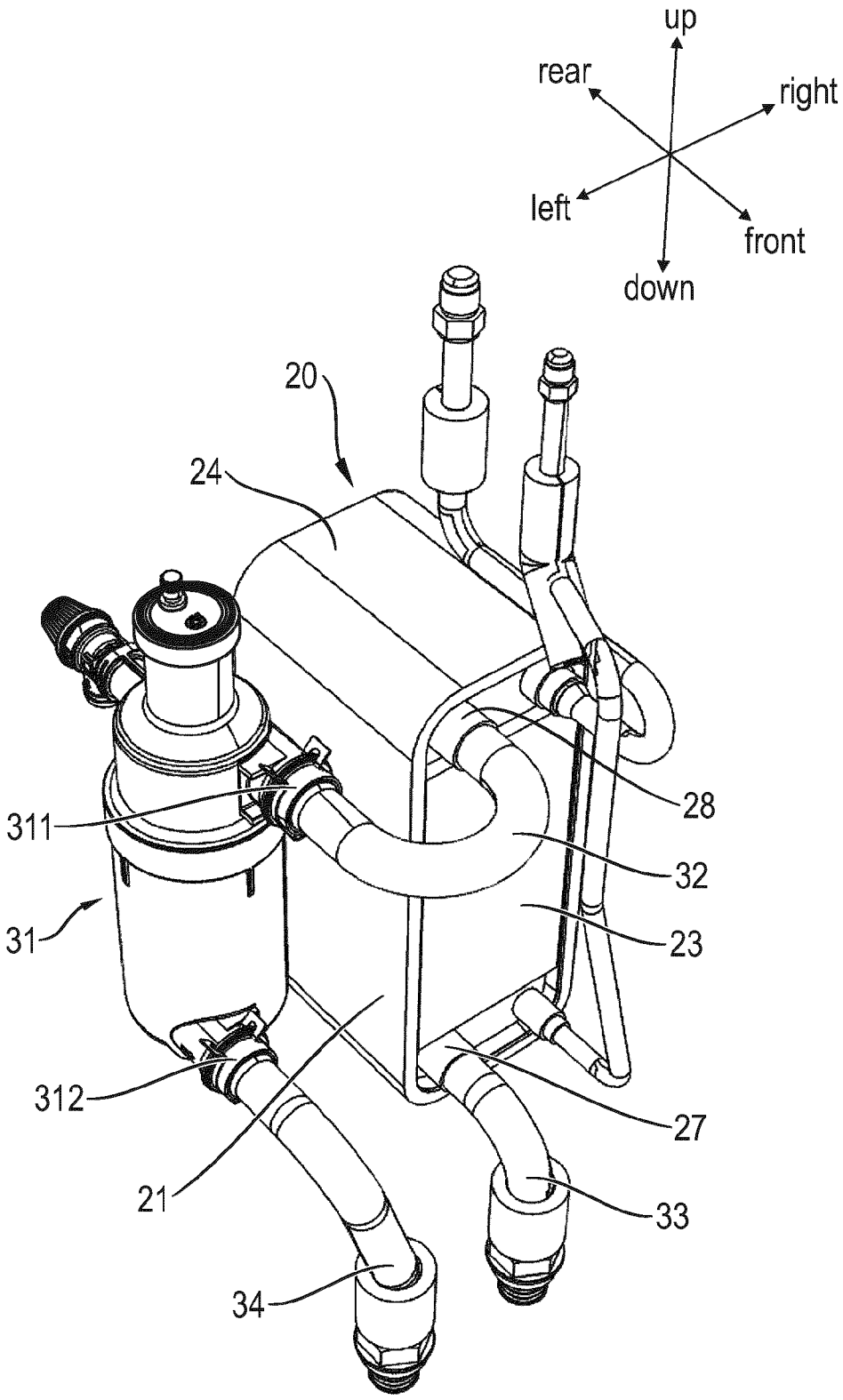
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Fig. 2

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat pump and, more particularly, to a relative arrangement between an intermediate heat exchanger and a gas-liquid separator of the heat pump.

BACKGROUND

[0002] A heat pump typically includes a refrigerant circuit, in which a refrigerant is circulated, and a heat medium circuit, in which a heat medium is circulated. The refrigerant circuit is configured so that the refrigerant takes up heat from the outdoors external environment by means of a heat source heat exchanger. Heat is then transferred to the heat medium in the heat medium circuit via an intermediate heat exchanger. Finally, heat is transferred to a usage-side heat exchanger, such as a radiator or floor heater. As such, heat is transported from outdoors to indoors, such as to an inside of a building.

[0003] Development of heat pumps is facing a variety of challenges due to environmental and technical requirements. On the one hand, heat pumps should work as efficient as possible. On the other hand, the refrigerant used in the heat pumps should avoid any environmental risks, such as ozone depletion or the potential to contribute to global warming.

[0004] To address these requirements, it has been proposed to use refrigerants such as propane (R290) or carbon dioxide (CO_2, R744) in heat pumps. These refrigerants have a good efficiency, while being environmentally friendly. However, they are also not completely risk-free. Propane is flammable and carbon dioxide can, when leaking, collect at the bottom of a room, for example, when part of the refrigerant piping of the heat pump is installed indoors, and displace the air, thereby leading to the risk of suffocation for persons.

[0005] In order to minimize these risks, several legal regulations have been made and international standards have been set up, for example, regarding the maximum amount of refrigerant used in a heat pump system or the required dispersion height of potentially leaking refrigerant inside heat pump systems. Examples of such standards are the series of standards EN 378 or the standards IEC 60335-1 and IEC 60335-2-40.

[0006] Besides these regulations, certain safety measures in terms of safety devices are used in heat pumps in order to avoid harm to persons in case of refrigerant leakage. One such safety device is a double-walled plate heat exchanger, as described, for example, in EP 3 598 039 A1. In case there is a leak in one of the walls of the plate heat exchanger, the second wall prevents the refrigerant from entering through the leak into the heat medium circuit. However, such double-walled plate heat exchangers are expensive. Therefore, other heat pumps employ a gas-liquid separator as a safety device. The gas-liquid separator is part of the heat medium circuit. When refrigerant is leaked into the heat medium circuit, which usually occurs at the intermediate heat exchanger, the refrigerant, which is in the gaseous state, is separated from the liquid heat medium, usually water, by the gas-liquid separator and released or discharged to the outside of the heat pump in a controlled manner. Such gas-liquid separator is disclosed, for example, in EP 4 075 078 A1.

[0007] However, the provision of a gas-liquid separator as a safety device in a heat pump requires additional space as the gas-liquid separator constitutes an additional component, for example, in an indoor unit of the heat pump. It is, however, generally desirable that units of a heat pump, such as the outdoor unit or the indoor unit, are kept as small as possible, which especially applies to indoor units of heat pumps.

SUMMARY

[0008] Taking the aforesaid into account, it is an object of the present disclosure to provide a heat pump comprising a heat medium circuit having a gas-liquid separator, wherein the heat pump has a space-efficient configuration.

[0009] This object is solved by a heat pump as defined in claim 1. Optional features and preferred embodiments of the heat pump are defined in the dependent claims.

[0010] According to a first aspect, a heat pump comprises a refrigerant circuit having a compressor, a heat source heat exchanger, an expansion valve, and an intermediate heat exchanger, and a heat medium circuit having the intermediate heat exchanger and a gas-liquid separator. The intermediate heat exchanger has a first side wall, a second side wall opposing the first side wall, a front wall extending between the first side wall and the second side wall, a top wall being connected to upper ends of the first side wall, the second side wall, and the front wall, a rear wall opposing the front wall in a front-rear direction, and a bottom wall opposing the top wall in an up-down direction. The intermediate heat exchanger has a first inlet opening and a first outlet opening for a heat medium, the first inlet opening and the first outlet opening being provided in the front wall. The gas-liquid separator has a second inlet opening and a second outlet opening for the heat medium. A heat medium connection pipe is provided between the first outlet opening and the second inlet opening for allowing the heat medium to flow from the intermediate heat exchanger to the gas-liquid separator. A majority of the gas-liquid separator is located in an arrangement region next to the intermediate heat exchanger, the arrangement region extending in the up-down direction from the top wall to the bottom wall of the intermediate heat exchanger and in the front-rear direction from the rear wall of the intermediate heat exchanger to a frontmost point of the heat medium connection pipe.

[0011] Since the majority of the gas-liquid separator is located in the arrangement region next to the intermedi-

ate heat exchanger, the gas-liquid separator and the intermediate heat exchanger are arranged relative to each other in a compact manner. This leads to a space-efficient configuration of the heat pump. For example, in case the majority of the gas-liquid separator were to be located above or below the intermediate heat exchanger, the arrangement of these two components would be less compact and less space-efficient. This is because the intermediate heat exchanger usually is one of the largest components in a unit of a heat pump, such as an indoor unit of a heat pump, so that a casing of a unit of a heat pump, such as an indoor unit casing, may have a height slightly higher than a height of the intermediate heat exchanger. If the gas-liquid separator were to be located on top or below the intermediate heat exchanger, the casing of the unit of the heat pump would need to be made higher accordingly, for the sole purpose of housing the gas-liquid separator in the casing of the unit of the heat pump. Such a configuration would therefore not be compact and be less space-efficient.

[0012] Moreover, since the majority of the gas-liquid separator is located in the arrangement region next to the intermediate heat exchanger, the gas-liquid separator can be located in close proximity to the intermediate heat exchanger. Not only does this lead to the advantage that less piping is necessary to connect the intermediate heat exchanger to the gas-liquid separator. Since the gas-liquid separator can be located close to the intermediate heat exchanger, in case a refrigerant leak occurs in or at the intermediate heat exchanger, the gaseous refrigerant leaking into the heat medium circuit is ejected earlier into the gas-liquid separator and a leakage can thereby be detected earlier, for example, when a leak detector for detecting leaked refrigerant is provided. This improves safety of the heat pump.

