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(54) HEAT PUMP AND METHOD FOR OPERATING A HEAT PUMP

(57) Provided is a heat pump and a method for operating a heat pump. In a heating mode, the heat pump comprises a refrigeration cycle including connected in a loop by fluid lines and in succession: a compressor, a first heat exchanger, a third heat exchanger, a second expansion valve, and a second heat exchanger. The refrigeration cycle further comprises an internal heat exchanger having a first conduit and a second conduit being in heat exchanging contact, wherein the first conduit is part of the fluid line between the third heat exchanger and the second expansion valve, and the second conduit is part of the fluid line between the second heat exchanger and the compressor, wherein the third heat exchanger is configured to reduce a temperature of the refrigerant provided from the first heat exchanger to the internal heat exchanger by giving off heat to a physical medium.

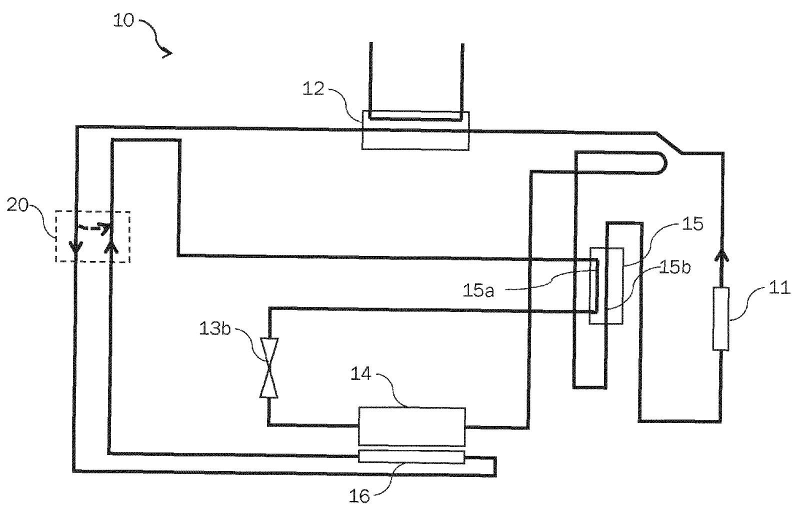

Fig. 1

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Description

Introduction

[0001] A compressor of a heat pump requires in many cases a completely evaporated refrigerant on the input side of the compressor to increase lifetime and efficiency of the heat pump. Suction superheat prevents the compressor from being flown through by liquid refrigerant. However, suction superheat needs to be controlled, such that a certain threshold is not passed, to improve a performance range of the compressor envelope having a high compression ratio area.

[0002] EP 1 886 076 A0 shows a heat pump system including a compressor, a reversing valve, an outdoor heat exchanger and an indoor heat exchanger coupled via refrigerant lines in a conventional refrigeration circuit, and a refrigerant-to-water heat exchanger. In the air cooling with water heating mode, the air heating with water heating mode and the water heating only mode, water from a water reservoir, such as a storage tank or swimming pool, is passed through the heat exchanger in heat exchanging relationship with refrigerant passing through line. A refrigerant reservoir may be provided for use in refrigerant charge control. A refrigerant line couples the reservoir to the refrigerant circuit intermediate the outdoor and indoor heat exchangers for directing liquid refrigerant into the reservoir and a refrigerant line couples the refrigerant circuit upstream of the suction inlet to the compressor for returning refrigerant to the refrigerant circuit. A controller controls flow into and from the refrigerant reservoir through selective opening and closing of a control valve in line. First and second expansion valves are disposed in a section of the refrigerant line. The first expansion valve is operatively associated with the outdoor heat exchanger and the second expansion valve is operatively associated with the indoor heat exchanger. Each of the expansion valves are provided with a bypass line equipped with a check valve permitting flow in only one direction. A check valve in bypass line associated with the outdoor heat exchanger expansion valve passes refrigerant flowing from the outdoor heat exchanger to the indoor heat exchanger, thereby bypassing the outdoor heat exchanger expansion valve and passing the refrigerant to the indoor heat exchanger expansion valve. A check valve in bypass line associated with the indoor heat exchanger expansion valve passes refrigerant flowing from the indoor heat exchanger to the outdoor heat exchanger, thereby bypassing the indoor heat exchanger expansion valve and passing the refrigerant to the outdoor heat exchanger expansion valve. Additionally, t refrigerant-to-water heat exchanger is operatively associated with the refrigerant line whereby refrigerant flowing through the refrigerant line passes in heat exchange relationship with water passing through water circulation line.

[0003] In view of that, it is an object to provide a heat pump and a method for operating a heat pump, which are cheap, efficient and reliable in particular in a heating mode.

Description

[0004] To solve the above problem, a heat pump and a method for operating a heat pump having the features of the independent claims are provided. The dependent claims refer to embodiments thereof. In the following, aspects and embodiments of the invention are described.

