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(54) **Title**: REFRIGERATION CIRCUIT AND HEATING AND COOLING SYSTEM

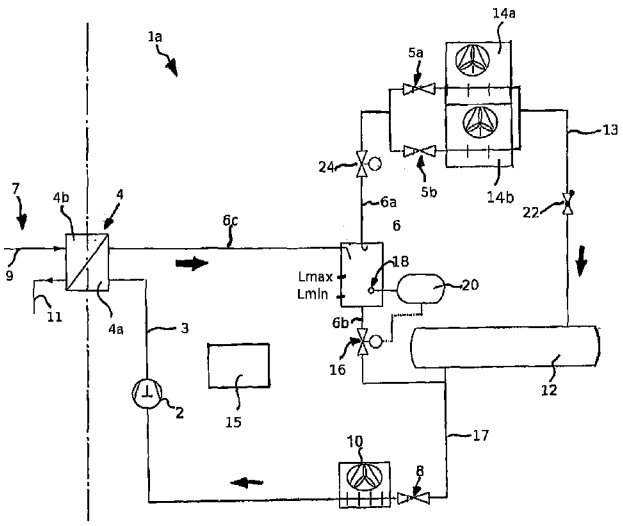


Fig. 1

(57) **Abstract**: A refrigeration circuit (1a, 1b, 1c, 1d, 1e) comprises a compressor (2), a condenser (14a, 14b), an expansion device (8), an evaporator (10), a heat rejecting heat exchanger (4), and a gas-liquid-separator (6), which is configured to separate the refrigerant leaving the heat rejecting heat exchanger (4) into a gaseous phase refrigerant portion and liquid phase refrigerant portion. The gas-liquid-separator (6) has a liquid phase output line (6b) with a liquid refrigerant control device (16). The refrigeration circuit (1a, 1 b, 1c, 1d, 1e) further comprises a liquid meter (18), which is configured to measure the level of liquid refrigerant within the gas-liquid-separator (6), and a liquid level control device (20) coupled to the liquid meter (18) and to the liquid refrigerant control device (16). The liquid level control device (20) is configured to drive the liquid refrigerant control device (16) based on a signal provided by the liquid meter (18).

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REFRIGERATION CIRCUIT AND HEATING AND COOLING SYSTEM

The present invention relates to a refrigeration circuit comprising a heat rejecting heat exchanger and a gas-liquid-separator, and to a heating and cooling system comprising such refrigeration circuit.

Refrigeration circuits circulating a refrigerant and comprising in the direction of the flow of the refrigerant a compressor, a condenser, an expansion device and an evaporator have been known for a long time.

The heat rejected in the condenser can be dissipated e.g. to ambient air or can be used for heating in a heating system, for example a heat pump system or a heat recovery system, coupled to the refrigeration circuit. A heating system can be coupled to the refrigeration circuit by means of the condenser of the refrigeration circuit, which may at the same time form the evaporator of the heating system. A refrigeration circuit coupled to a heating system in that way is efficient, since the heat generated by the condenser is not wasted, but rather utilized by the heating system. However, in such a refrigeration circuit coupled to a heating system, problems may arise when the heat needed by the heating system differs from the heat to be dissipated in order to operate the refrigeration circuit for obtaining the desired cooling capacity at the evaporator(s) of the refrigeration circuit.

Another option of coupling a heating system to the refrigeration circuit is to provide a heat rejecting heat exchanger between the compressor and the condenser(s) of the refrigeration circuit. In this case, however, it is difficult to handle the refrigerant leaving the heat rejecting heat exchanger being in varying conditions of aggregation and to operate the refrigeration circuit efficiently.

It therefore would be beneficial to provide a refrigeration circuit which allows for an efficient operation of the refrigeration circuit and which in particular allows to obtain the desired cooling at the evaporator(s), no matter how much the heat demand of the heating system is.

Exemplary embodiments of the invention include a refrigeration circuit circulating a refrigerant and comprising in the direction of flow of the refrigerant: at least one compressor; at least one condenser for rejecting heat from the refrigerant to the environment; a refrigerant line (condenser output line) fluidly connected to an output side of the at least one condenser; an expansion device inlet line; at least one expansion device for expanding the refrigerant; and at least one evaporator for evaporating the refrigerant. The refrigeration circuit further comprises: a heat rejecting heat exchanger being configured for heat exchange of the refrigerant with a heating system, an input side of the heat rejecting heat exchanger being fluidly connected the output side of the at least one compressor; a gas-liquid-separator fluidly connected to an output side of the heat rejecting heat exchanger and being configured to separate the refrigerant leaving the heat rejecting heat exchanger into a gaseous phase refrigerant portion and a liquid phase refrigerant portion, the gas-liquid-separator having a gaseous phase output line fluidly connected to an inlet side of the at least one condenser and a liquid phase output line fluidly connected to the expansion device inlet line and/or a collecting container, which may be arranged upstream of the expansion device for collecting liquid refrigerant; a liquid refrigerant control device, which may be a control valve arranged in the liquid phase output line, allowing to control the flow of liquid refrigerant flowing out of the gas-liquid-separator; and a liquid meter which is configured to measure the level of liquid refrigerant collected within the gas-liquid-separator and to provide at least one signal indicative of the level of liquid refrigerant collected within the gas-liquid-separator. The refrigeration circuit also comprises a liquid level control device coupled to both, the liquid meter and the liquid refrigerant control device. The liquid refrigerant control device is configured to drive the liquid refrigerant control device based on the at least one signal provided by the liquid meter in order to adjust the level of liquid refrigerant within the gas-liquid-separator.

Exemplary embodiments of the invention further include a heating and cooling system comprising a heating system and a refrigeration circuit according to an exemplary embodiment of the invention, wherein the heat rejecting heat exchanger of the refrigeration circuit is configured to serve as a heat source for the heating system.

Exemplary embodiments of the invention further include a method for controlling a refrigeration circuit circulating a refrigerant and comprising in the direction of flow of the refrigerant: at least one compressor; at least one condenser for rejecting heat from the refrigerant to the environment; at least one expansion device for expanding the refrigerant; and at least one evaporator for evaporating the refrigerant. The refrigeration circuit further comprises: a heat rejecting heat exchanger for heat exchange of the refrigerant with a heating system, an input side of the heat rejecting heat exchanger being fluidly connected the output side of the compressor; a gas-liquid-separator fluidly connected to an output side of the heat rejecting heat exchanger and being configured to separate the refrigerant leaving the heat rejecting heat exchanger into a gaseous phase refrigerant portion and a liquid phase refrigerant portion, the gas-liquid-separator having a gaseous phase output line fluidly connected to the at least one condenser and a liquid phase output line fluidly connected to at least one of the expansion device and/or a collecting container (receiver) for collecting the refrigerant; a liquid refrigerant control device arranged in the liquid phase output line allowing to control the flow of liquid refrigerant flowing out of the gas-liquid-separator; and a liquid meter measuring the level of liquid refrigerant collected within the gas-liquid-separator and providing at least one signal indicative of the level of liquid refrigerant collected within the gas-liquid-separator. The method includes to control the liquid refrigerant control device based on the at least one signal provided by the liquid meter in order to adjust the level of liquid refrigerant collected within the gas-liquid-separator.