[0013] The heat pump may be a mono-block heat pump. In this configuration, the compressor, the heat source heat exchanger, the expansion valve, and the intermediate heat exchanger form an outdoor unit of the heat pump and are arranged together in an outdoor unit casing. Alternatively, the heat pump may be a split-configuration heat pump. In this configuration, the heat source heat exchanger, the expansion valve, and the compressor form an outdoor unit of the heat pump and are arranged together in an outdoor unit casing, while the intermediate heat exchanger is located indoors.

[0014] The heat source heat exchanger and may be an evaporator, in which the refrigerant exchanges heat with outside air, for example.

[0015] The refrigerant may include propane or carbon dioxide. Furthermore, the refrigerant may be R32 or R410A.

[0016] The heat medium circuit may include water as heat medium.

[0017] The gas-liquid separator may be a conventional gas-liquid separator, as known from the prior art. In general, the gas-liquid separator may have a cylindrical, in particular, an elongated cylindrical, body, or may have a cuboid shape. As such, the gas-liquid separator may have a longitudinal axis, extending in a direction parallel to the direction of gravity when the gas-liquid separator is in an installed state, i.e., when the heat pump is in an installed state. The gas-liquid separator is generally configured to allow a gas-liquid mixture to separate therein. For this purpose, the gas-liquid separator needs to have a certain height to allow for the formation of a steady state in which the liquid heat medium is accumulated in a lower portion of the gas-liquid separator and the gaseous refrigerant is accumulated in an upper portion of the gas-liquid separator.

[0018] The intermediate heat exchanger may be a condenser of the refrigerant circuit. The term "intermediate" may indicate that the intermediate heat exchanger is a heat exchanger between the heat source heat exchanger of the refrigerant circuit and the usage-side heat exchanger, which may be installed indoors, in a room of a building, and which may be a radiator or a floor heater or the like.

[0019] The intermediate heat exchanger may be a plate heat exchanger. The intermediate heat exchanger may have a generally cuboid or box-like shape.

[0020] The first side wall, the second side wall, the front wall, the top wall, the rear wall, and the bottom wall of the intermediate heat exchanger may be outer surfaces of the intermediate heat exchanger, including, for example, an additional outer enclosure of the intermediate heat exchanger, in which constituent parts of the intermediate heat exchanger, and only of the intermediate heat exchanger, are accommodated. Such constituent parts may include piping and plates, for example, in case the intermediate heat exchanger is a plate heat exchanger.

[0021] The second side wall may oppose the first side wall so that the first and second side walls are parallel to each other, or substantially parallel to each other. The same holds true for the rear wall opposing the front wall in the front-rear direction and the bottom wall opposing the top wall in the up-down direction.

[0022] As used herein, the term "substantially" may designate a direction, or an angle, or a positional relationship, or the like not only including the precise direction, or value of the angle, or positional relationship, but also small variations around that direction, or value of the angle, or positional relationship, such as 5%, for example, in case of a given value.

[0023] The up-down direction may be the direction parallel to the direction of gravity when the heat pump is installed at a desired location, such as a building or the like. The front-rear direction may be perpendicular, or substantially perpendicular, to the up-down direction. The direction in that the second side wall opposes the first side wall may be perpendicular, or substantially perpendicular, to the up-down direction and to the front-rear direction.

[0024] The first inlet opening may be for allowing the heat medium to enter the intermediate heat exchanger and exchange heat with the refrigerant of the refrigerant

circuit. The first outlet opening may be for allowing the heat medium, which has exchanged heat with the refrigerant in the intermediate heat exchanger, to exit the intermediate heat exchanger. The first inlet opening and the first outlet opening of the intermediate heat exchanger may be separated from each other in the up-down direction.

[0025] The second inlet opening may be for allowing the heat medium to enter the gas-liquid separator. The second outlet opening may be for allowing the heat medium to exit the gas-liquid separator. In case of a cylindrical gas-liquid separator, the second inlet opening may be provided at the lateral surface of the cylinder and the second outlet opening may be provided at the bottom surface of the cylinder. Furthermore, the second inlet opening may be provided at the lateral surface of the cylinder, and the second outlet opening may also be provided at the lateral surface of the cylinder.

[0026] The heat medium connection pipe may be a single pipe, consisting of one integral piece, i.e., a one-piece pipe, or may be composed of more than one pipe segments that, when being assembled together, form the heat medium connection pipe. Such pipe segments may be appropriately assembled using pipe joints.

[0027] The term "majority" in "majority of the gas-liquid separator" may be understood as more than 50% of the gas-liquid separator. More than 50% may relate to the outer dimension of the gas-liquid separator or to the volume occupied by the gas-liquid separator.

[0028] The arrangement region may generally be understood as a three-dimensional space next to the intermediate heat exchanger, which may be confined in the up-down direction by a plane including the top wall, or an uppermost portion of the top wall, of the intermediate heat exchanger, and by a plane including the bottom wall, or a lowermost portion of the bottom wall, of the intermediate heat exchanger. Moreover, this space may be confined in the front-rear direction by a plane including the rear wall, or a rearmost portion of the rear wall, of the intermediate heat exchanger, and by a plane including the frontmost point of the heat medium connection pipe, which plane may be parallel, or substantially parallel, to the plane including the rear wall of the intermediate heat exchanger.

[0029] The arrangement region may be next to the first side wall or next to the second side wall of the intermediate heat exchanger.

[0030] According to a second aspect, the second inlet opening and the second outlet opening may be separated from each other in a first direction, wherein the gas-liquid separator may have a maximum length in the first direction and a maximum width in a direction perpendicular to the first direction, wherein at least 50%, preferably at least 70%, more preferably at least 80%, most preferably at least 90%, of the maximum length and the maximum width may be located in the arrangement region.

[0031] The first direction may be parallel, or substantially parallel, to the up-down direction, the up-down direction as defined above with respect to the intermediate heat exchanger.

[0032] The maximum length of the gas-liquid separator may be understood as a maximum length of the gas-liquid separator when considering its outer dimension in the first direction. The maximum width of the gas-liquid separator may be understood as a maximum width of the gas-liquid separator when considering its outer dimension in the direction perpendicular to the first direction.

[0033] The maximum length of the gas-liquid separator in the first direction may include the length of a gas purge valve in the first direction, which may be provided at the gas-liquid separator, for example, at an upper side of the gas-liquid separator. The gas purge valve may be provided for releasing gas, which accumulates in the gas-liquid separator, to the outside of the gas-liquid separator.

[0034] With this configuration, the gas-liquid separator and the intermediate heat exchanger are arranged relative to each other in an even more compact manner. The greater the percentage of the maximum length and the maximum width that are located in the arrangement region, the more compact the arrangement of the gas-liquid separator and the intermediate heat exchanger.

[0035] According to a third aspect, the second side wall may oppose the first side wall in a left-right direction, wherein the arrangement region may further extend in the left-right direction from one of the first side wall and the second side wall to a point no more than 35 cm away from the one of the first side wall and the second side wall.

[0036] The left-right direction may be perpendicular, or substantially perpendicular, to the up-down direction and the front-rear direction.

[0037] In this configuration, the three-dimensional space of the arrangement region next to the intermediate heat exchanger may further be confined in the left-right direction by a plane being parallel, or substantially parallel, to the first side wall or the second side wall of the intermediate heat exchanger, the plane being not more than 35 cm away from the first side wall or the second side wall, respectively.

[0038] With this configuration, the gas-liquid separator is located even closer to the intermediate heat exchanger, thereby leading to a more compact arrangement of the gas-liquid separator relative to the intermediate heat exchanger.

[0039] Moreover, as explained above, with this configuration, less piping is necessary to connect the intermediate heat exchanger to the gas-liquid separator. Since the gas-liquid separator can be located close to the intermediate heat exchanger, in case a refrigerant leak occurs in or at the intermediate heat exchanger, the gaseous refrigerant leaking into the heat medium circuit is ejected earlier into the gas-liquid separator and a leakage can thereby be detected earlier, which improves safety of the heat pump.

[0040] According to a fourth aspect, a space between the gas-liquid separator and the intermediate heat ex-

changer may be free from other constituent parts of the heat pump.

[0041] Examples of other constituent parts of the heat pump may include piping, electronic components, a heat medium pump, valves, etc.

[0042] With this configuration, the gas-liquid separator can be located even closer to the intermediate heat exchanger, thereby achieving the above-mentioned effects relating to the compact design, less piping, and earlier ejection of gaseous refrigerant into the gas-liquid separator.

[0043] According to a fifth aspect, the second inlet opening and the second outlet opening may be provided at the gas-liquid separator so as to be open in a direction crossing the first direction, preferably, crossing the first direction at an angle of 90°, or substantially 90°.

[0044] For example, in case of a gas-liquid separator having an elongated cylindrical shape, the gas-liquid separator may have a longitudinal axis and the first direction may be parallel to the longitudinal axis of the gas-liquid separator. In this configuration, when the second inlet opening and the second outlet opening are provided at the gas-liquid separator so as to be open in a direction crossing the first direction, the second inlet opening and the second outlet opening are open to the side of the gas-liquid separator.

[0045] With this configuration, a compact design of the gas-liquid separator is achieved, compared to a configuration in which, for example, the second inlet opening is open to the side of the gas-liquid separator and the second outlet opening is open to the bottom of the gas-liquid separator, in which case the piping connected to the second inlet opening and the second outlet opening extends from the side and from the bottom of the gas-liquid separator. This requires more space for the piping. Hence, with this configuration, the overall configuration of the intermediate heat exchanger and the gas-liquid separator is more compact.