[0005] A first aspect refers to a heat pump comprising a refrigeration cycle. The refrigeration cycle comprises, in a heating mode, connected in a loop by fluid lines and in succession: a compressor, a first heat exchanger, a third heat exchanger, a second expansion valve, and a second heat exchanger. The refrigeration cycle further comprises in the heating mode an internal heat exchanger having a first conduit and a second conduit, the first conduit being in heat exchanging contact with the second conduit, wherein the first conduit is part of the fluid line between the third heat exchanger and the second expansion valve, and the second conduit is part of the fluid line between the second heat exchanger and the compressor.

[0006] In the heating mode, the compressor is configured to compress a refrigerant in the refrigeration cycle and the first heat exchanger is a condenser and is configured to add thermal energy from the refrigerant to a fluid circuit to be heated. The third heat exchanger is configured to reduce a temperature of the refrigerant provided from the first heat exchanger to the internal heat exchanger by giving off heat to a second physical medium and the second expansion valve is configured to reduce a pressure of the refrigerant after the refrigerant passes the expansion valve. The second heat exchanger is an evaporator, evaporating the refrigerant by adding thermal energy of a first physical medium to the refrigerant. This has the advantage that suction superheat in the heating mode is reduced such that a working range of the compressor is optimized and therefore a performance range of the compressor envelope having a high compression ratio area is increased in the heating mode.

[0007] In some embodiments, the refrigeration cycle may comprise connected in a loop by fluid lines and in succession in a cooling mode: the compressor, the second heat exchanger, a first expansion valve, and the first heat exchanger. The refrigeration cycle may further comprise in the cooling mode the internal heat exchanger, wherein the first conduit of the internal heat exchanger is part of the fluid line between the second heat exchanger and the first expansion valve and the second conduit of the internal heat exchanger is part of the fluid line between the first heat exchanger and the compressor.

[0008] The compressor may be configured to compress a refrigerant in the refrigeration cycle and the first heat exchanger may be an evaporator and may be configured to add thermal energy from a fluid circuit to the refrigerant. The first expansion valve may be configured to reduce a pressure of the refrigerant after the refrigerant passes the expansion valve. The second heat exchanger may be a condenser, condensing the refrigerant by giving off thermal energy of the refrigerant to the third physical medium. This has the advantage that suction superheat in the cooling mode may be reduced such that a working range of the compressor is optimized and therefore a performance range of the compressor envelope having a high compression ratio area is increased in the cooling mode.

[0009] In some embodiments, the heat pump may be configured to switch between the heating mode and the cooling mode and the refrigeration cycle may comprise for switching between the heating mode and the cooling mode: a four-way valve, a first one-way valve, and a second one-way valve. The four-way valve may be configured to link the fluid line from a compressor output to the first heat exchanger and to link a fluid line from the second heat exchanger to the second conduit of the internal heat exchanger for the heating mode, and to link the fluid line from the compressor output to the second heat exchanger and to link the fluid line from the first heat exchanger to the second conduit of the internal heat exchanger for the cooling mode. A bypass of the first expansion valve in a direction from the first heat exchanger to the first conduit of the internal heat exchanger may be provided by a fluid line comprising the third heat exchanger and the first one-way valve. A bypass of the second expansion valve in a direction from the second heat exchanger to the first conduit of the internal heat exchanger may be provided by a fluid line comprising the second one-way valve.

[0010] Thus, a heat pump efficiently usable in a heating mode and a cooling mode is provided.

[0011] In some embodiments, a bypass of the first conduit of the internal heat exchanger may be provided by a fluid line comprising a bypass valve, in particular a controllable valve. This leads to the technical effect that suction superheat is controllable in the cooling mode such that a temperature of the refrigerant provided to the compressor is above a predetermined temperature. This leads to an improved performance range of the compressor envelope having a high compression area. As a consequence, an overall efficiency of the heat pump is increased.

[0012] In very advantageous embodiments, the heat pump may be configured to control the bypass valve such that the temperature of the refrigerant provided to the input of the compressor is below a first predetermined temperature in the cooling mode and/or such that the temperature of the refrigerant provided to the input of the compressor is above a second predetermined temperature in the cooling mode. This has the advantage that usage of the compressor can be optimized with low effort, since the refrigerant provided to the compressor has a preferable temperature.

[0013] In a very controllable embodiment, the refrigeration cycle may further comprise in the heating mode a three-way valve and a bypass of the third heat exchanger. The heat pump may be configured to control the flow rate through the bypass of the third heat exchanger and through the third heat exchanger by means of the three-way valve such that the temperature of the refrigerant provided to the input of the compressor is below a third predetermined temperature in the heating mode and/or such that a temperature of the refrigerant provided to the input of the compressor is above a fourth predetermined temperature in the heating mode. This may have the advantage that an overall efficiency of the heat pump, in particular of the compressor, may be improved, since the temperature of the refrigerant provided to the compressor may be within a preferable temperature range such that the compressor may work at a preferable working point having a high efficiency and a large performance range.