A refrigeration circuit and a heating and cooling system according to exemplary embodiments of the invention allow to adjust the level of liquid refrigerant collected within the gas-liquid-separator and the pressure of the gaseous liquid delivered to the condenser(s). It therefore allows to operate the refrigeration circuit with high efficiency independently of the actual amount of heat transferred to the heating system.

Exemplary embodiments of the invention will be described in more detail with reference to the enclosed figures, wherein:

Fig. 1 shows a schematic view of an exemplary refrigeration circuit according to a first embodiment of the invention;

Fig. 2 shows a schematic view of an exemplary refrigeration circuit according to a second embodiment of the invention;

Fig. 3 shows a schematic view of an exemplary refrigeration circuit according to a third embodiment of the invention;

Fig. 4 shows a schematic view of an exemplary refrigeration circuit according to a fourth embodiment of the invention;

Fig. 5 shows a schematic view of an exemplary refrigeration circuit according to a fifth embodiment of the invention; and

Fig. 6 shows a schematic view of an exemplary gas-liquid-separator which may be used in a refrigeration circuit according to an embodiment of the invention.

Figure 1 shows a schematic view of a refrigeration circuit 1a according to a first exemplary embodiment of the invention.

The refrigeration circuit 1a is depicted on the right-hand side of the dashed line shown in figure 1. On the left-hand side of said dashed line part of a heating system 7 is shown, in particular a heating system side 4b of a heat rejecting heat exchanger 4 and fluid lines 9, 11 fluidly connecting to the heating system side 4b of the heat rejecting heat exchanger 4.

The refrigeration circuit 1a shown in figure 1 comprises in the flow direction of a refrigerant circulating in the refrigeration circuit 1a as indicated by the arrows at least one compressor 2 for compressing the refrigerant to a relatively high pressure and a pressure line (compressor output line) 3 fluidly connected to the (high pressure) output side of the compressor 2.

The pressure line 3 further connects to the refrigeration circuit side 4a of the heat rejecting heat exchanger 4, and after passage through the refrigeration circuit side 4a of the heat rejecting heat exchanger 4 the refrigerant is delivered via a refrigerant inlet line 6c into a gas-liquid-separator 6.

The refrigerant leaving the heat rejecting heat exchanger 4 generally comprises a gaseous phase and a liquid phase, wherein the ratio between the gaseous phase and the liquid phase of the refrigerant depends on the operational parameters of the refrigeration circuit 1a and the amount of heat transferred to the heating system 7 by means of the heat rejecting heat exchanger 4.

The gas-liquid-separator 6 is configured for separating the gaseous phase of the refrigerant from the liquid phase. The gaseous phase is output via a gaseous phase output line 6a, which is attached to an upper portion of the gas-liquid-separator 6, and the liquid phase of the refrigerant is output via a liquid phase output line 6b, which is attached to a bottom portion of the gas-liquid-separator 6.

In the exemplary embodiment shown in figure 1 the gaseous phase output line 6a fluidly connects to a first and second, e.g. air-cooled, condenser 14a, 14b, the two condensers 14a, 14b being connected in parallel. Switchable valves 5a and 5b may be provided in the gaseous phase output line 6a upstream of the respective condenser 14a, 14b allowing to activate and deactivate each of the condensers 14a, 14b by respectively opening and closing the associated switchable valve 5a, 5b in order to adjust the cooling capacity provided by the condensers 14a, 14b.

Providing more than one condenser 14a, 14b and providing switchable valves 5a, 5b for selectively activating and deactivating each of a plurality of condensers 14a, 14b is optional. Alternative exemplary embodiments of the invention, which are not explicitly shown in the figures, may be provided with only a single condenser 14a and without any switchable valve 5a, 5b in order to reduce the costs for providing the system.

The outlet side of the at least one condenser 14a, 14b is fluidly connected by means of a common refrigerant line 13 (condenser output line) to a collecting container (receiver) 12, which is configured for collecting the condensed (liquid) refrigerant.

The collecting container 12, in particular its bottom portion, is fluidly connected by means of a expansion device inlet line 17 to the inlet side of an expansion device 8, and the output side of said expansion device 8 is fluidly connected to an evaporator 10, which is configured for evaporating the refrigerant thereby cooling the environment of the evaporator 10, e. g. in a refrigerating sales furniture or an air conditioning system. The evaporated refrigerant leaving the evaporator 10 is supplied to the inlet side of the compressor 2. This completes the cycle of refrigerant circulating in the refrigeration circuit 1a.

The liquid phase output line 6b of the gas-liquid-separator 6 is fluidly connected to the expansion device inlet line 17 upstream of the expansion device 8.

A liquid refrigerant control device 16, which may be a refrigerant control valve, is arranged in the liquid phase output line 6b allowing to control the flow of liquid refrigerant flowing out of the gas-liquid-separator 6 via the liquid phase output line 6b.

As mentioned before, the ratio between the liquid phase portion and the gaseous phase portion of the refrigerant leaving the heat rejecting heat exchanger 4 depends inter alia on the amount of heat which is needed/dissipated by the heating system 7. In particular, if the heat dissipated by the heating system 7 is less than the condensing power needed by the refrigerating circuit 1a, only a portion of the refrigerant is liquefied. On the other hand, it is possible that in another mode of operation the heating system 7 absorbs all the heat from the refrigerant so that the refrigerant is completely liquefied. In this case only liquid refrigerant will leave the heat rejecting heat exchanger 4.

A liquid meter 18, which is configured to measure the level of liquid refrigerant collected within the gas-liquid-separator 6, is provided at or in the gas-liquid-separator 6. The liquid meter 18 is, e.g. electrically or mechanically, coupled to a liquid level control device 20 in order to transfer at least one signal

indicating the level of liquid refrigerant collected within the gas-liquid-separator 6 to the liquid level control device 20. The liquid level control device 20 is further coupled, e.g. electrically or mechanically, to the liquid refrigerant control device 16 and configured to drive the liquid refrigerant control device 16 based on the at least one signal provided by the liquid meter 18 in order to adjust the level of liquid refrigerant within the gas-liquid-separator 6 to at least one predetermined level.

The combination and interaction of the liquid meter 18, the liquid level control device 20 and the liquid refrigerant control device 16 thus allow to maintain at least one predetermined level of liquid refrigerant within the gas-liquid-separator 6 independently of the amount of heat transferred by the heat-rejecting heat exchanger 4 from the refrigeration circuit 1a to the heating system 7. It therefore allows for a very efficient operation of the refrigeration circuit 1a even under varying operational conditions.

Optionally an additional non-return valve 22 may be arranged in the refrigerant line 13 fluidly connecting the at least one condenser 14a, 14b to the collecting container 12 in order to prevent refrigerant from flowing back from the collecting container 12 into the at least one condenser 14a, 14b when the compressor 2 is not operating.

Furthermore and also optionally a pressure regulation valve 24 may be arranged in the gaseous phase output line 6a fluidly connecting the gas-liquid-separator 6 to the at least one condenser 14a, 14b in order to allow to additionally adjust the pressure of the gaseous refrigerant portion in the gas-liquid-separator 6. Adjusting the pressure of the gaseous refrigerant portion in the gas-liquid-separator 6 allows to optimize the efficiency of the heat recovery system even further.

All monitoring and switching steps as described herein can be carried out by a control unit 15 which is in communication with appropriate sensors and actuators. For the sake of clarity these sensors and actuators are not explicitly shown in the figures.