[0046] According to a sixth aspect, the heat pump may further comprise a heat medium inflow pipe connected to the first inlet opening of the intermediate heat exchanger for allowing the heat medium to flow into the intermediate heat exchanger, and a heat medium outflow pipe connected to the second outlet opening of the gas-liquid separator for allowing the heat medium to flow out from the gas-liquid separator, wherein the heat medium inflow pipe and the heat medium outflow pipe may be arranged on the same side of the intermediate heat exchanger, preferably, in parallel, or substantially in parallel, with each other.

[0047] The heat medium inflow pipe and the heat medium outflow pipe may be understood as piping segments of the heat medium circuit that are directly connected to the first inlet opening of the intermediate heat exchanger and the second outlet opening of the gas-liquid separator, respectively.

[0048] The feature that the heat medium inflow pipe and the heat medium outflow pipe may be arranged on the same side of the intermediate heat exchanger, preferably, in parallel, or substantially in parallel, with each other, may mean that a portion of the heat medium inflow pipe and a portion of the heat medium outflow pipe may be arranged on the same side of the intermediate heat exchanger, preferably, in parallel, or substantially in parallel, with each other. Such portion may be a portion of the respective pipe that is further away from the first inlet opening or the second outlet opening than a portion of the respective pipe that is connected to the first inlet opening and the second outlet opening, respectively.

[0049] The feature that the heat medium inflow pipe and the heat medium outflow pipe may be arranged on the same side of the intermediate heat exchanger may mean that the respective pipes, or portions thereof, are located on the same side of a plane that includes one of the surfaces of the intermediate heat exchanger and that is parallel to the respective one of the surfaces of the intermediate heat exchanger.

[0050] With this configuration, the overall configuration of the intermediate heat exchanger and the gas-liquid separator is more compact because the heat medium inflow pipe and the heat medium outflow pipe require less space as they are arranged on the same side of the intermediate heat exchanger.

[0051] According to a seventh aspect, the heat medium inflow pipe and the heat medium outflow pipe may be arranged so that a center line of the heat medium inflow pipe and a center line of the heat medium outflow pipe lie in a plane that is substantially perpendicular or parallel to the up-down direction.

[0052] The center line of a pipe may be understood as a line extending in the same direction as the pipe and passing through the centers of the cross-sections at each position along the pipe. In case of a cylindrical pipe with a circular cross-section, a distance from a pipe wall to the center line is the same along the circumference of the pipe.

[0053] For example, a portion of the heat medium inflow pipe and a portion of the heat medium outflow pipe may be arranged so that a center line of the portion of the heat medium inflow pipe and a center line of the portion of the heat medium outflow pipe lie in a plane that is substantially perpendicular or parallel to the up-down direction. Such portion may be a portion of the respective pipe that is further away from the first inlet opening or the second outlet opening than a portion of the respective pipe that is connected to the first inlet opening and the second outlet opening, respectively.

[0054] The feature that a center line of the heat medium inflow pipe and a center line of the heat medium outflow pipe lie in a plane that is substantially perpendicular or parallel to the up-down direction includes, for example, a configuration in that the center line of the heat medium inflow pipe and the center line of the heat medium outflow pipe are parallel to the up-down direction or perpendicular to the up-down direction. In case the center line of the heat medium inflow pipe and the center line of the

heat medium outflow pipe are perpendicular to the up-down direction, the heat medium inflow pipe and the heat medium outflow pipe may be arranged next to each other in the front-rear direction or may be arranged next to each other in the up-down direction.

[0055] With this configuration, the overall configuration of the intermediate heat exchanger and the gas-liquid separator is more compact because the heat medium inflow pipe and the heat medium outflow pipe require less space as they are arranged on the same side of the intermediate heat exchanger and their center lines lie in the same plane.

[0056] According to an eighth aspect, the gas-liquid separator is arranged next to the first side wall or the second side wall of the intermediate heat exchanger.

[0057] For example, the complete gas-liquid separator or a majority of the gas-liquid separator may be located in region next to the first side wall or the second side wall of the intermediate heat exchanger, the region extending in the up-down direction from the top wall to the bottom wall of the intermediate heat exchanger and in the front-rear direction from the rear wall to the front wall of the intermediate heat exchanger.

[0058] With this configuration, the intermediate heat exchanger and the gas-liquid separator are even more compactly arranged with respect to each other so that the overall configuration of the intermediate heat exchanger and the gas-liquid separator can be kept small. Such an arrangement may be preferable in case the intermediate heat exchanger and the gas-liquid separator are installed in an indoor unit casing of the heat pump in that only little space is available for housing the intermediate heat exchanger together with the gas-liquid separator.

[0059] According to a ninth aspect, the first outlet opening of the intermediate heat exchanger and the second inlet opening of the gas-liquid separator may be open in the same direction.

[0060] For example, the intermediate heat exchanger and the gas-liquid separator may be arranged so that the first outlet opening and the second inlet opening are arranged at the same height, as seen in the up-down direction.

[0061] With this configuration, the intermediate heat exchanger and the gas-liquid separator are even more compactly arranged with respect to each other so that the overall configuration of the intermediate heat exchanger and the gas-liquid separator can be kept small. In addition, since the respective openings are open in the same direction, piping length of the heat medium connection pipe can be kept small.

[0062] According to a tenth aspect, the heat medium connection pipe may have a U-shape.

[0063] A U-shape may include round shapes and angular shapes, for example, in which the U-shape includes two 90° angles.

[0064] With this configuration, the intermediate heat exchanger and the gas-liquid separator can be connected in a simple and compact manner.

[0065] According to an eleventh aspect, the gas-liquid separator may be arranged next to an edge of the intermediate heat exchanger formed by the front wall and the first side wall or the second side wall of the intermediate heat exchanger.

[0066] For example, the complete gas-liquid separator or a majority of the gas-liquid separator may be located in region next to the edge of the intermediate heat exchanger formed by the front wall and the first side wall or the second side wall of the intermediate heat exchanger, the region extending in the up-down direction from the top wall to the bottom wall of the intermediate heat exchanger and in the front-rear direction from the front wall of the intermediate heat exchanger to the frontmost point of the heat medium connection pipe.

[0067] With this configuration, the intermediate heat exchanger and the gas-liquid separator are compactly arranged with respect to each other so that the overall configuration of the intermediate heat exchanger and the gas-liquid separator is space-efficient. Such an arrangement may be preferable in case the intermediate heat exchanger and the gas-liquid separator are installed in an indoor unit casing of the heat pump in that more space is available for housing the intermediate heat exchanger together with the gas-liquid separator.

[0068] According to a twelfth aspect, the first outlet opening of the intermediate heat exchanger and the second outlet opening of the gas-liquid separator may be open in directions that cross each other, preferably, that cross each other at an angle of 90°, or substantially 90°.

[0069] For example, the intermediate heat exchanger and the gas-liquid separator may be arranged so that the first outlet opening and the second inlet opening are arranged at the same height, as seen in the up-down direction.

[0070] With this configuration, the intermediate heat exchanger and the gas-liquid separator are compactly arranged with respect to each other so that the overall configuration of the intermediate heat exchanger and the gas-liquid separator is space-efficient. In addition, since the respective openings are open in directions that cross each other, piping length of the heat medium connection pipe can be kept small.

[0071] According to a thirteenth aspect, the heat medium connection pipe may have an L-shape.

[0072] An L-shape may include round shapes and angular shapes, for example, in which the L-shape includes one 90° angle.

[0073] With this configuration, the intermediate heat exchanger and the gas-liquid separator can be connected in a simple and compact manner.

[0074] According to a fourteenth aspect, an inlet opening connection pipe may be provided between the heat medium connection pipe and the second inlet opening of the gas-liquid separator, wherein the inlet opening connection pipe may have a length of at least 5 cm.

[0075] The inlet opening connection pipe may be an

integral part of the heat medium connection part or a separate pipe segment.

[0076] The inlet opening connection pipe may be a straight pipe.

[0077] The inlet opening connection pipe may be made of copper.

[0078] With this configuration, i.e., providing the inlet opening connection pipe between the heat medium connection pipe and the second inlet opening of the gas-liquid separator, the inlet opening connection pipe having a length of at least 5 cm, proper functioning of the gas-liquid separator is promoted.

[0079] According to a fifteenth aspect, the heat pump may further comprise a container, in which the intermediate heat exchanger and the gas-liquid separator may be housed, wherein the container may be separate from a casing of a heat source unit.

[0080] The heat source unit may be an outdoor unit of the heat pump. Alternatively, or additionally, the container may be separate from a casing of an indoor unit of the heat pump.

[0081] The container may be housed within an indoor unit casing of the heat pump or within an outdoor unit casing of the heat pump. The container may be located outside of the indoor unit casing and the outdoor unit casing and may be spaced apart from the indoor unit casing and the outdoor unit casing. The container may be attached to the inside or the outside of the indoor unit casing or the outdoor unit casing.

[0082] The container may be located outdoors or indoors, for example, outside of a building or inside a building.

[0083] The container may have a substantially cuboid shape or may have an L-shape configuration, depending on the relative positioning between the intermediate heat exchanger and the gas-liquid separator. The container may have a shape that conforms to the outer shape of the configuration of the intermediate heat exchanger and the gas-liquid separator.

[0084] The container may be made of a plastic material, such as acrylonitrile styrene acrylate or similar.

[0085] With this configuration, safety of the heat pump is further improved. This is because in case of a refrigerant leak at or in the intermediate heat exchanger, and in case the refrigerant is discharged from the gas-liquid separator to the outside of the heat medium circuit, the refrigerant accumulates in the container and is kept away from ignition sources, such as electronic components, of the heat pump. Furthermore, by providing the container, a higher amount of refrigerant can be used in the refrigerant circuit, while still complying with regulations and standards, because the container is an additional safety measure against leakage of refrigerant.

[0086] According to a sixteenth aspect, an inner space of the container may be hermetically sealed from the outside of the container.

[0087] In this context, hermetically sealed may mean that neither air nor refrigerant can enter or escape through the container, including any sealings used between different parts of the container, for example, in case the container includes a lid.