[0014] In some embodiments, the three-way valve may be implemented by means of one or more, in particular two or more three-way valve components.

[0015] The first predetermined temperature may be equal to or may differ from the third predetermined temperature. The second predetermined temperature may be equal to or may differ from the fourth predetermined temperature. The first, the second, the third, and/or the fourth predetermined temperature may be predetermined based on a working point, a working mode, a working range, physical properties of the refrigerant within the refrigeration cycle, and/or an efficiency of the compressor with respect to the temperature of the refrigerant provided to the compressor. The working mode, the working point and/or the working range of the compressor may be provided based on an efficiency of the compressor compared to other working points, working ranges, and/or working modes of the compressor.

[0016] In a very adapted embodiment, one or more of the following group may be a predetermined constant value: the first predetermined temperature, the second predetermined temperature, the third predetermined temperature, the fourth predetermined temperature. Further, in embodiments, one or more of the following group may be determined in dependence of a temperature difference of the internal heat exchanger: the first predetermined temperature, the second predetermined temperature, the third predetermined temperature, the fourth predetermined temperature. A temperature difference of the internal heat exchanger may be at least one of the group: a temperature difference between an input of the first conduit and the output of the second conduit, a temperature difference between the input of the first conduit and the output of the first conduit, and a temperature difference between the input of the second conduit and the output of the second conduit.

[0017] In some embodiments, one or more of the following group may be determined in dependence on a measured temperature: the first predetermined temperature, the second predetermined temperature, the third predetermined temperature, the fourth predetermined temperature. The measured temperature may be at least one of the group: an input temperature of the first conduit of the internal heat exchanger, an output temperature of the first conduit of the internal heat exchanger, an input temperature of the second conduit of the internal heat exchanger, and an output temperature of the second conduit of the internal heat exchanger.

[0018] This may have the advantage that the temperature of the refrigerant provided to the compressor may be controlled very efficiently and with low effort and with low time delay. Another advantage is that a compressor lifetime may be increased.

[0019] The first expansion valve may be an electronic expansion valve and/or a thermal expansion valve. In some embodiments, the second expansion valve may be an electronic expansion valve and/or a thermal expansion valve. This may have the advantage that control of the refrigeration cycle can be executed very exactly and with low effort and low costs.

[0020] In some embodiments, the first and/or the second and/or the third physical medium may be one or more of the group: air, water, brine, and soil. In some embodiments, the first and/or the second physical medium may be the same or may be different. In some embodiments, the first and the third physical medium may be the same or may be different. In some embodiments, the second and the third physical medium may be the same or different. This may have the advantage that resources may be used highly optimized and flexibly, whereas effort is maintained low.

[0021] Preferably, the heat pump may be one or more of the group: an air-water heat pump, a geothermal heat pump and a brine-water heat pump.

[0022] In a very advantageous embodiment, the second heat exchanger may comprise a first fin tube for a heat exchange of the refrigerant with air and/or water and/or any other physical medium. In some embodiments, the third heat exchanger may comprise a second fin tube for heat exchange of the refrigerant with air and/or water and/or any other physical medium. A fin tube may have the advantage that a heat exchange with a medium like air, water, and other fluids is very efficient.

[0023] In a very efficient embodiment, at least a section of the first fin tube may be disposed above at least a section of the second fin tube, when seen from a top view. This may have the advantage that a heat provided by the third heat exchanger may be used for avoiding an icing, in particular glacier icing within the first fin tube.

[0024] In some embodiments, the heat pump may comprise a third fin tube, wherein a first section of the third fin tube comprises at least a part of the second heat exchanger, in particular the whole second heat exchanger, and a second section of the third fin tube comprises at least a part of the third heat exchanger, in particular the whole third heat exchanger. In some embodiments, the first section of the third fin tube and the second section of the third fin tube may not intersect. In some embodiments, the first section of the third fin tube and the second section of the third fin tube may intersect. The third fin tube may have the advantage that the second heat exchanger and the third heat exchanger may be realized within one component very cheap.

[0025] In very advanced embodiments, at least a part of the first section of the third fin tube may be disposed above at least a part of the second section of the third fin tube, when seen from a top view. In some embodiments, at least a part of the second section of the third fin tube may be disposed on a bottom side of the third fin tube. This may have the technical benefit that an icing, in particular glacier icing, on a bottom side and/or of parts of the second heat exchanger may be avoided.

[0026] A heat exchanger may be a unit to transfer heat from a source medium to a receiver medium, wherein the source medium may be separated by a solid wall to prevent mixing or direct contact to the receiving medium. Non-limiting examples for heat exchangers are a double-pipe heat exchanger (parallel flow and/or counter flow), a shell-and-tube heat exchanger, a plate heat exchanger, a condenser heat exchanger, and a boiler heat exchanger.