In particular, the condensing power needed for providing the desired cooling at the evaporator 10 can be determined based on the temperature measured at the evaporator 10.

In a first exemplary mode of operation no condensing power at all is supplied by the heating system 7, for example because the heating system 7 is deactivated. In this case no refrigerant is liquefied by the heat-rejecting heat exchanger 4 and all the (gaseous) refrigerant entering the gas-liquid-separator 6 is directed to the condensers 14a, 14b in order to be liquefied.

The condensing power provided by the condensers 14a, 14b may be adjusted by selectively opening and closing the switchable valves 5a, 5b respectively activating and deactivating the associated condenser 14a, 14b.

In an embodiment comprising at least two condensers 14a, 14b, as it is shown in figure 1, the capacity of the first condenser 14a may be different, e. g. twice as large, from the capacity of the second condenser 14b allowing a flexible multi-stage adjustment of the condensing capacity provided by the condensers 14a, 14b. Of course, additional condensers fluidly connected to the refrigeration circuit 1a by means of additional valves may be added to allow an even finer adjustment of the condensing capacity provided by the condensers 14a, 14b.

In a second exemplary mode of operation some condensing power is delivered by the heating system 7, which is now operating, and as a result a mixture of gaseous and liquid phase refrigerant is delivered from the heat-rejecting heat exchanger 4 to the gas-liquid-separator 6. Said refrigerant mixture is separated by the gas-liquid-separator 6 into a gas phase portion and a liquid phase portion. The gas phase portion is delivered to the condensers 14a, 14b via the gaseous phase output line 6a in order to be liquefied, as described before with respect to the gaseous refrigerant present in the first mode of operation.

The liquid phase portion of the refrigerant mixture collects at the bottom of the gas-liquid-separator 6 and may not exit from the gas-liquid-separator 6 as long as the liquid refrigerant control device 16 provided in the liquid phase output line 6b is closed. The liquid meter 18 detects the level of liquid refrigerant col-

lected at the bottom of the gas-liquid-separator 6 and reports said level of liquid refrigerant to the liquid level control device 20.

When the level of liquid refrigerant collected at the bottom of the gas-liquid-separator 6, as it is detected by the liquid meter 18, raises above a first predetermined (maximum) level L_{max}, the liquid level control device 20 drives the liquid refrigerant control device 16 to open in order to allow liquid refrigerant to flow out of the gas-liquid-separator 6 to the expansion device 8 via the liquid phase output line 6b.

When the level of the liquid phase refrigerant portion collected within the gas-liquid-separator 6, as detected by the liquid meter 18, falls below a second predetermined (minimum) level L_{min}, which may be equal to or below the first predetermined level L_{max}, the liquid level control device 20 drives the liquid refrigerant control device 16 to close in order to stop the flow of liquid phase refrigerant out of the gas-liquid-separator 6. In this way the level of liquid refrigerant collected in the gas-liquid-separator 6 may be held close to a predetermined level $L=L_{min}=L_{max}$ or within a range which is defined by the first and second predetermined levels $L_{max} > L_{min}$.

In a third exemplary mode of operation the condensing power delivered by the heating system 7 is large enough to liquefy all the refrigerant delivered by the compressor 2 to the heat-rejecting heat exchanger 4. In this case, only liquid refrigerant is delivered from the heat-rejecting heat exchanger 4 into the gas-liquid-separator 6 and the level of liquid refrigerant collected within the gas-liquid-separator 6 raises rapidly. When the level of liquid refrigerant collected at the bottom of the gas-liquid-separator 6, as detected by the liquid meter 18, exceeds the first predetermined (maximum) level L_{max}, the liquid level control device 20 drives the liquid refrigerant control device 16 to open in order to allow liquid refrigerant to flow from the gas-liquid-separator 6 through the liquid phase output line 6b to the expansion device inlet line 17 and further into the expansion device 8. When the level of liquid refrigerant collected within the gas-liquid-separator 6, as detected by the liquid meter 18, falls below the second predetermined (minimum) level L_{min}, which may be equal to or lower than the first predetermined level L_{max}, the liquid level control device 20 drives the liquid refrigerant control device 16 to close in order to stop the flow of li-

quid phase refrigerant out of the gas-liquid-separator 6. Thus, the level of liquid refrigerant collected within the gas-liquid-separator 6 may be controlled in the same way as it has been described before with respect to the second mode of operation.

Figure 2 shows an example of a refrigeration circuit 1b according to a second embodiment of the invention. The same features are denoted by the same reference signs and will not be discussed in detail again.

The second embodiment differs from the first embodiment in that the liquid phase output line 6b of the the gas-liquid-separator 6 is not directly connected to the expansion device inlet line 17 but to the inlet side of the collecting container 12 in order to allow to collect the liquid phase refrigerant portion delivered by the gas-liquid-separator 6 in the collecting container 12, as well.

Figure 3 shows another example of a refrigeration circuit 1c according to a third embodiment of the invention. The same features are denoted by the same reference signs and will not be discussed in detail again.

The third embodiment differs from the second embodiment in that the common refrigerant line 13 is not connected to the inlet side of the collecting container 12 but directly to the expansion device inlet line 17. In consequence, the liquid refrigerant provided by the condensers 14a, 14b is delivered directly to to the expansion device 8 via the common refrigerant line 13 and the expansion device inlet line 17 bypassing the collecting container 12.

Figure 4 shows a further example of a refrigeration circuit 1d according to a fourth embodiment of the invention. The same features are denoted by the same reference signs and will not be discussed in detail again.

The fourth embodiment differs from the second embodiment in that the liquid phase output line 6b of the gas-liquid-separator 6 is not directly connected to the expansion device inlet line 17 but to the refrigerant line 13 upstream of the collecting container 12 in order to deliver the liquid refrigerant leaving the gas-liquid-separator 6 into the collecting container 12 together with the liquid refrigerant from the condenser(s) 14a, 14b.

In a fifth embodiment of a refrigeration circuit 1e, which is shown in figure 5, no collecting container 12 is provided at all and the common refrigerant line 13 as well as the liquid phase output line 6b are both connected directly to the expansion device inlet line 17 thereby delivering the liquid phase refrigerant portion from the gas-liquid-separator 6 as well as the liquid refrigerant from the condenser(s) 14a, 14b directly into the expansion device 8 without using a collecting container 12.

The exemplary modes of operation, which have been described in detail with respect to the refrigeration circuit 1a of the first embodiment accordingly apply to the operation of the refrigeration circuits 1b, 1c, 1d, 1e according to the second to fifth exemplary embodiments, as well.

Figure 6 shows a schematic view of a gas-liquid-separator 6 according to an exemplary embodiment of the invention, which may be used as the gas-liquid-separator 6 in any of the refrigeration circuits 1a, 1b, 1c, 1d, 1e described before. Such gas-liquid-separator 6 can also be called condensate and oil separator, since it separates in operation the gaseous phase refrigerant from the condensate/liquid phase refrigerant and oil.

In the exemplary embodiment shown in figure 6 the gas-liquid-separator 6 comprises a first separator pipe 60, which extends in a basically vertical direction and which is connected to the gaseous phase output line 6a and to the liquid phase output line 6b at its respective upper and lower ends. The refrigerant inlet line 6c opens in a basically horizontal direction into a middle portion of the first separator pipe 60.