[0088] For example, in case a hermetically sealed container that has a cuboid shape with several side walls is used for a heat pump in that the heat medium inflow pipe and the heat medium outflow pipe are arranged on the same side of the intermediate heat exchanger, the heat medium inflow pipe and the heat medium outflow pipe may penetrate the container at the same side wall, through the same opening. With this configuration, only one opening at the side wall of the container is required that needs to be hermetically sealed, as opposed to a configuration in that the heat medium inflow pipe and the heat medium outflow pipe are not arranged on the same side of the intermediate heat exchanger and penetrate the container at different side walls of the container and, thus, through more than one opening.

[0089] With this configuration, safety of the heat pump against refrigerant leakage is further improved.

[0090] Further aspects of the present disclosure may be found in the following description of particular embodiments referring to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0091]

Fig. 1 is a schematic diagram of a heat pump according to the present disclosure.

Fig. 2 is a perspective view of an intermediate heat exchanger and a gas-liquid separator according to a first embodiment of the present disclosure.

Fig. 3 is a front view of the intermediate heat exchanger and the gas-liquid separator of Fig. 2.

Fig. 4 is a top view of the intermediate heat exchanger and the gas-liquid separator of Fig. 2.

Fig. 5 is a bottom view of the intermediate heat exchanger and the gas-liquid separator of Fig. 2.

Fig. 6 is a perspective view of an intermediate heat exchanger and a gas-liquid separator contained in a container according to a second embodiment of the present disclosure.

Fig. 7 is a perspective view of an intermediate heat exchanger and a gas-liquid separator contained in a container according to a third embodiment of the present disclosure.

Fig. 8 is a top view of the intermediate heat exchanger, the gas-liquid separator, and the container of Fig. 7.

Fig. 9 is a perspective cross-sectional view of the intermediate heat exchanger and the gas-liquid separator of Fig. 2 contained in a container.

DETAILED DESCRIPTION OF PARTICULAR EMBODIMENTS

[0092] Hereinafter, embodiments according to the 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.

[0093] Throughout the drawings, the same reference numerals are used for the same or similar elements.

[0094] Fig. 1 is a schematic diagram of a heat pump 1 according to the present disclosure. The heat pump 1 comprises a refrigerant circuit 10 and a heat medium circuit 30. The refrigerant circuit 10 has a compressor 11, a heat source heat exchanger 12, which is an evaporator in the present embodiment, an expansion valve 13, and an intermediate heat exchanger 20, which is a condenser in the present embodiment. The heat medium circuit 30 has the intermediate heat exchanger 20 and a gas-liquid separator 31. The heat medium in the heat medium circuit 30 is circulated by means of a pump 36. A usage-side heat exchanger of the heat pump, which may be a radiator or a floor heater or the like, is not shown.

[0095] In the embodiment shown in Fig. 1, the compressor 11, the heat source heat exchanger 12, and the expansion valve 13 form part of a heat source unit 100 having a heat source unit casing 101 accommodating the compressor 11, the heat source heat exchanger 12, and the expansion valve 13. The heat source unit 100 is located outdoors, as an outdoor unit of the heat pump 1. The intermediate heat exchanger 20, the gas-liquid separator 31, and the pump 36 are located indoors and form part of an indoor unit of the heat pump 1. The outdoor unit and the indoor unit are separated by a wall of a building.

[0096] Fig. 2 is a perspective view of an intermediate heat exchanger 20 and a gas-liquid separator 31 according to a first embodiment of the present disclosure. The intermediate heat exchanger 20 has a first side wall 21, a second side wall 22 (not visible in Fig. 2) opposing the first side wall 21 in a left-right direction, a front wall 23 extending between the first side wall 21 and the second side wall 22, a top wall 24 being connected to upper ends of the first side wall 21, the second side wall 22, and the front wall 23, a rear wall 25 (not visible in Fig. 2) opposing the front wall 23 in a front-rear direction, and a bottom wall 26 (not visible in Fig. 2) opposing the top wall 24 in an up-down direction.

[0097] The intermediate heat exchanger 20 has a first inlet opening 27 for allowing the heat medium to flow into the intermediate heat exchanger 20, and a first outlet opening 28 for allowing the heat medium to flow out from the intermediate heat exchanger 20, after having exchanged heat with the refrigerant in the intermediate heat exchanger 20. The first inlet opening 27 and the first outlet opening 28 are provided in the front wall 23 of the intermediate heat exchanger 20. In addition, in the front wall 23, further inlet and outlet openings are provided for allowing the refrigerant to flow into and out from the intermediate heat exchanger 20.

[0098] The gas-liquid separator 31 has a second inlet opening 311 for allowing the heat medium to flow into the gas-liquid separator 31, after having flown out from the intermediate heat exchanger 20, and a second outlet opening 312 for allowing the heat medium to flow out from the gas-liquid separator 31. In the embodiment shown, the second inlet opening 311 and the second outlet opening 312 are separated from each other in a first direction FD (indicated in Fig. 3), wherein the first direction FD is parallel to the up-down direction in the present embodiment. Furthermore, the second inlet opening 311 and the second outlet opening 312 are provided at the gas-liquid separator 31 so as to be open in a direction crossing the first direction FD, the direction being parallel to the front-rear direction in the present embodiment.

[0099] Moreover, the first outlet opening 28 of the intermediate heat exchanger 20 and the second inlet opening 311 of the gas-liquid separator 31 are open in the same direction, namely, in the front-rear direction in the present embodiment.

[0100] A heat medium connection pipe 32 is provided between the first outlet opening 28 and the second inlet opening 311 for allowing the heat medium to flow from the intermediate heat exchanger 20 to the gas-liquid separator 31. In the first embodiment, the heat medium connection pipe 32 is an integral one-piece pipe. Moreover, the heat medium connection pipe 32 has a U-shape.

[0101] Furthermore, as shown in Fig. 2, a heat medium inflow pipe 33 is connected to the first inlet opening 27 of the intermediate heat exchanger 20 for allowing the heat medium to flow into the intermediate heat exchanger 20, and a heat medium outflow pipe 34 connected to the second outlet opening 312 of the gas-liquid separator 31 for allowing the heat medium to flow out from the gas-liquid separator 31.

[0102] Fig. 3 is a front view of the intermediate heat exchanger 20 and the gas-liquid separator 31 of Fig. 2, and Fig. 4 is a top view of the intermediate heat exchanger 20 and the gas-liquid separator 31 of Fig. 2. As shown in Figs. 3 and 4, a majority of the gas-liquid separator 31 is located in an arrangement region AR next to the intermediate heat exchanger 20. The arrangement region AR extends in the up-down direction from the top wall 24 to the bottom wall 26 of the intermediate heat exchanger 20, and in the front-rear direction from the rear wall 25 of the intermediate heat exchanger 20 to a frontmost point of the heat medium connection pipe 32.

[0103] As mentioned above, since the majority of the gas-liquid separator 31 is located in the arrangement region AR next to the intermediate heat exchanger 20,

the gas-liquid separator 31 and the intermediate heat exchanger 20 are arranged relative to each other in a compact manner. This leads to a space-efficient configuration of the heat pump 1.

[0104] Moreover, since the majority of the gas-liquid separator 31 is located in the arrangement region AR next to the intermediate heat exchanger 20, the gas-liquid separator 31 can be located in close proximity to the intermediate heat exchanger 20. Not only does this lead to the advantage that less piping is necessary to connect the intermediate heat exchanger 20 to the gas-liquid separator 31. Since the gas-liquid separator 31 can be located close to the intermediate heat exchanger 20, in case a refrigerant leak occurs in or at the intermediate heat exchanger 20, the gaseous refrigerant leaking into the heat medium circuit 30 is ejected earlier into the gas-liquid separator 31 and a leakage can thereby be detected earlier, for example, when a leak detector for detecting leaked refrigerant is provided. This improves safety of the heat pump 1.

[0105] More specifically, in the embodiment shown in Figs. 3 and 4, the gas-liquid separator 31 has a maximum length Lmax in the first direction FD and a maximum width Wmax in a direction perpendicular to the first direction FD, and more than 50% of the maximum length Lmax and the maximum width Wmax are located in the arrangement region AR. Moreover, as can be seen in Figs. 3 and 4, the gas-liquid separator 31 is arranged next to the first side wall 21 of the intermediate heat exchanger 20, and a space between the gas-liquid separator 31 and the intermediate heat exchanger 20 is free from other constituent parts of the heat pump 1, thereby achieving an even more compact arrangement of the as-liquid separator 31 and the intermediate heat exchanger 20.

[0106] The arrangement region AR may extend in the left-right direction from the first side wall 21 to a point no more than 35 cm away from the first side wall 21. Alternatively, the gas-liquid separator 31 may be arranged on the other side of the intermediate heat exchanger 20, and the arrangement region AR may extend in the left-right direction from the second side wall 22 to a point no more than 35 cm away from the second side wall 22.

[0107] As shown in Fig. 4, an inlet opening connection pipe 35 is provided between the heat medium connection pipe 32 and the second inlet opening 311 of the gas-liquid separator 31. The inlet opening connection pipe 35 has a length of at least 5 cm, so as to promote proper functioning of the gas-liquid separator 31. In this embodiment, the inlet opening connection pipe 35 and the heat medium connection pipe 32 are integrally formed as a one-piece pipe.