[0027] A bypass may comprise one or more fluid lines to provide a work around for the refrigerant regarding the bypassed unit. In some embodiments, a bypass may be one-directional, for example realized by a one-way valve. That means that the bypass only exists in the one direction, but not in the other direction.

[0028] A second aspect of the present application refers to a method for operating a heat pump as described above. This may have the advantage that performance range, efficiency, and durability when operating the heat pump may be improved.

[0029] A third aspect of the present application refers to a method for operating a heat pump. The heat pump includes a refrigeration cycle comprising in a heating mode a compressor, an internal heat exchanger being configured to provide heat from a high pressure section in a refrigeration cycle of the heat pump to a low pressure section of the refrigeration cycle before the refrigerant gets to an input of the compressor in the low pressure section of the refrigeration cycle. The refrigeration cycle comprises additionally in the heating mode a third heat exchanger being configured to cool down the refrigerant before getting to a high pressure section of the internal heat exchanger, a bypass of the third heat exchanger, and a three-way valve being configured to control a flow rate to the third heat exchanger and a flow rate being bypassed of the third heat exchanger.

[0030] The method comprises, in the heating mode, the steps of capturing one or more physical system parameters of the heat pump comprising one or more of the group: a pressure within the refrigeration cycle, a temperature within the refrigeration cycle, and an electrical power of an inverter of the heat pump. The method further comprises controlling the three-way valve based on the captured one or more physical system parameters and one or more predetermined thresholds. The one or more physical system parameters and one or more predetermined thresholds may refer to each other. For example, a captured temperature (physical system parameter) may have a minimum and/or a maximum temperature as a predetermined threshold. Same applies analogously to a measured pressure.

[0031] In one or more embodiments, the refrigeration cycle may comprise in a cooling mode the compressor, the internal heat exchanger being configured to provide heat from the high pressure section in the refrigeration cycle of the heat pump to a low pressure section of the refrigeration cycle before the refrigerant gets to an input of the compressor in the low pressure section of the refrigeration cycle, and a bypass of the high-pressure section of the internal heat exchanger, the bypass comprising a bypass valve, the bypass valve being configured to control a flow rate of the refrigerant through the internal heat exchanger on the high pressure section in the refrigeration cycle of the heat pump and a flow rate of the refrigerant through the bypass of the high-pressure section of the internal heat exchanger. The method may comprise in the cooling mode the steps of capturing one or more physical system parameters of the heat pump comprising one or more of the group: a pressure within the refrigeration cycle, a temperature within the refrigeration cycle, and an electrical power of an inverter of the heat pump; and controlling the bypass valve based on the captured one or more physical system parameters and one or more predetermined thresholds.

Description of Drawings

[0032]

Fig. 1 shows schematically a diagram of a heat pump comprising a refrigeration cycle in the heating mode.

Fig. 2 shows schematically a diagram of a heat pump comprising a refrigeration cycle in a cooling mode.

Fig. 3 shows schematically a diagram of a heat pump usable in a heating mode and in a cooling mode.

Fig. 4 shows schematically a method for operating a heat pump in a heating mode.

Fig. 5 shows schematically a method for operating a heat pump in a cooling mode.

[0033] Fig. 1 shows schematically a diagram of a heat pump comprising a refrigeration cycle in the heating mode. The refrigeration cycle comprises a compressor 11, a first heat exchanger 12, a third heat exchanger 16, a second expansion valve 13b, and a second heat exchanger 14, wherein the components are connected in a loop by fluid lines and in succession. The refrigeration cycle further comprises in the heating mode an internal heat exchanger 15 having a first conduit 15a and a second conduit 15b, the first conduit 15a being in heat exchanging contact with the second conduit 15b, and the first conduit is part of the fluid line between the third heat exchanger 16 and the second expansion valve 13b. The second conduit 15b is part of the fluid line between the second heat exchanger 14 and the compressor 11.

[0034] In the heating mode, the compressor is configured to compress a refrigerant in the refrigeration cycle. The first heat exchanger is a condenser and is configured to add thermal energy from the refrigerant to a fluid circuit to be heated and the third heat exchanger is configured to reduce a temperature of the refrigerant provided from the first heat exchanger to the internal heat exchanger by giving off heat to a second physical medium. The second expansion valve 13b is configured to reduce a pressure of the refrigerant after the refrigerant passes the expansion valve, and the second heat exchanger is an evaporator, evaporating the refrigerant by adding thermal energy of a first physical medium to the refrigerant.

[0035] By means of the third heat exchanger 16, it is possible to reduce a temperature of the refrigerant passing the first conduit 15a of the internal heat exchanger. Thus, less heat is transmitted from the first conduit 15a to the second conduit 15b within the internal heat exchanger 15. As a consequence, the refrigerant provided to the compressor has a reduced temperature because suction superheat is reduced. By reducing suction superheat, a performance range of the compressor envelope, at which the compressor exhibits a high compression ratio area is increased.