The liquid phase portion of a gas-liquid-mixture of refrigerant entering via the refrigerant inlet line 6c into the first separator pipe 60 drops due to gravity to the lower portion of the first separator pipe 60 and exits through the liquid phase output line 6b connected to the bottom of the first separator pipe 60.

The gaseous phase portion of the gas-liquid-mixture collects in the upper portion of the first separator pipe 60 and may be extracted from the first separator

pipe 60 via the gaseous phase output line 6a connected to the upper portion of the first separator pipe 60.

In the lower portion of the first separator pipe 60, i.e. between the inlet line 6c and the liquid phase output line 6b, three connections 61, 62, 63 are formed within the first separator pipe 60 at different heights which correspond to a maximum liquid level L_{max}, an intermediate liquid level L_{opt} and a minimum liquid level L_{min}, respectively, and which allow to determine the level of liquid refrigerant collected in the first separator pipe 60 using level detection means connected to the individual connections 61, 62, 63.

A second separator pipe 66, which is considerably shorter than the first separator pipe 60, extends basically parallel to the lower portion of the first separator pipe 60. The bottom end of the second separator pipe 66 is connected to the liquid phase output line 6b, as well. The upper portion of the second separator pipe 66 is fluidly connected to the first separator pipe 60 by means of a horizontally extending connecting pipe 65. The second separator pipe 66 is provided with an inspection glass 64 arranged at the same height as the second connection 62 provided in the first separator pipe 60 at the intermediate liquid level L_{opt}.

A mechanical or capacitive liquid meter 18, which is not shown in figure 6, is furnished in or connected to at least one of the first and second separator pipes 60, 66 in order to allow to determine the level of the liquid phase refrigerant portion collected within the gas-liquid-separator 6.

The exemplary embodiment shown in figure 6 provides a gas-liquid-separator 6 which is easy to produce at low costs and which provides a sufficient gas-liquid-separation for many applications and in particular for the refrigerant circuit 1a, 1b, 1c, 1d, 1e as it has been described with respect to figures 1 to 5.

However, the gas-liquid-separator 6 shown in figure 6 is neither limited to any of the refrigeration circuits 1a, 1b, 1c, 1d, 1e shown in figures 1 to 5, nor to the position 6 in the lines 6a, 6c, 6b of the refrigeration circuits 1a, 1b, 1c, 1d, 1e shown the figures. It rather can be provided in any refrigeration circuit 1a, 1b,

1c, 1d, 1e where a gas-liquid mixture of a refrigerant is to be separated into a gaseous phase portion and a liquid phase portion.

The exemplary embodiments of the refrigeration circuits 1a, 1b, 1c, 1d, 1e shown figures 1 to 5 depict only one compressor 2, one expansion device 8 and one evaporator 10, respectively. The skilled person, however, will be aware that a plurality of compressors 2, expansion devices 8 and evaporators 10 may be provided without departing from the scope of the invention. The skilled person will also recognize that a deep-freezing circuit for providing even lower (deep-freezing) temperatures may be combined with the refrigeration circuits 1a, 1b, 1c, 1d, 1e shown in the figures, as it is known in the state of the art.

Similarly, additional heat rejecting heat exchangers may be arranged in parallel or serially to the heat rejecting heat exchanger 4 in order to connect further heat absorbing systems or components to the refrigeration circuit 1a, 1b, 1c, 1d, 1e.

In a refrigeration circuit according to an exemplary embodiment the liquid portion of the refrigerant leaving the heat rejecting heat exchanger is delivered directly to the expansion device while the gas portion of the refrigerant leaving the heat rejecting heat exchanger is separated from said liquid portion and condensed in an additional condenser before being delivered to the expansion device.

Thus, only liquid refrigerant is supplied to the expansion device, increasing the efficiency of the refrigeration circuit and securing its operability under all environmental circumstances.

In a refrigeration circuit according to exemplary embodiments as described herein no liquid refrigerant is delivered to the condenser(s) and in consequence an undesirable collection of liquid refrigerant, which would increase the amount of refrigerant needed for operating the refrigeration circuit, can be avoided.

Exemplary embodiments of the refrigeration circuit as described herein provide a refrigeration circuit in which the amount of liquid refrigerant collected in the gas-liquid-separator may be controlled so that the refrigeration circuit may be operated securely and with high efficiency under all environmental circumstances and which in particular can be adjusted to different heat dissipation rates of the heat rejecting heat exchanger.

In an embodiment the liquid refrigerant control device is a shutoff-valve. A shutoff-valve provides an inexpensive and reliable valve, which is easy to control, for controlling the level of liquid refrigerant within the gas-liquid-separator.

In an embodiment the liquid refrigerant control device is an adjustable valve, in particular a continuously adjustable valve. An adjustable valve, in particular a continuously adjustable valve, allows to control the level of liquid refrigerant within the gas-liquid-separator in a more sophisticated way.

In an embodiment the liquid refrigerant control device is an electrically or mechanically driven valve. An electrically or mechanically driven valve is easy to control by electrical means.

In an embodiment the liquid meter is a mechanical liquid meter, in particular a floating gauge. A mechanical liquid meter, in particular a floating gauge, provides an inexpensive and reliable meter for measuring the level of liquid refrigerant collected within the gas-liquid-separator.

In an embodiment the liquid meter is a capacity based liquid meter. A capacity based liquid meter provides a reliable liquid meter allowing to measure the level of liquid refrigerant collected within the gas-liquid-separator with high accuracy and without moving mechanical parts which may be subject to wear or degenerated by the refrigerant.

In an embodiment the liquid meter is configured to provide at least one signal if the level of liquid refrigerant collected in the gas-liquid-separator exceeds and/or falls below a predetermined level, respectively. A liquid meter providing such a signal allows a control of the level of liquid refrigerant collected within the gas-liquid-separator which is easy to implement.

In an embodiment the liquid meter is configured to provide a signal continuously indicating the level of liquid refrigerant collected within the gas-liquid-separator. A signal continuously indicating the level of liquid refrigerant collected within the gas-liquid-separator allows a sophisticated control of the level of liquid refrigerant in the gas-liquid-separator, in particular in combination with an adjustable valve, which may be opened partially. In this case, the opening degree of the adjustable valve may be controlled as a continuous function of the level of liquid refrigerant collected in the gas-liquid-separator, which is continuously indicated by the liquid meter.

In an embodiment a non-return valve is arranged in the refrigerant line preventing refrigerant from flowing back into at least one of the condensers after the compressor has been switched off in order to avoid that liquid refrigerant collects in the condenser(s) when the compressor is not operating.

In an embodiment a collecting container is provided downstream of the refrigerant line and upstream of the expansion device inlet line for collecting liquid refrigerant delivered by the condenser(s). A collecting container allows to store excessive refrigerant, which is not needed in the actual operation.

In an embodiment a collecting container is provided downstream of the liquid phase output line and upstream of the expansion device inlet line allowing to collect the liquid phase refrigerant, which is delivered by the gas-liquid-separator, in the collecting container.

The liquid phase output line may be fluidly connected to the refrigerant line (condenser output line) upstream of the collecting container or to an inlet side of the collecting container.