[0108] As shown in Figs. 2 and 3, the heat medium inflow pipe 33 and the heat medium outflow pipe 34 are arranged on the same side of the intermediate heat exchanger 20. That is, in the first embodiment, the heat medium inflow pipe 33 and the heat medium outflow pipe 34 are both arranged on a side of the intermediate heat exchanger 20 that is below the bottom wall 26 of the intermediate heat exchanger 20, as seen in the up-down direction. Specifically, a portion of the heat medium inflow pipe 33 and a portion of the heat medium outflow pipe 34 are both arranged on the side of the intermediate heat exchanger 20 that is below the bottom wall 26 of the intermediate heat exchanger 20, as seen in the up-down direction, wherein said portion is a portion of the respective pipe that is further away from the first inlet opening 27 or the second outlet opening 312 than a portion of the respective pipe that is connected to the first inlet opening 27 and the second outlet opening 312, respectively. More specifically, the portion of the heat medium inflow pipe 33 and the portion of the heat medium outflow pipe 34 that are arranged on the side of the intermediate heat exchanger 20 that is below the bottom wall 26 of the intermediate heat exchanger 20, as seen in the up-down direction, are arranged in parallel with each other.

[0109] Fig. 5 is a bottom view of the intermediate heat exchanger 20 and the gas-liquid separator 31 of Fig. 2. As shown in Fig. 5, the heat medium inflow pipe 33 and the heat medium outflow pipe 34 are arranged so that a center line CLin of the heat medium inflow pipe 33 and a center line CLout of the heat medium outflow pipe 34 lie in a plane that is substantially parallel to the up-down direction. Specifically, a portion of the heat medium inflow pipe 33 and a portion of the heat medium outflow pipe 34, said portion being a portion of the respective pipe that is further away from the first inlet opening 27 or the second outlet opening 312 than a portion of the respective pipe that is connected to the first inlet opening 27 and the second outlet opening 312, respectively, are both arranged so that a center line CLin of that portion of the heat medium inflow pipe 33 and a center line CLout of that portion of the heat medium outflow pipe 34 lie in a plane that is parallel to the up-down direction. This plane is indicated in Fig. 5 by the dashed line passing through the center lines CLin and CLout.

[0110] Fig. 9 is a perspective cross-sectional view of the intermediate heat exchanger 20 and the gas-liquid separator 31 of Fig. 2 contained in a container 201, according to the first embodiment.

[0111] The container 201 houses or accommodates the intermediate heat exchanger 20 and the gas-liquid separator 31. The container 201 has a substantially cuboid shape with several side walls that conforms to the outer shape of the configuration of the intermediate heat exchanger 20 and the gas-liquid separator 31. The container 201 may be separate from the casing 101 of the heat source unit 100.

[0112] As can be seen in Fig. 9, since the heat medium inflow pipe 33 and the heat medium outflow pipe 34 are arranged on the same side of the intermediate heat exchanger 20, the heat medium inflow pipe 33 and the heat medium outflow pipe 34 penetrate the container 201 at the same side wall, through the same opening. With this configuration, only one opening at the side wall of the container 201 is required that needs to be hermetically sealed in case a hermetically sealed container is re-

quired.

[0113] Fig. 6 is a perspective view of an intermediate heat exchanger 20 and a gas-liquid separator 31 contained in a container 201, according to a second embodiment of the present disclosure. In the second embodiment, the gas-liquid separator 31 is arranged next to the second side wall 22 of the intermediate heat exchanger 20.

[0114] The heat medium inflow pipe 33 and the heat medium outflow pipe 34 are arranged in the second embodiment on a side of the intermediate heat exchanger 20 that is next to the second side wall 22 of the intermediate heat exchanger 20, as seen in the left-right direction. Specifically, a portion of the heat medium inflow pipe 33 and a portion of the heat medium outflow pipe 34 are both arranged in parallel with each other on the side of the intermediate heat exchanger 20 that is next to the second side wall 22 of the intermediate heat exchanger 20, wherein said portion is a portion of the respective pipe that is further away from the first inlet opening 27 or the second outlet opening 312 than a portion of the respective pipe that is connected to the first inlet opening 27 and the second outlet opening 312, respectively. More specifically, a center line CLin of that portion of the heat medium inflow pipe 33 and a center line CLout of that portion of the heat medium outflow pipe 34 lie in a plane that is perpendicular to the up-down direction.

[0115] In the second embodiment, the heat medium connection pipe has an angular U-shape and consists of several pipe segments, which together form the U-shape. The inlet opening connection pipe 35 is a separate pipe segment provided between the heat medium connection pipe 32 and the second inlet opening 311.

[0116] The container 201 houses or accommodates the intermediate heat exchanger 20 and the gas-liquid separator 31. The container 201 has a substantially cuboid shape with several side walls that conforms to the outer shape of the configuration of the intermediate heat exchanger 20 and the gas-liquid separator 31. The container 201 may be separate from the casing 101 of the heat source unit 100.

[0117] As can be seen in Fig. 6, since the heat medium inflow pipe 33 and the heat medium outflow pipe 34 are arranged on the same side of the intermediate heat exchanger 20, the heat medium inflow pipe 33 and the heat medium outflow pipe 34 penetrate the container 201 at the same side wall, through the same opening. With this configuration, only one opening at the side wall of the container 201 is required that needs to be hermetically sealed in case a hermetically sealed container is required.

[0118] Fig. 7 is a perspective view of an intermediate heat exchanger 20 and a gas-liquid separator 31 contained in a container 201, according to a third embodiment of the present disclosure. Fig. 8 is a top view of the intermediate heat exchanger 20, the gas-liquid separator 31, and the container 201 of Fig. 7. As can be seen, the gas-liquid separator 31 is arranged next to an edge of the intermediate heat exchanger 20 formed by the front wall 23 and the second side wall 22 of the intermediate heat exchanger 20. The first outlet opening 28 of the intermediate heat exchanger 20 and the second outlet opening 312 of the gas-liquid separator 31 are open in directions that cross each other at an angle of 90°. The heat medium connection pipe 32 has an L-shape in the third embodiment. The inlet opening connection pipe 35 is omitted in Figs. 7 and 8.

LIST OF REFERENCE SIGNS

[0119]

1	Heat pump
10	Refrigerant circuit
11	Compressor
12	Heat source heat exchanger
13	Expansion valve
20	Intermediate heat exchanger
30	Heat medium circuit
31	Gas-liquid separator
21	First side wall
22	Second side wall
23	Front wall
24	Top wall
25	Rear wall
26	Bottom wall
27	First inlet opening
28	First outlet opening
311	Second inlet opening
312	Second outlet opening
32	Heat medium connection pipe
33	Heat medium inflow pipe
34	Heat medium outflow pipe
35	Inlet opening connection pipe
36	Pump
201	Container
100	Heat source unit
101	Casing of heat source unit
AR	Arrangement region
FD	First direction
Lmax	Maximum length of gas-liquid separator
Wmax	Maximum width of gas-liquid separator
CLin	Center line of heat medium inflow pipe
CLout	Center line of heat medium outflow pipe

Claims

1. A heat pump (1), comprising

a refrigerant circuit (10) having a compressor (11), a heat source heat exchanger (12), an expansion valve (13), and an intermediate heat exchanger (20),

a heat medium circuit (30) having the intermediate heat exchanger (20) and a gas-liquid separator (31),

wherein the intermediate heat exchanger (20) has a first side wall (21), a second side wall (22) opposing the first side wall (21), a front wall (23) extending between the first side wall (21) and the second side wall (22), a top wall (24) being connected to upper ends of the first side wall (21), the second side wall (22), and the front wall (23), a rear wall (25) opposing the front wall (23) in a front-rear direction, and a bottom wall (26) opposing the top wall (24) in an up-down direction,
wherein the intermediate heat exchanger (20) has a first inlet opening (27) and a first outlet opening (28) for a heat medium, the first inlet opening (27) and the first outlet opening (28) being provided in the front wall (23),
wherein the gas-liquid separator (31) has a second inlet opening (311) and a second outlet opening (312) for the heat medium,
wherein a heat medium connection pipe (32) is provided between the first outlet opening (28) and the second inlet opening (311) for allowing the heat medium to flow from the intermediate heat exchanger (20) to the gas-liquid separator (31),
wherein a majority of the gas-liquid separator (31) is located in an arrangement region (AR) next to the intermediate heat exchanger (20), the arrangement region (AR) extending in the up-down direction from the top wall (24) to the bottom wall (26) of the intermediate heat exchanger (20) and in the front-rear direction from the rear wall (25) of the intermediate heat exchanger (20) to a frontmost point of the heat medium connection pipe (32).

2. The heat pump (1) according to claim 1,

wherein the second inlet opening (311) and the second outlet opening (312) are separated from each other in a first direction (FD),
wherein the gas-liquid separator (31) has a maximum length (Lmax) in the first direction (FD) and a maximum width (Wmax) in a direction perpendicular to the first direction (FD),
wherein at least 50% of the maximum length (Lmax) and the maximum width (Wmax) are located in the arrangement region (AR).

3. The heat pump (1) according to claim 1 or 2,

wherein the second side wall (22) opposes the first side wall (21) in a left-right direction,
wherein the arrangement region (AR) further extends in the left-right direction from one of the first side wall (21) and the second side wall (22) to a point no more than 35 cm away from the one of the first side wall (21) and the second side wall (22).

4. The heat pump (1) according to any one of the preceding claims,
wherein a space between the gas-liquid separator (31) and the intermediate heat exchanger (20) is free from other constituent parts of the heat pump (1).

5. The heat pump (1) according to any one of claims 2 to 4,
wherein the second inlet opening (311) and the second outlet opening (312) are provided at the gas-liquid separator (31) so as to be open in a direction crossing the first direction (FD).

6. The heat pump (1) according to any one of the preceding claims,

further comprising
a heat medium inflow pipe (33) connected to the first inlet opening (27) of the intermediate heat exchanger (20) for allowing the heat medium to flow into the intermediate heat exchanger (20), and
a heat medium outflow pipe (34) connected to the second outlet opening (312) of the gas-liquid separator (31) for allowing the heat medium to flow out from the gas-liquid separator (31),
wherein the heat medium inflow pipe (33) and the heat medium outflow pipe (34) are arranged on the same side of the intermediate heat exchanger (20).