[0036] In some embodiments, the third heat exchanger 16 may be arranged nearby the second heat exchanger 14. Thus, a waste heat of the third heat exchanger 16 may be used by the second heat exchanger 14. In particular, the heat provided by the third heat exchanger 16 may be used to avoid icing, in particular "glacier icing" at least of parts of the second heat exchanger 14. In some embodiments, the second heat exchanger may comprise a first fin tube for heat exchange of the refrigerant with air and/or water and/or any other physical medium, and/or the third heat exchanger may comprise a second fin tube for heat exchange of the refrigerant with air and/or water and/or any other physical medium. Advantageously, at least a section of the first fin tube, in particular the whole first fin tube may be disposed above at least a section of the second fin tube, in particular the whole second fin tube, when seen from a top view, as shown in Fig. 1.

[0037] However, in some embodiments, the second heat exchanger 14 and the third heat exchanger 16 may be arranged in a distance to each other, in particular such that no or no meaningful heat exchange between the second heat exchanger and the third heat exchanger occurs, in particular when the first and second physical medium differ.

[0038] In some embodiments, the heat pump may comprise a third fin tube, wherein a first section of the third fin tube may comprise at least a part of the second heat exchanger 14, and a second section of the third fin tube may comprise at least a part of the third heat exchanger 16. In dependence of the embodiment, the first section of the third fin tube and the second section of the third fin tube may border to each other, may intersect each other, or may be disposed in a distance from each other within the third fin tube. The third fin tube may have a single housing.

[0039] Preferably, at least a part of the first section of the third fin tube, in particular the whole first section of the third fin tube, may be disposed above at least a part of the second section of the third fin tube, in particular the whole second section of the third fin tube, when seen from a top view. In some embodiments, at least a part of the second section of the third fin tube may be disposed on a bottom side of the third fin tube.

[0040] As can be seen in Fig. 1, the refrigeration cycle may further comprise in the heating mode a three-way valve 20 and a bypass of the third heat exchanger, wherein the heat pump is configured to control the flow rate through the bypass of the third heat exchanger and through the third heat exchanger by means of the three-way valve such that the temperature of the refrigerant provided to the input of the compressor is below a third predetermined temperature in the heating mode and/or such that the temperature of the refrigerant provided to the input of the compressor is above a fourth predetermined temperature in the heating mode. As a consequence, the temperature of the refrigerant provided to the compressor may be optimized regarding a working point or a working range of a compressor. In some embodiments, the three-way valve may be realized by means of an two way valve or an one-way valve and/or a flow resistance.

[0041] Advantageously, the third and/or the fourth predetermined temperature may be predetermined by a working point, a working range of the compressor and/or the heat pump, and/or the physical properties of the refrigerant within the refrigeration cycle.

[0042] Fig. 2 shows schematically a diagram of a heat pump comprising a refrigeration cycle connected in a loop by fluid lines and in succession in a cooling mode. The refrigeration cycle comprises in the cooling mode a compressor 11, a second heat exchanger 14, a first expansion valve 13a, a first heat exchanger 12. The refrigeration cycle may further comprise in the cooling mode an internal heat exchanger 15, wherein a first conduit 15a of the internal heat exchanger is part of the fluid line between the second heat exchanger 14 and the first expansion valve 13a, and the second conduit 15b of the internal heat exchanger 15 is part of the fluid line between the first heat exchanger 12 and the compressor.

[0043] In the cooling mode, the compressor is configured to compress a refrigerant in the refrigeration cycle, and the first heat exchanger is an evaporator and is configured to add thermal energy from a fluid circuit to the refrigerant. The first expansion valve 13a is configured to reduce a pressure of the refrigerant after the refrigerant passes the expansion valve, and the second heat exchanger is a condenser, condensing the refrigerant by giving off thermal energy of the refrigerant to a third physical medium.

[0044] Optionally, the refrigeration cycle may comprise a bypass of the first conduit 15a of the internal heat exchanger 15, wherein the bypass of the first conduit 15a is provided by a fluid line comprising a bypass valve 17. The bypass valve may be a controllable valve, in particular a controllable ball valve.

[0045] By means of the bypass of the first conduit and the bypass valve within the first conduit, it is possible to control a heat transmission of the first conduit 15a to the second conduit 15b of the internal heat exchanger 15. Therefore, control of a temperature of the refrigerant provided by the second conduit 15b of the internal heat exchanger 15 to the compressor 11 can be reduced. Thus, suction superheat can be controlled to improve a performance range of the compressor envelope having a high compression area.