Alternatively, the liquid phase output line may be fluidly connected to the expansion device inlet line downstream of the collecting container. Connecting the liquid phase output line to the expansion device inlet line downstream of the collecting container may help to avoid fluctuations in the refrigerant circuit and to provide a more stable operation of the refrigerant circuit.

In embodiments without collecting container the refrigerant line and the liquid phase output line open directly into the expansion device inlet line and the refrigerant line and/or the liquid phase output line may be formed integrally with the expansion device inlet line.

In an embodiment a pressure regulation valve is arranged in the gaseous phase output line allowing to control the gas pressure within the gas-liquid-separator in order to optimize the efficiency of the refrigeration circuit even further.

In an embodiment the pressure regulation valve is a shutoff-valve which may be operated periodically. A periodically operated shutoff-valve provides an inexpensive, reliable and easy way for adjusting the gas pressure within the gas-liquid-separator.

In an embodiment the pressure regulation valve is an adjustable valve, in particular a continuously adjustable valve. An adjustable valve, in particular a continuously adjustable valve, allows to control the gas pressure within the gas-liquid-separator in a more sophisticated way.

In an embodiment the pressure regulation valve is an electrically or mechanically driven valve. An electrically or mechanically driven valve is easy to control e.g. by electromechanical means.

In an embodiment of the refrigeration circuit at least two condensers connected in parallel are provided and the gaseous phase output line branches into separate line portions, one portion connected to each of the condensers. By providing two or more condensers, the condensing capacity can be adjusted to the needs of the refrigeration circuit in order to operate the refrigeration circuit with high efficiency.

In an embodiment of the refrigeration circuit at least one switchable valve is arranged upstream of each of the condensers allowing to selectively activate and deactivate the corresponding condenser.

In a further embodiment of the refrigeration circuit the at least two condensers being connected in parallel differ in their maximum achievable condensing

power. By providing two or more condensers with different condensing power/capacities, the condensing capacity can be adjusted more precisely to the needs of the refrigeration circuit in order to operate the refrigeration circuit with high efficiency.

According to a further embodiment the refrigeration circuit is configured to determine the condensing power needed in order to provide the desired cooling at the evaporator. This condensing power needed is used as a command variable for controlling the refrigeration circuit.

According to a further embodiment the refrigeration circuit is configured to measure the condensing power delivered by the heat rejecting heat exchanger. For performing said measurement an appropriate sensor may be provided at the heat rejecting heat exchanger.

According to a further embodiment the refrigeration circuit is configured to compare the condensing power needed to the condensing power available through the heat rejecting heat exchanger and the condenser(s). For determining such available condensing power the specifications of the heat rejecting heat exchanger and the condenser(s), appropriate sensors at the heat rejecting heat exchanger and/or the condenser(s) may be used. The comparison may be carried out in an appropriate controller of the refrigeration circuit.

While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalence my be substitute for elements thereof without departing from the scope of the invention. In addition, modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention is not limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope of the pendent claims.

Reference Numerals

1a, 1b, 1c, 1d, 1e	refrigeration circuit
2	compressor
3	pressure line
4	heat rejecting heat exchanger
5a	first switchable valve
5b	second switchable valve
6	gas-liquid separator
6a	gaseous phase output line of the gas-liquid separator
6b	liquid phase output line of the gas-liquid separator
6c	inlet line of the gas-liquid separator
7	heating system
8	expansion device
9	first fluid line of the heating system
10	evaporator
11	second fluid line of the heating system
12	collecting container (receiver)
13	refrigerant line (condenser output line)
14a	first condenser
14b	second condenser
15	control unit
16	liquid refrigerant control device
17	expansion device inlet line
18	liquid meter
20	liquid level control device
22	non-return valve
24	pressure regulation valve
60	first separator pipe
61, 62, 63	connections
64	inspection glass
65	horizontal connecting pipe
66	second separator pipe

Claims

1. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) circulating a refrigerant and comprising in the direction of flow of the refrigerant:

at least one compressor (2);

at least one condenser (14a, 14b);

a refrigerant line (13);

an expansion device inlet line (17);

at least one expansion device (8); and

at least one evaporator (10);

wherein the refrigeration circuit (1a, 1b, 1c, 1d, 1e) further comprises:

a heat rejecting heat exchanger (4) for heat exchange of the refrigerant with a heating system (7), an input side of the heat rejecting heat exchanger (4) being fluidly connected the output side of the compressor (2);

a gas-liquid-separator (6) fluidly connected to an output side of the heat rejecting heat exchanger (4) and being configured to separate the refrigerant leaving the heat rejecting heat exchanger (4) into a gaseous phase refrigerant portion and a liquid phase refrigerant portion, the gas-liquid-separator (6) having a gaseous phase output line (6a) fluidly connected to an inlet side of the at least one condenser (14a, 14b) and a liquid phase output line (6b) which is fluidly connected to the expansion device inlet line (17) and/or a collecting container (12) provided upstream of the at least one expansion device inlet line (17);

a liquid refrigerant control device (16) arranged in the liquid phase output line (6b), which is configured to control the flow of liquid refrigerant flowing out of the gas-liquid-separator (6);

a liquid meter (18), which is configured to measure the level of liquid refrigerant collected within the gas-liquid-separator (6) and to provide at least one signal indicative of the level of liquid refrigerant collected within the gas-liquid-separator (6); and

a liquid level control device (20) coupled to the liquid meter (18) and to the liquid refrigerant control device (16), the liquid level control device (20) being configured to drive the liquid refrigerant control device (16) based on the at least one signal provided by the liquid meter (18).

2. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of claim 1, wherein the liquid meter (18) is configured to provide a first signal if the level of liquid refrigerant in the gas-liquid-separator (6) raises above a predetermined level and/or to provide a second signal if the level of liquid refrigerant in the gas-liquid-separator (6) falls below a predetermined level.

3. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of claim 1 or 2, wherein the liquid meter (18) is configured to provide a continuous signal indicating the level of liquid refrigerant collected within the gas-liquid-separator (6).

4. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of any of the preceding claims, wherein the liquid meter (18) is a mechanical liquid meter, in particular a floating gauge, or a capacity based liquid meter.

5. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of any of the preceding claims, wherein the liquid refrigerant control device (16) is a shutoff-valve or an adjustable valve, in particular a continuously adjustable valve.

6. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of claim 5, wherein the liquid refrigerant control device (16) is an electrically, mechanically or electro-mechanically driven valve.

7. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of any of the preceding claims, wherein a non-return valve (22) is arranged in the refrigerant line (13).

8. Refrigeration circuit (1a, 1b, 1d) of any of the preceding claims, wherein a collecting container (12) is provided between the refrigerant line (13) and the expansion device inlet line (17).

9. Refrigeration circuit (1b, 1c, 1d) of any of the preceding claims, wherein a collecting container (12) is provided between the liquid phase output line (6b) and the expansion device inlet line (17).

10. Refrigeration circuit (1a, 1b, 1c, 1d) of claim 9, wherein the liquid phase output line (6b) is fluidly connected to an inlet side of the collecting container (12).

11. Refrigeration circuit (1c) of claim 8 or 9, wherein the liquid phase output line (6b) is fluidly connected to the refrigerant line (13) upstream of the collecting container (12).

12. Refrigeration circuit (1a) of claim 8, wherein the liquid phase output line (6b) is fluidly connected to the expansion device inlet line (17) downstream of the collecting container (12).

13. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of any of the preceding claims, wherein a pressure regulation valve (24) is arranged in the gaseous phase output line (6a).

14. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of claim 13, wherein the pressure regulation valve (24) is a shutoff-valve, an adjustable valve, particularly a continuously adjustable valve, and/or an electrically, mechanically or electro-mechanically driven valve.

15. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of any of the preceding claims, wherein at least two condensers (14a, 14b) are provided which are connected in parallel.

16. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of claim 15, wherein the at least two condensers (14a, 14b) connected in parallel differ in their respective maximum achievable condensing power.

17. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of claim 15 or 16, wherein at least one switchable valve (5a, 5b) is arranged upstream of each of the condensers (14a, 14b) allowing to activate and deactivate the corresponding condenser (14a, 14b).

18. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of any of the preceding claims, wherein the refrigeration circuit (1a, 1b, 1c, 1d, 1e) further comprises means which are configured to determine the condensing power needed in order to provide the desired cooling at the evaporator (10).

19. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of claim 18, wherein the refrigeration circuit (1a, 1b, 1c, 1d, 1e) further comprises means which are configured to measure the condensing power delivered by the heat rejecting heat exchanger (4).

20. Refrigeration circuit (1a, 1b, 1c, 1d, 1e) of claim 18 or 19, wherein the refrigeration circuit (1a, 1b, 1c, 1d, 1e) comprises means which are configured to compare the condensing power needed with the condensing power which is available through the heat rejecting heat exchanger (4) and the condenser(s) (14a, 14b).

21. Heating and cooling system comprising

a refrigeration circuit (1a, 1b, 1c, 1d, 1e) according to one of the preceding claims; and

a heating system (7);

wherein the heat rejecting heat exchanger (4) of the refrigeration circuit (1a, 1b, 1c, 1d, 1e) is configured to serve as a heat source for the heating system (7).

22. Heating and cooling system of claim 21, wherein the heating system (7) comprises a heat pump.

23. Method of operating a refrigeration circuit (1a, 1b, 1c, 1d, 1e) circulating a refrigerant and comprising in the direction of flow of the refrigerant:

at least one compressor (2);

at least one condenser (14a, 14b);

at least one expansion device (8); and

at least one evaporator (10);

wherein the refrigeration circuit (1a, 1b, 1c, 1d, 1e) further comprises:

a heat rejecting heat exchanger (4) for heat exchange of the refrigerant with a heating system (7), an input side of the heat rejecting heat exchanger (4) being fluidly connected the output side of the compressor (2);

a gas-liquid-separator (6) which is fluidly connected to an output side of the heat rejecting heat exchanger (4) and which is configured to separate the refrigerant leaving the heat rejecting heat exchanger (4) into a gaseous phase refrigerant portion and a liquid phase refrigerant portion, the gas-liquid-separator

(6) having a gaseous phase output line (6a) fluidly connected to the at least one condenser (14a, 14b) and a liquid phase output line (6b) fluidly connected to the expansion device (8) and/or a the collecting container (12) provided upstream of the at least one expansion device (8),

a liquid refrigerant control device (16) arranged in the liquid phase output line (6b) which is configured to control the flow of liquid refrigerant flowing out of the gas-liquid-separator (6);

a liquid meter (18) which measures the level of liquid refrigerant within the gas-liquid-separator (6) and which provides at least one signal indicative of the level of liquid refrigerant within the gas-liquid-separator (6);

wherein the method includes to control the level of liquid refrigerant collected within the gas-liquid-separator (6) by means of driving the liquid refrigerant control device (16) based on the at least one signal provided by the liquid meter (18).

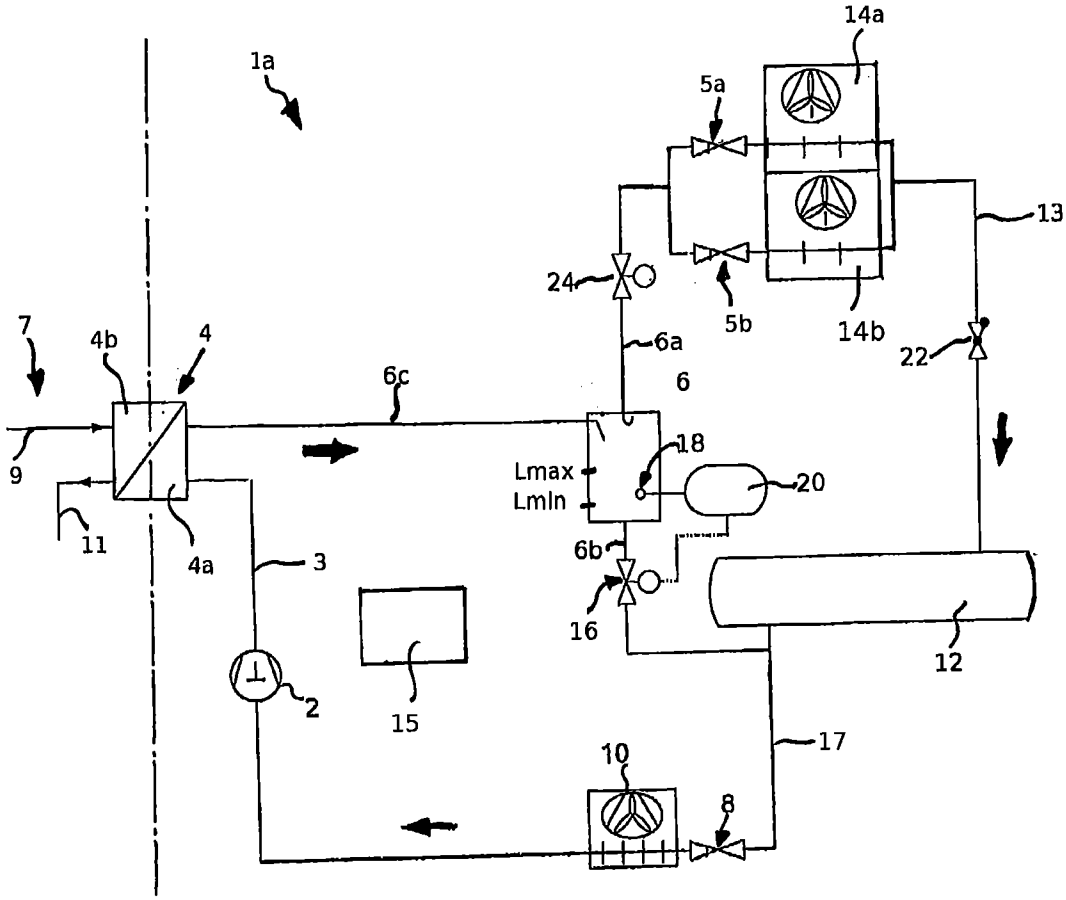

1a
14a
5a
13
24
5b
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22
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4b
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6
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8