7. The heat pump (1) according to claim 6,
wherein the heat medium inflow pipe (33) and the heat medium outflow pipe (34) are arranged so that a center line (CLin) of the heat medium inflow pipe (33) and a center line (CLout) of the heat medium outflow pipe (34) lie in a plane that is substantially perpendicular or parallel to the up-down direction.

8. The heat pump (1) according to any one of the preceding claims,
wherein the gas-liquid separator (31) is arranged next to the first side wall (21) or the second side wall (22) of the intermediate heat exchanger (20).

9. The heat pump (1) according to any one of the preceding claims,
wherein the first outlet opening (28) of the intermediate heat exchanger (20) and the second inlet opening (311) of the gas-liquid separator (31) are open in the same direction.

10. The heat pump (1) according to any one of the preceding claims,
wherein the heat medium connection pipe (32) has a U-shape.

11. The heat pump (1) according to any one of claims 1 to 7,
wherein the gas-liquid separator (31) is arranged next to an edge of the intermediate heat exchanger (20) formed by the front wall (23) and the first side wall (21) or the second side wall (22) of the intermediate heat exchanger (20) .

12. The heat pump (1) according to claim 11,
wherein the first outlet opening (28) of the intermediate heat exchanger (20) and the second outlet opening (312) of the gas-liquid separator (31) are open in directions that cross each other.

13. The heat pump (1) according to claim 12,
wherein the heat medium connection pipe (32) has an L-shape.

14. The heat pump (1) according to any one of the preceding claims,

wherein an inlet opening connection pipe (35) is provided between the heat medium connection pipe (32) and the second inlet opening (311) of the gas-liquid separator (31),
wherein the inlet opening connection pipe (35) has a length of at least 5 cm.

15. The heat pump (1) according to any one of the preceding claims,

further comprising
a container (201), in which the intermediate heat exchanger (20) and the gas-liquid separator (31) are housed,
wherein the container (201) is separate from a casing (101) of a heat source unit (100).

16. The heat pump (1) according to claim 15,
wherein an inner space of the container (201) is hermetically sealed from the outside of the container (201).

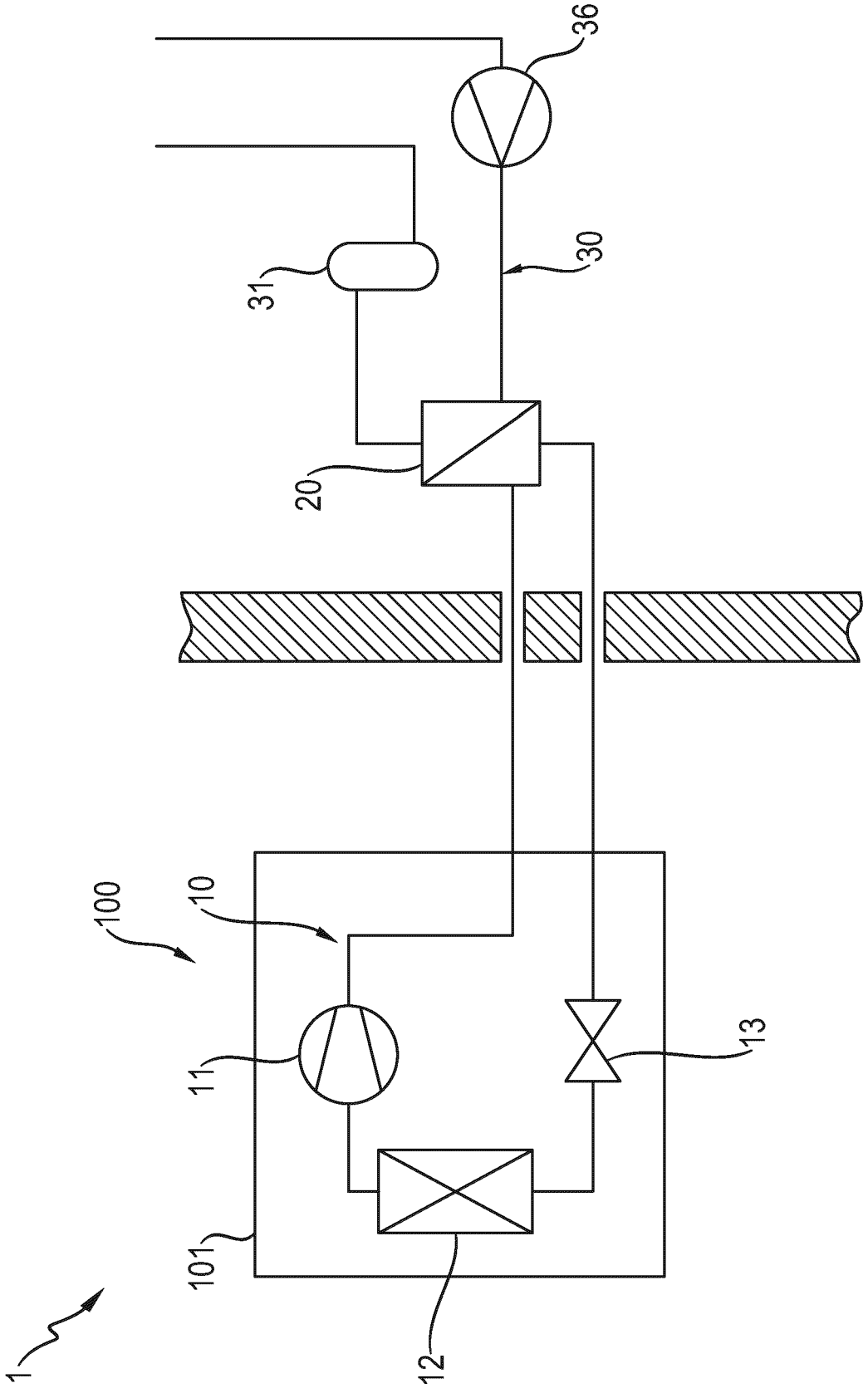

Fig. 1

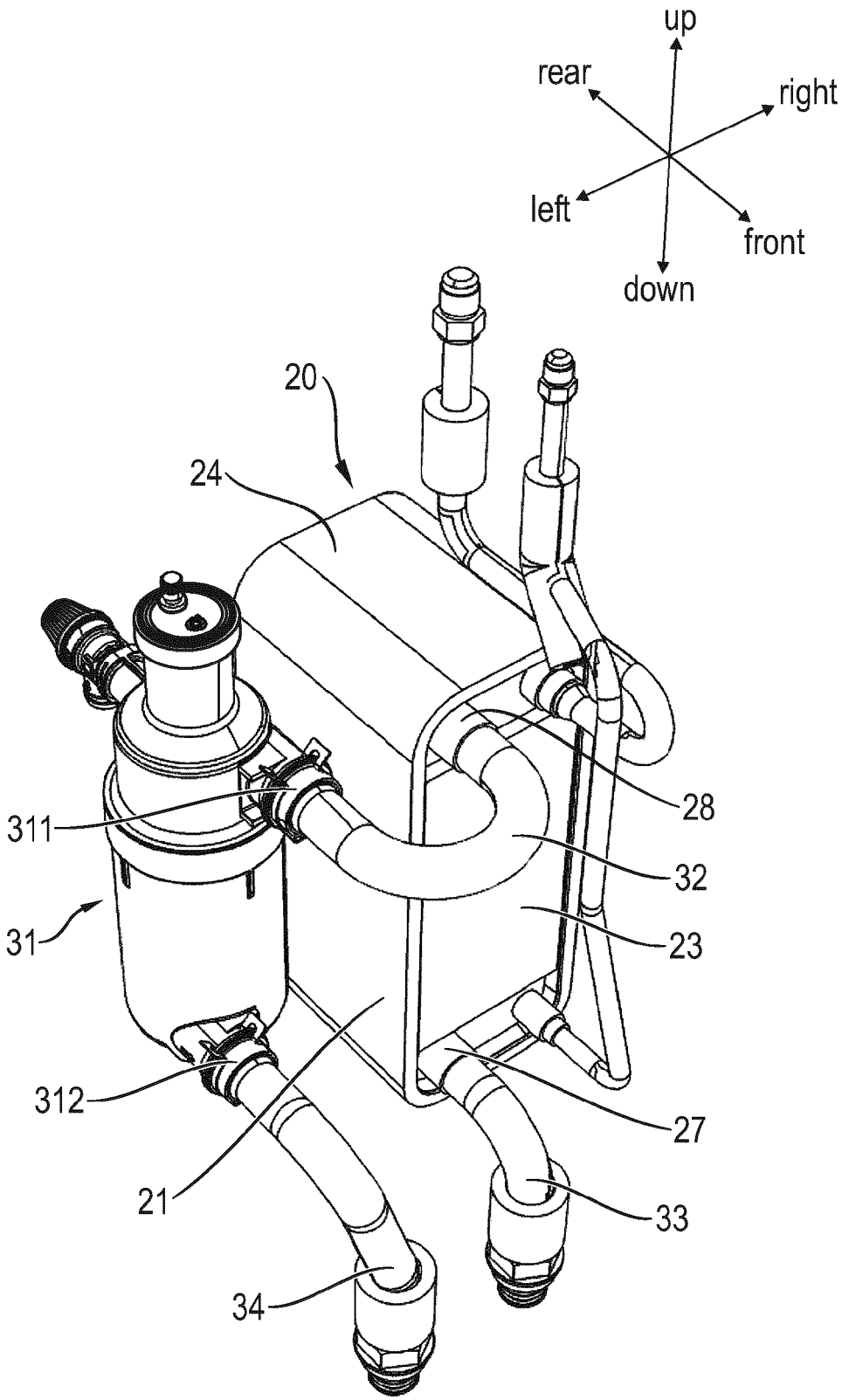
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Fig. 2