[0046] In some embodiments, the heat pump may be configured to control the bypass valve such that the temperature of the refrigerant provided to the input of the compressor is below a first predetermined temperature in the cooling mode and/or such that the temperature of the refrigerant provided to the input of the compressor is above a second predetermined temperature in the cooling mode.

[0047] The first predetermined temperature and/or the second predetermined temperature may be predetermined based on a working point and/or a working range of the compressor and/or of the heat pump, and/or the physical properties of the refrigerant within the refrigeration cycle.

[0048] In some embodiments, the bypass of the third heat exchanger may be realized by means of a three-way valve instead of the bypass valve having the same technical effect.

[0049] Fig. 3 shows schematically a diagram of a heat pump usable in a heating mode and in a cooling mode. The heat pump shown in Fig. 3 is based on the heat pumps shown in Figs. 1 and 2. The heat pump is configured to switch between the heating mode and the cooling mode, wherein the refrigeration cycle comprises for switching between the heating mode and the cooling mode a four-way valve, 18, a first one-way valve 19a, and a second one-way valve 19b.

[0050] The four-way valve 18 is configured to link the fluid line from a compressor output to the first heat exchanger and to link the fluid line from the second heat exchanger to the second conduit 15b of the internal heat exchanger for the heating mode and to link a fluid line from the compressor output to the second heat exchanger and to link the fluid line from the first heat exchanger to a second conduit 15b of the internal heat exchanger 15 for the cooling mode. A bypass of the first expansion valve in a direction from the first heat exchanger to the first conduit 15a of the internal heat exchanger 15 is provided by a fluid line comprising the third heat exchanger

16 and the first one-way valve 19a. A bypass of the second expansion valve in a direction from the second heat exchanger to the first conduit of the internal heat exchanger is provided by a fluid line comprising the second one-way valve 19b.

[0051] Therefore, a flexible heat exchanger for use in a heating mode, as shown in Fig. 1, and in a cooling mode, as shown in Fig. 2 is provided.

[0052] As discussed above, a bypass of the first conduit 15a of the internal heat exchanger 15 may be provided by a fluid line optionally. The bypass of the first conduit 15a may comprise a bypass valve 17 or any other components to control a flow through the bypass of the first conduit 15a and a flow through the first conduit 15a.

[0053] Again optionally, as discussed with regard to Fig. 1, the refrigeration cycle may comprise additionally in the heating mode a three-way valve 20 and a bypass of the third heat exchanger, wherein a flow rate through the bypass of the third heat exchanger and a flow rate through the third heat exchanger is controlled by the three-way valve 20 such that the temperature of a refrigerant provided to the input of the compressor is below a third predetermined temperature in the heating mode and/or such that the temperature of the refrigerant provided to the input of the compressor is above a fourth predetermined temperature in the heating mode.

[0054] In some embodiments, the first predetermined temperature and the third predetermined temperature may be identical or may differ. In some embodiments, the second predetermined temperature and the fourth predetermined temperature may be identical or may differ.

[0055] In some embodiments, the first expansion valve may be an electronic expansion valve and/or a thermal expansion valve. Advantageously, the first expansion valve may be electronically controllable. In some embodiments, the second expansion valve may be an electronic expansion valve and/or a thermal expansion valve. Advantageously, the second expansion valve may be electronically controllable.

[0056] Examples for the first, the second and/or the third physical medium are air, water, brine, and soil, but are not limited thereto. In some embodiments, the first and the second physical medium may be identical or different, the first and the third physical medium may be identical or different, and/or the third physical medium and the second physical medium may be identical or different.

[0057] Advantageously, the heat pump may be one or more of the group: an air water heat pump, a geothermal heat pump, and a brine water heat pump.

[0058] In some embodiments, the first, the second, the third, and/or the fourth predetermined temperature may be predetermined based on a working point of the compressor, a working range of the compressor, and/or the physical properties of the refrigerant within the refrigeration cycle.

[0059] In some embodiments, the first, the second, the third, and/or the fourth predetermined temperature may be a constant value. In some embodiments, the first, the second, the third, and/or the fourth predetermined temperature may be predetermined, in particular additionally predetermined, in dependence of a temperature difference of the internal heat exchanger.

[0060] A temperature difference of the internal heat exchanger may be a temperature difference between an input of the first conduit and the output of the second conduit, a temperature difference between the input of the first conduit and the output of the first conduit, and a temperature difference between the input of the second conduit and the output of the second conduit. In some embodiments, the first, the second, the third, and/or the fourth predetermined temperature may be determined in dependence of one or more measured temperatures.

[0061] A measured temperature may be an input temperature of the first conduit of the internal heat exchanger, an output temperature of the first conduit of the internal heat exchanger, an input temperature of the second conduit of the internal heat exchanger, and an output temperature of the second conduit of the internal heat exchanger, for example.