Fig. 1

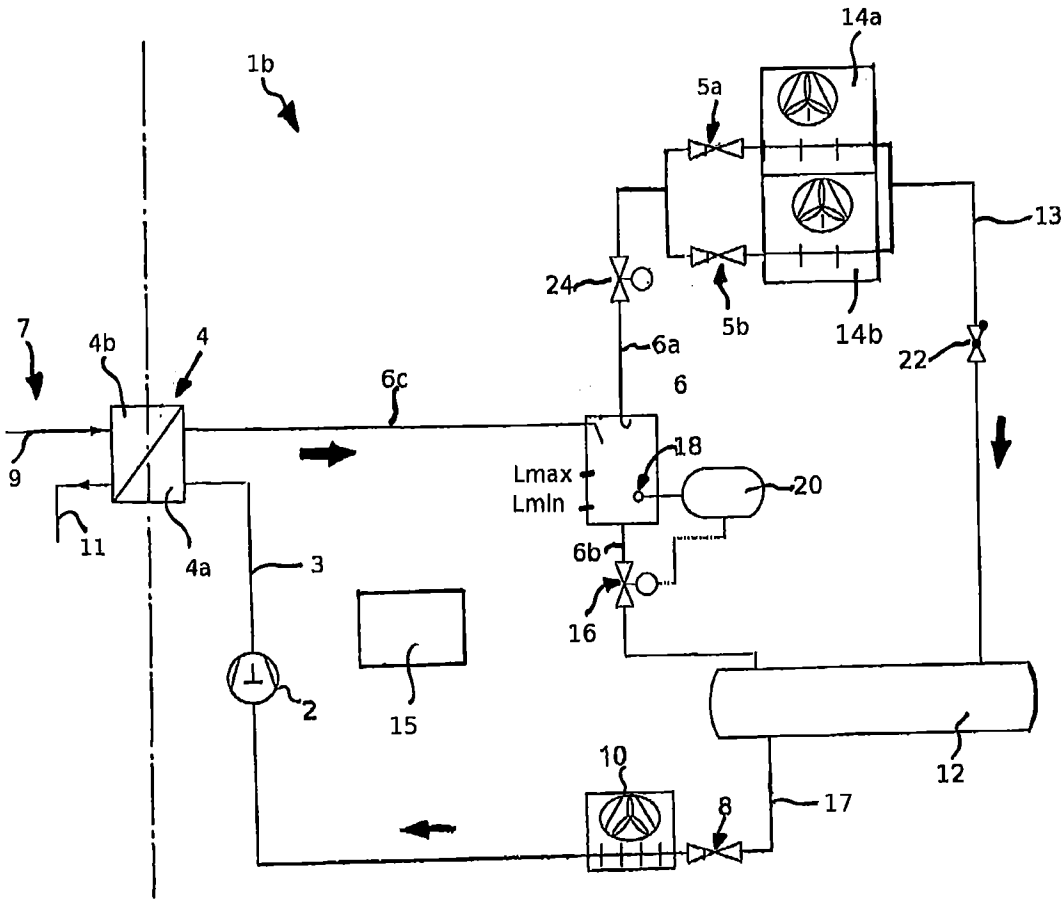

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Fig. 2

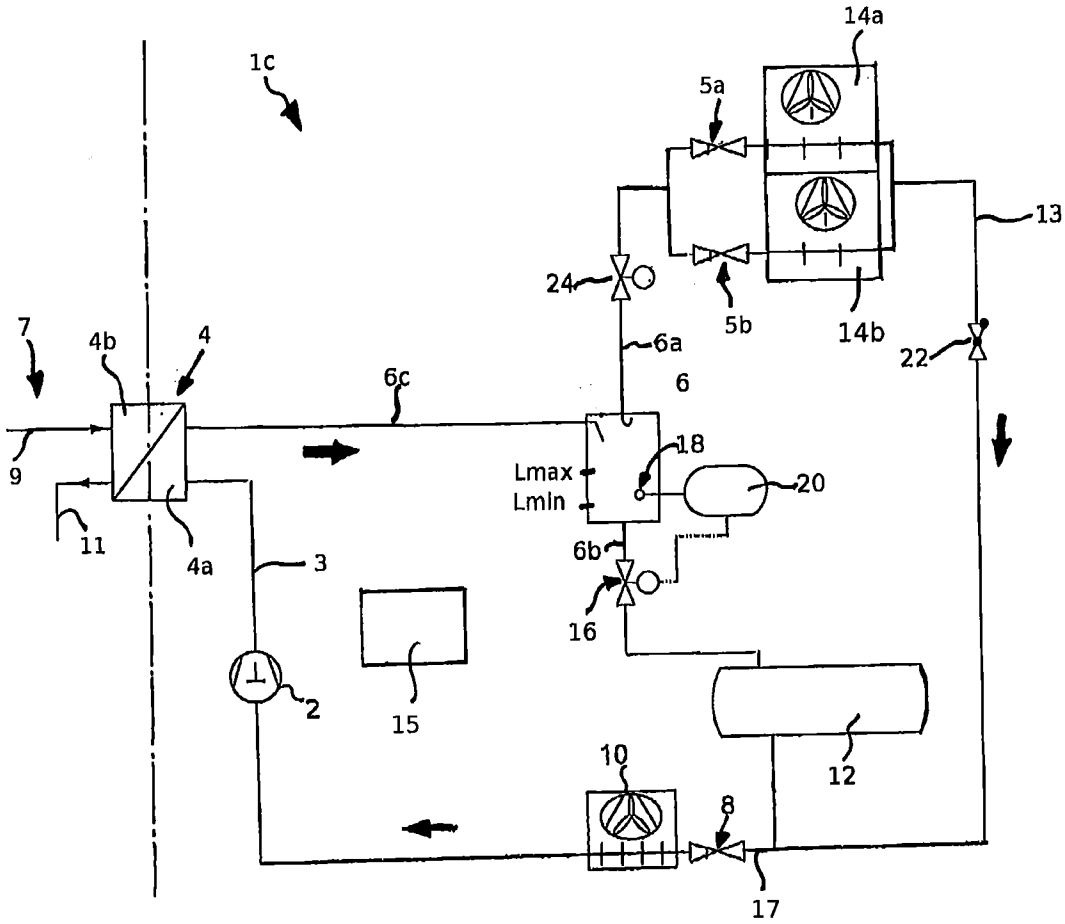

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Fig. 3

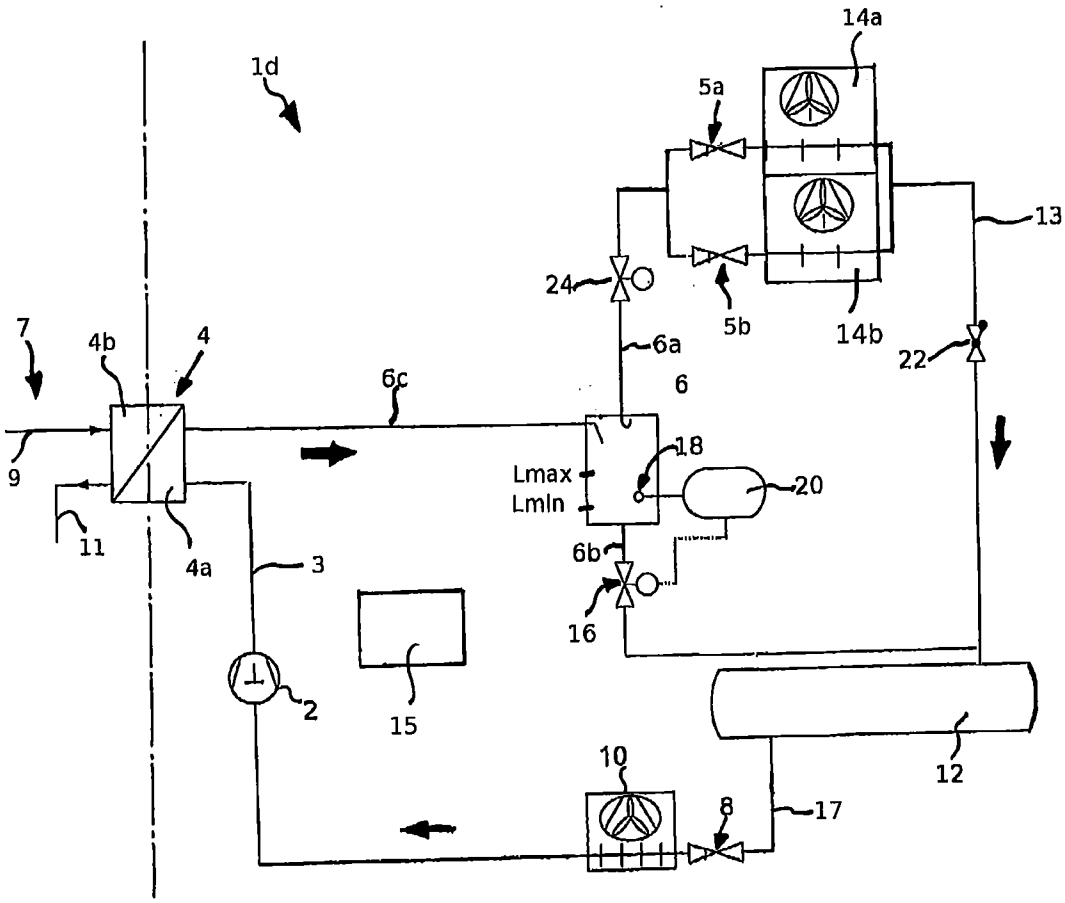

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Fig. 4

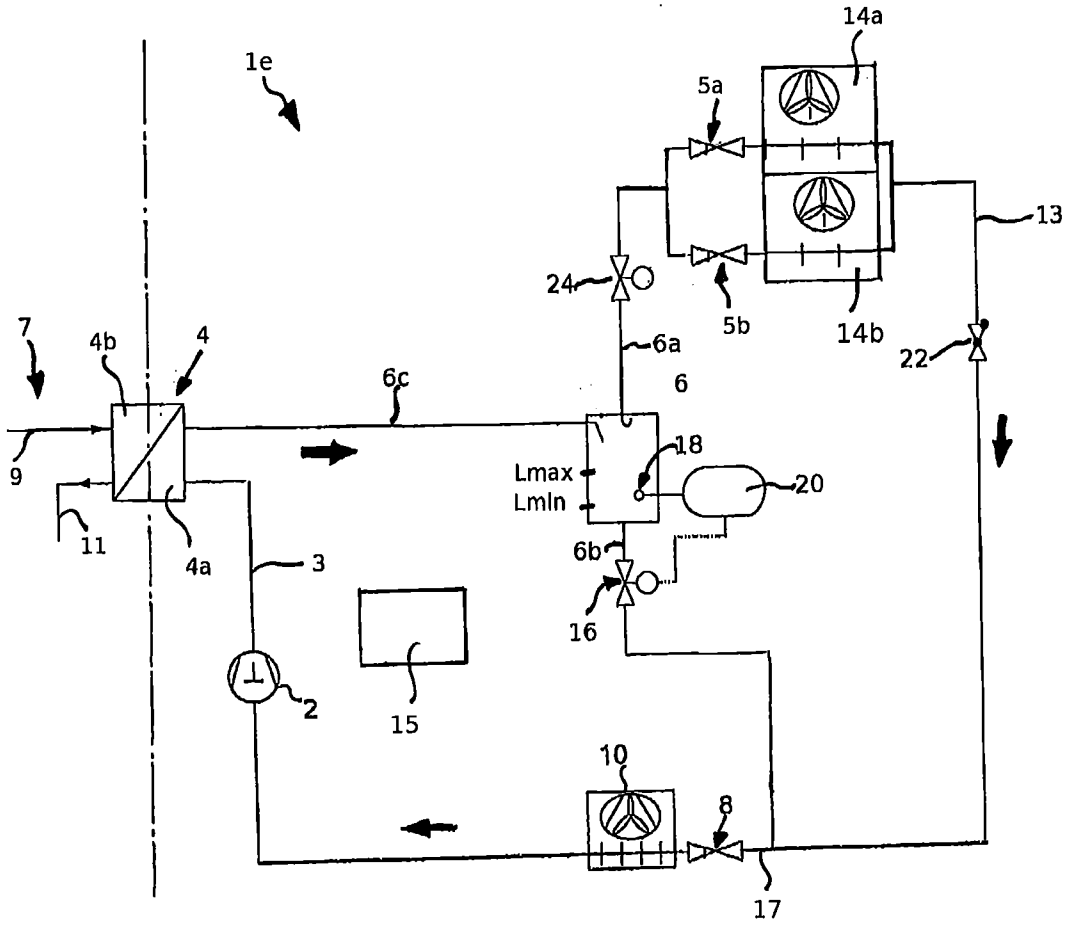

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Fig. 5

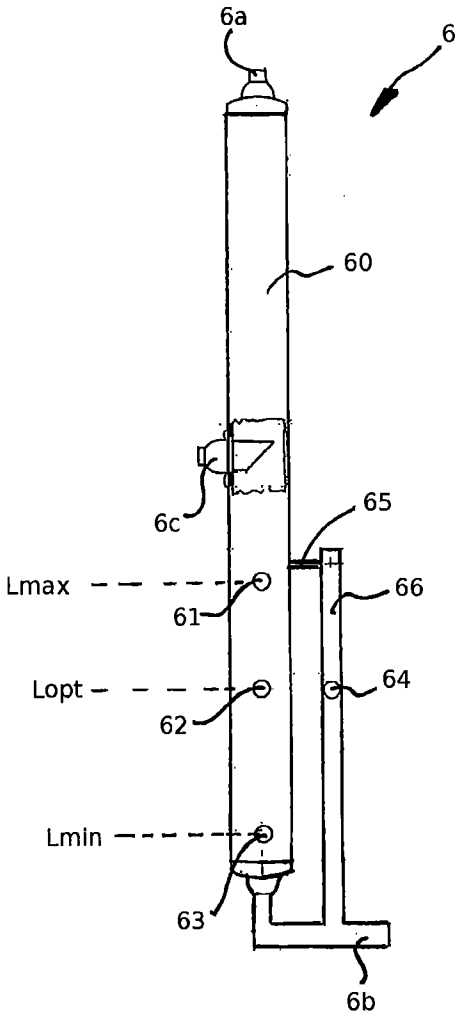


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/058274

A. CLASSIFICATION OF SUBJECT MATTER
INV. F25B6/04
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 420 218 A2 (RHOSS S P A [IT]) 19 May 2004 (2004-05-19) figures 1,2 -----	1-23

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 January 2013	08/02/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Dezso, Gabor

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/058274

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1420218 A2	19-05-2004	AT 408103 T	15-09-2008
		EP 1420218 A2	19-05-2004
		ES 2312712 T3	01-03-2009