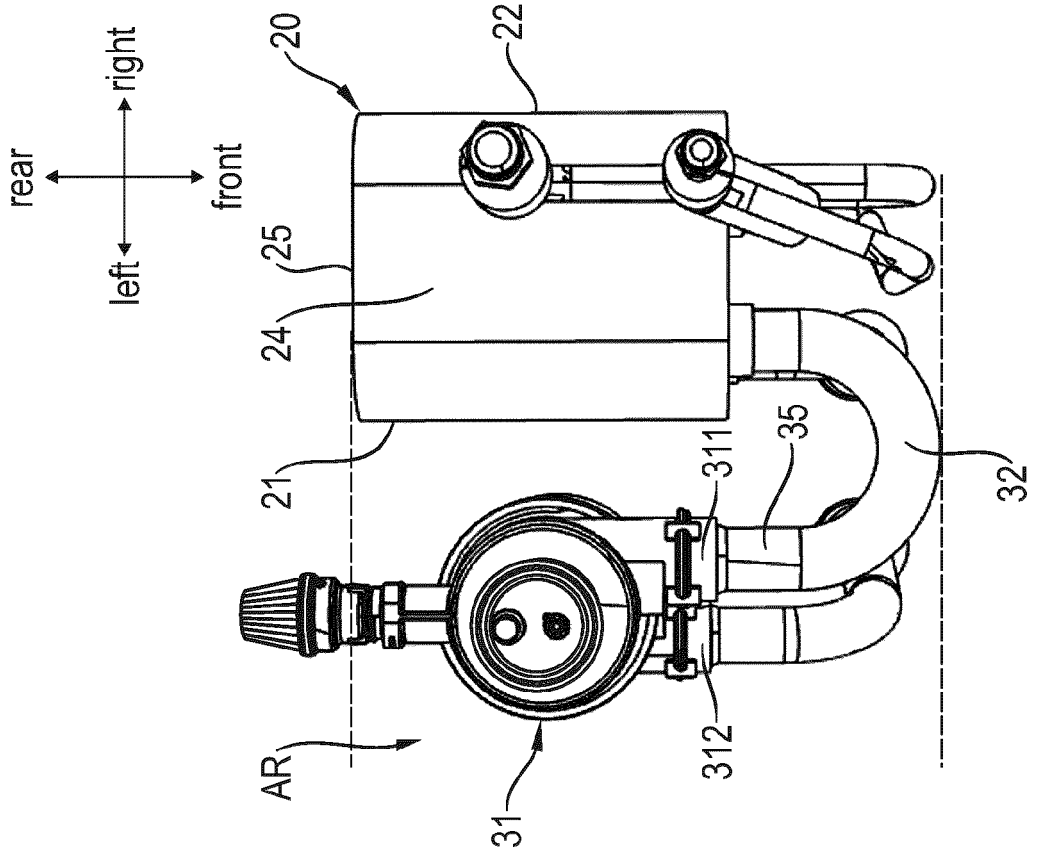
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Fig. 4

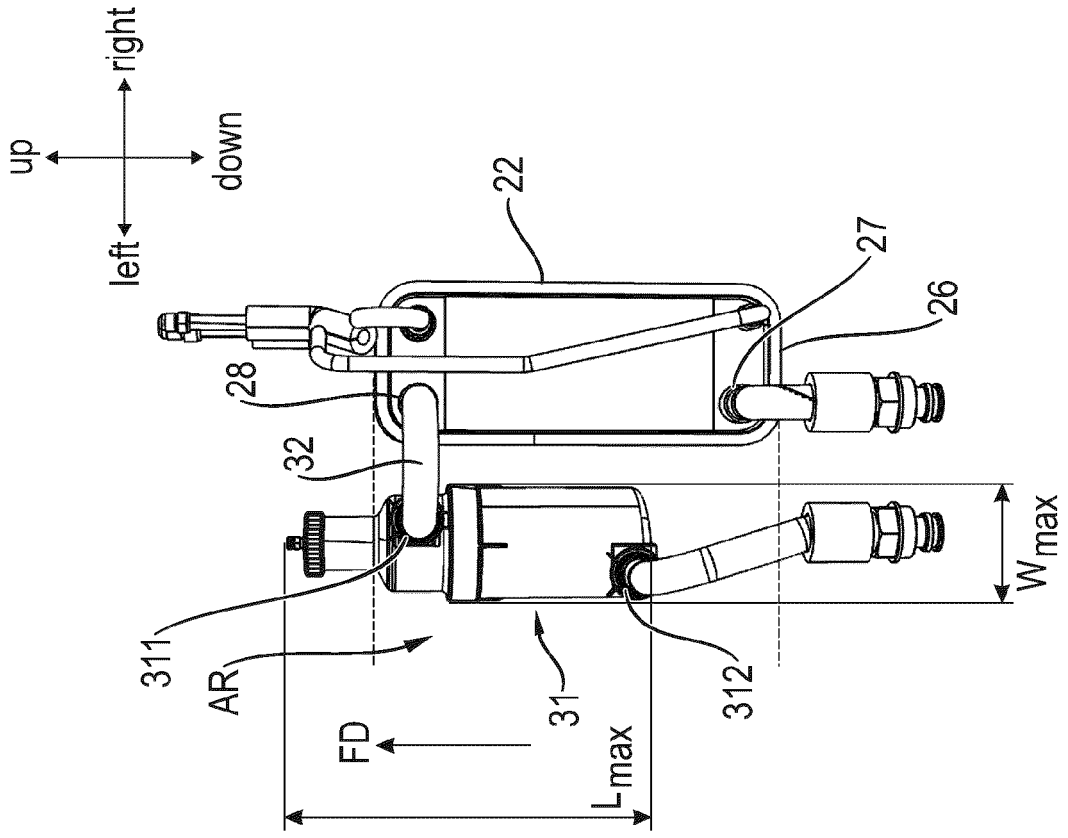
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Fig. 3

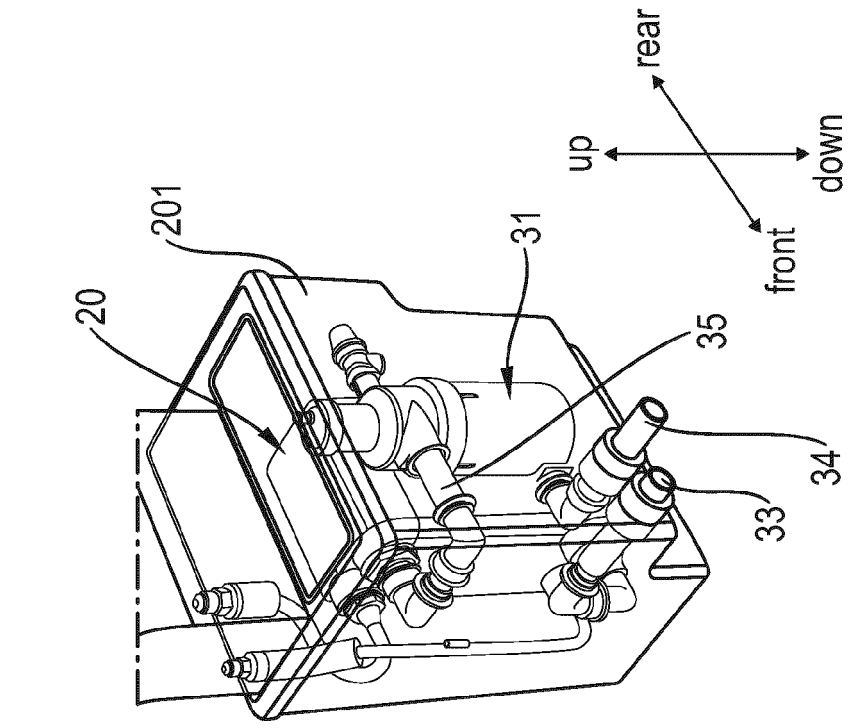
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Fig. 6

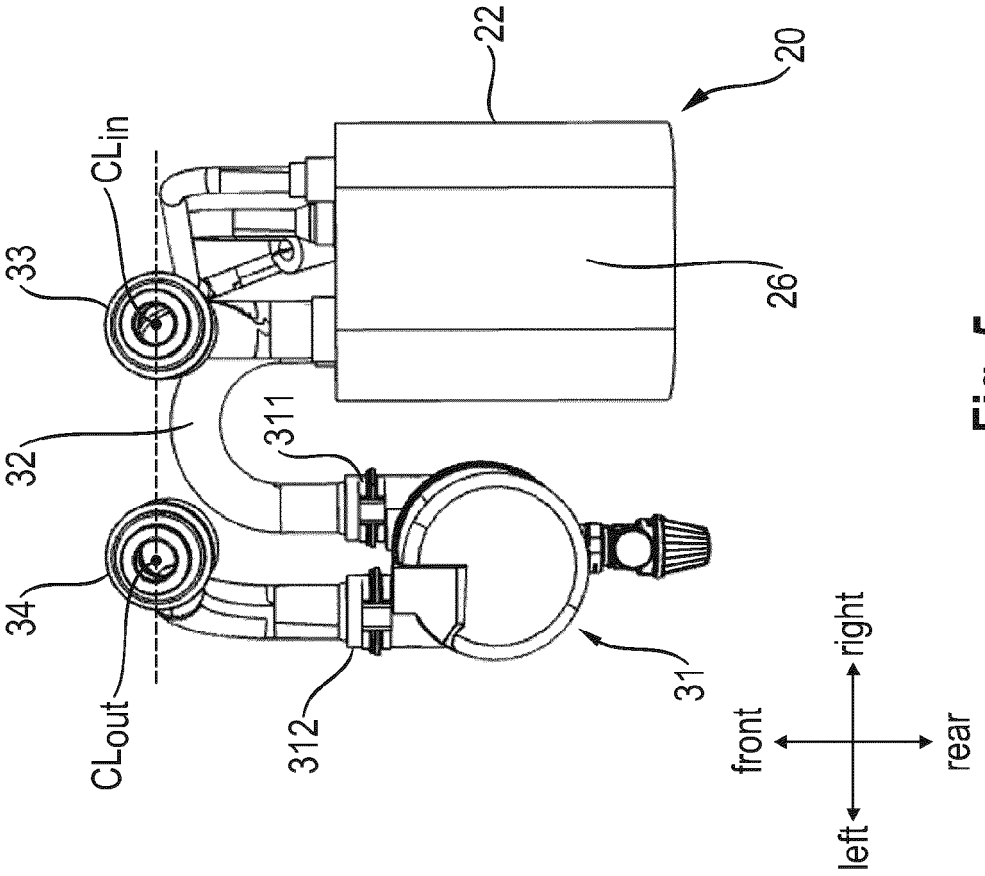
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Fig. 5