[0062] Fig. 4 shows schematically a method for operating a heat pump in a heating mode. The heat pump includes a refrigeration cycle. The refrigeration cycle comprises in a heating mode a compressor, an internal heat exchanger being configured to provide heat from a high-pressure section in a refrigeration cycle of the heat pump to a low-pressure section of the refrigeration cycle before the refrigerant gets to an input of the compressor in the low-pressure section of the refrigeration cycle. The refrigeration cycle comprises further a third heat exchanger being configured to cool down the refrigerant before getting to a high-pressure section of the internal heat exchanger, a bypass of the third heat exchanger, and a three-way valve being configured to control a flow rate through the third heat exchanger and a flow rate being bypassed of the third heat exchanger.

[0063] The method comprises the steps of capturing S41 of one or more physical system parameters of the heat pump comprising one or more of the group: a pressure within the refrigeration cycle, a temperature within the refrigeration cycle, and an electrical power of an inverter of the heat pump. A further step of the method is controlling S42 the three-way valve based on the captured one or more physical system parameters and one or more predetermined thresholds. The one or more predetermined thresholds may be predetermined such that the heat pump is operated in the heating mode at a predetermined working point and/or within a predetermined working range, wherein the predetermined working point and/or the predetermined working range of the heat pump is indicated by the predetermined thresholds.

[0064] Fig. 5 shows schematically a method for operating a heat pump in a cooling mode. The heat pump includes a refrigeration cycle. The refrigeration cycle comprises in a cooling mode a compressor, an internal heat exchanger being configured to provide heat from the high pressure section in the refrigeration cycle of the heat pump to a low pressure section of the refrigeration cycle before the refrigerant gets to an input of the compressor in the low pressure section of the refrigeration cycle. The refrigeration cycle comprises further a bypass of the high pressure section of the internal heat exchanger. The bypass of the high pressure section of the internal heat exchanger comprises a bypass valve. The bypass valve is configured to control a flow rate of the refrigerant through the internal heat exchanger on the high pressure section in the refrigeration cycle of the heat pump and a flow rate of the refrigerant through the bypass of the high pressure section of the internal heat exchanger.

[0065] The method comprises the step of capturing S51 of one or more physical system parameters of the heat pump comprising one or more of the group: a pressure within the refrigeration cycle, a temperature within the refrigeration cycle, and an electrical power of an inverter of the heat pump. A further step of the method is controlling S52 the bypass valve based on the captured one or more physical system parameters and one or more predetermined thresholds. The one or more predetermined thresholds may be predetermined such that the heat pump is operated in the cooling mode at a predetermined working point and/or within a predetermined working range, wherein the predetermined working point and/or the predetermined working range of the heat pump is indicated by the predetermined thresholds.

[0066] Advantageously, the method described by use of Fig. 4 may be combined with the method described by use of Fig. 5 to control suction superheat of a heat pump in a heating mode as well as in a cooling mode.

[0067] In some embodiments, in particular in embodiments as described above by means of Figs. 1 to 5, one or more units may be added merged, separated and/or omitted without any effect on the teaching of the present patent application. In some embodiments, in particular in embodiments as described above by means of Figs. 1 to 5, one or more method steps may be split up, merged, added and/or omitted without affecting the teaching of the present patent application.

[0068] In some embodiments, one or more components may be realized by one or more different components leading to the same technical effect without affecting the teaching of the present patent application as described.

[0069] In some embodiments, a computer program product may comprise instructions, which, when the program is executed by a computer, cause the computer to carry out one or more methods as described above.

Claims

1. A heat pump comprising a refrigeration cycle, wherein

   the refrigeration cycle comprises in a heating mode connected in a loop by fluid lines and in succession:

   - a compressor,
   - a first heat exchanger,
   - a third heat exchanger,
   - a second expansion valve, and
   - a second heat exchanger,

   wherein the refrigeration cycle further comprises in the heating mode:

   - an internal heat exchanger having a first conduit and a second conduit, the first conduit being in heat exchanging contact with the second conduit, wherein the first conduit is part of the fluid line between the third heat exchanger and the second expansion valve, and the second conduit is part of the fluid line between the second heat exchanger and the compressor,

   wherein in the heating mode:

   the compressor is configured to compress a refrigerant in the refrigeration cycle,
   the first heat exchanger is a condenser and is configured to add thermal energy from the refrigerant to a fluid circuit to be heated,
   the third heat exchanger is configured to reduce a temperature of the refrigerant provided from the first heat exchanger to the internal heat exchanger by giving off heat to a second physical medium,
   the second expansion valve is configured to reduce a pressure of the refrigerant after the refrigerant passes the expansion valve, and
   the second heat exchanger is an evaporator, evaporating the refrigerant by adding thermal energy of a first physical medium to the refrigerant.