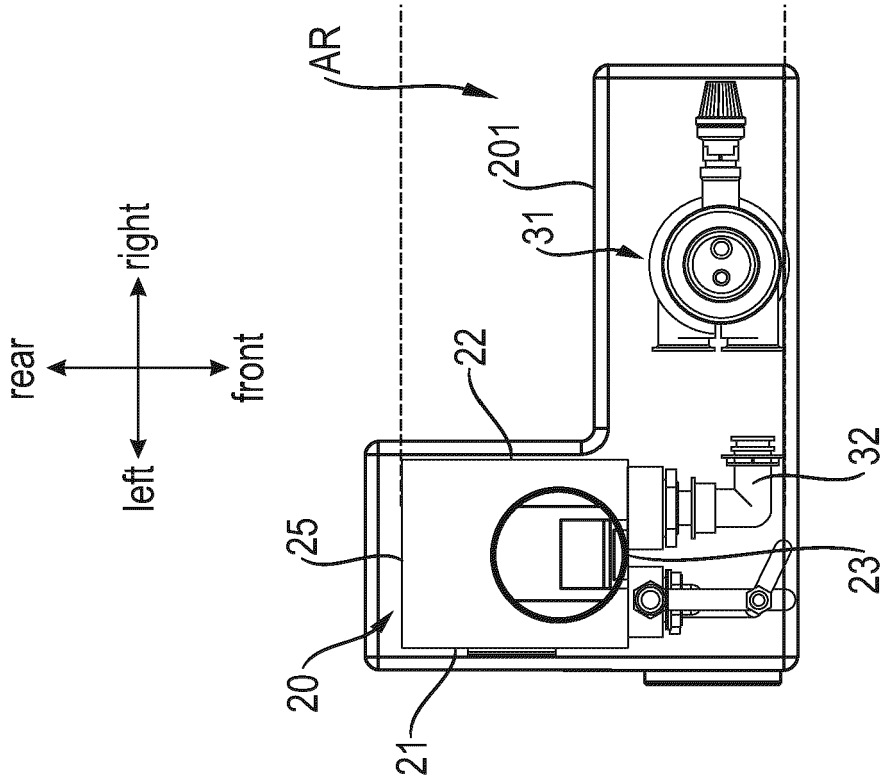
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Fig. 8

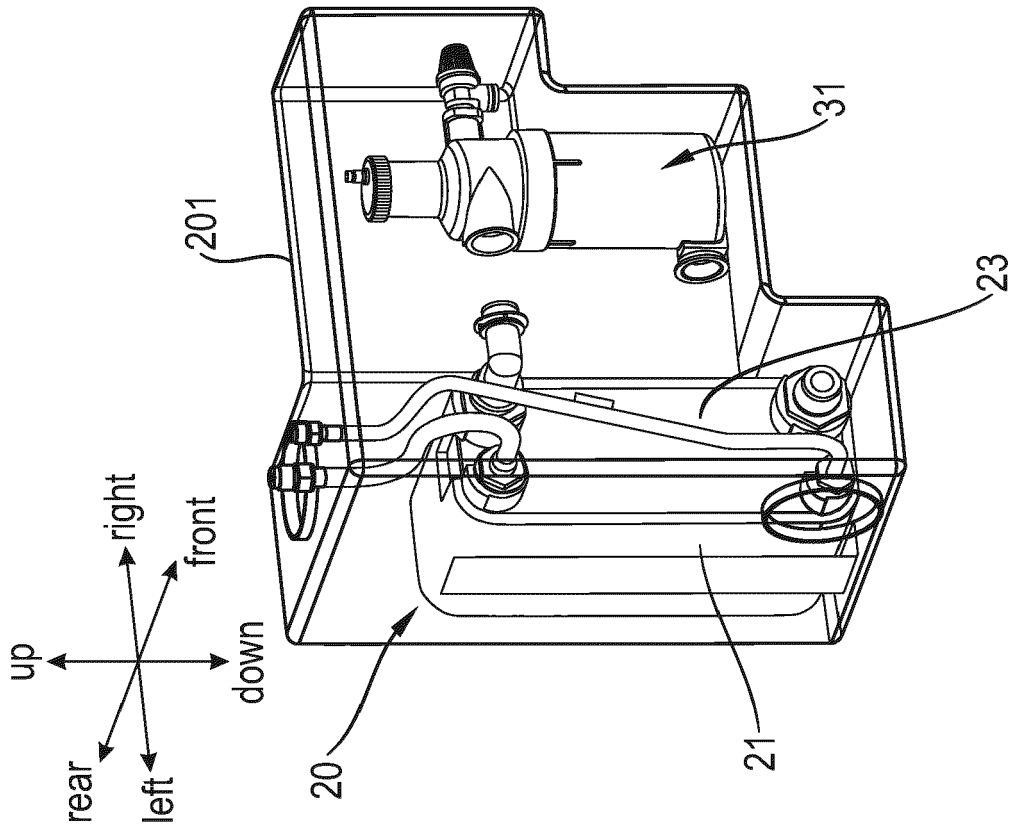
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Fig. 7

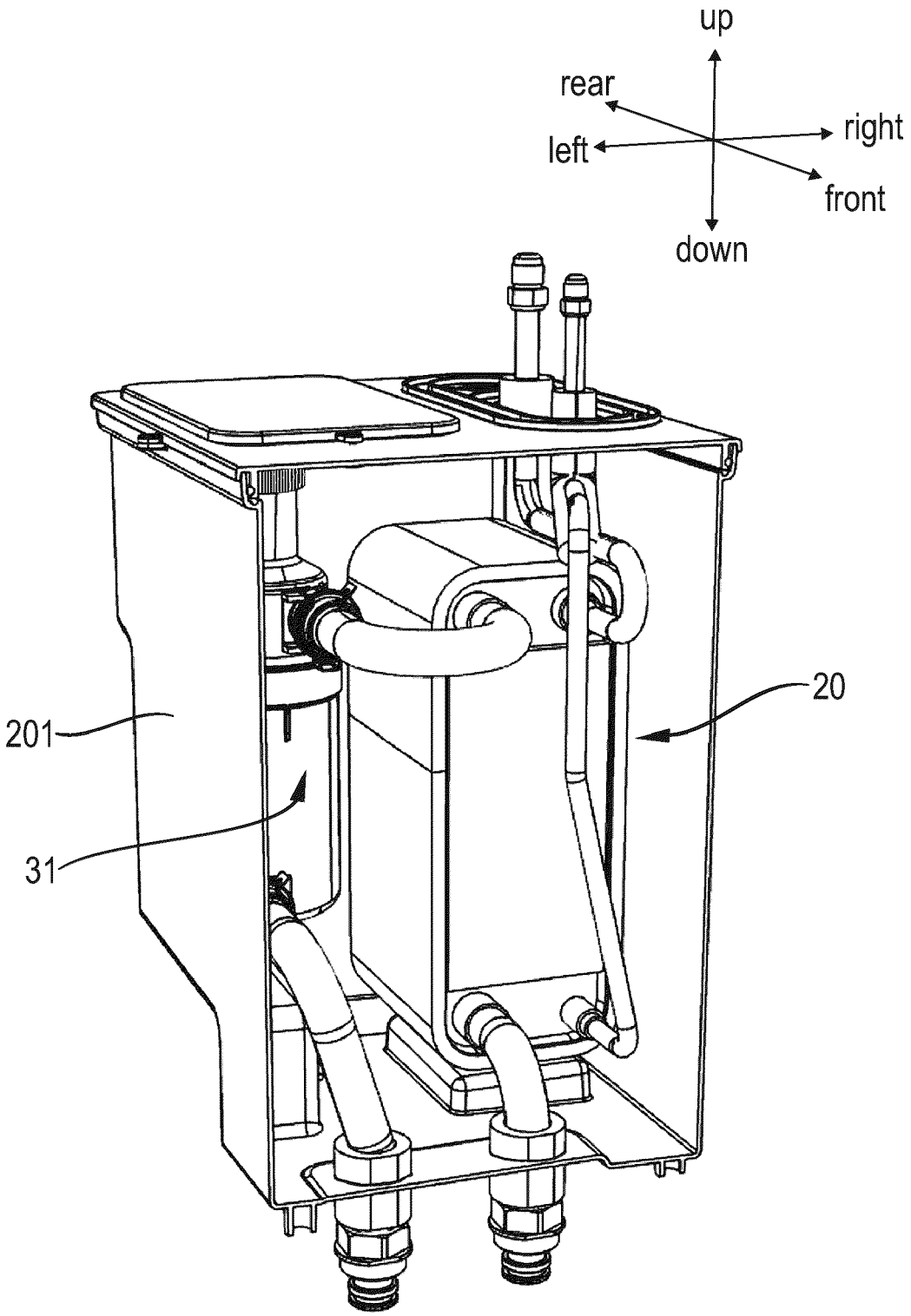

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 23 17 5730

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F25B
F24F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	8 November 2023	Ritter, Christoph

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08-11-2023

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