2. The heat pump according to claim 1, wherein

   the refrigeration cycle comprises in a cooling mode connected in a loop by fluid lines and in succession:

   - the compressor,
   - the second heat exchanger,
   - a first expansion valve,
   - the first heat exchanger,

   wherein the refrigeration cycle further comprises in the cooling mode:

- the internal heat exchanger, wherein the first conduit is part of the fluid line between the second heat exchanger and the first expansion valve, and the second conduit is part of the fluid line between the first heat exchanger and the compressor,

wherein in the cooling mode:

the compressor is configured to compress a refrigerant in the refrigeration cycle,
the first heat exchanger is an evaporator and is configured to add thermal energy from a fluid circuit to the refrigerant,
the first expansion valve is configured to reduce a pressure of the refrigerant after the refrigerant passes the expansion valve,
the second heat exchanger is a condenser, condensing the refrigerant by giving off thermal energy of the refrigerant to a third physical medium,

wherein
the heat pump is configured to switch between the heating mode and the cooling mode and the refrigeration cycle comprises for switching between the heating mode and the cooling mode:

- a four-way valve,
- a first one-way valve, and
- a second one-way valve,

wherein

the four-way valve is configured to link the fluid line from a compressor output to the first heat exchanger and to link the fluid line from the second heat exchanger to the second conduit of the internal heat exchanger for the heating mode, and to link the fluid line from the compressor output to the second heat exchanger and to link the fluid line from the first heat exchanger to the second conduit of the internal heat exchanger for the cooling mode,
a bypass of the first expansion valve in a direction from the first heat exchanger to the first conduit of the internal heat exchanger is provided by a fluid line comprising the third heat exchanger and the first one-way valve,
a bypass of the second expansion valve in a direction from the second heat exchanger to the first conduit of the internal heat exchanger is provided by a fluid line comprising the second one-way valve.

3. The heat pump according to claim 2, wherein a bypass of the first conduit of the internal heat exchanger is provided by a fluid line comprising a bypass valve, in particular a controllable valve.

4. The heat pump according to claim 3, wherein the heat pump is configured to control the bypass valve such that the temperature of the refrigerant provided to the input of the compressor is below a first predetermined temperature in the cooling mode and/or such that the temperature of the refrigerant provided to the input of the compressor is above a second predetermined temperature in the cooling mode.

5. The heat pump according to one of claims 1 to 4, wherein the refrigeration cycle further comprises in the heating mode:

a three-way valve, and
a bypass of the third heat exchanger, wherein the heat pump is configured to control, by means of the three-way valve, the flow rate through the bypass of the third heat exchanger and through the third heat exchanger such that the temperature of the refrigerant provided to the input of the compressor is below a third predetermined temperature in the heating mode and/or such that the temperature of the refrigerant provided to the input of the compressor is above a fourth predetermined temperature in the heating mode.

6. The heat pump according to claim 4 or 5, wherein

one or more of the following group is a predetermined constant value: the first predetermined temperature, the second predetermined temperature, the third predetermined temperature, the fourth predetermined temperature; and/or
one or more of the following group is determined in dependence of a temperature difference of the internal heat exchanger: the first predetermined temperature, the second predetermined temperature, the third predetermined temperature, the fourth predetermined temperature; wherein a temperature difference of the internal heat exchanger is in particular at least one of the group:

- a temperature difference between an input of the first conduit and the output of the second conduit,
- a temperature difference between the input of the first conduit and the output of the first conduit, and
- a temperature difference between the input of the second conduit and the output of the second conduit; and/or

one or more of the following group is determined in dependence on a measurement temperature: the first predetermined temperature, the second predetermined temperature, the third predetermined temperature, the fourth predetermined temperature; wherein the measurement temperature is in particular at least one of the group:

an input temperature of the first conduit of the internal heat exchanger;
an output temperature of the first conduit of the internal heat exchanger;
an input temperature of the second conduit of the internal heat exchanger; and
an output temperature of the second conduit of the internal heat exchanger.

7. The heat pump according to one of claims 1 to 6, wherein

the first expansion valve is an electronic expansion valve and/or a thermal expansion valve, and/or
the second expansion valve is an electronic expansion valve and/or a thermal expansion valve.

8. The heat pump according to one of claims 1 to 7, wherein

the first and/or the second and/or the third physical medium is one or more of the group:

air,
water,
brine, and
soil; and/or

the heat pump is one or more of the group:

- an air-water heat pump,
- a geothermal heat pump, and
- a brine-water heat pump.

9. The heat pump according to one of claims 1 to 8, wherein

the second heat exchanger comprises a first fin tube for heat exchange of the refrigerant with air and/or water, and/or
the third heat exchanger comprises a second fin tube for heat exchange of the refrigerant with air and/or water.

10. The heat pump according to claim 9, wherein at least a section of the first fin tube is disposed above at least a section of the second fin tube, when seen from a top view.

11. The heat pump according to one of claims 1 to 8, comprising:

a third fin tube, wherein
a first section of the third fin tube comprises at least part of the second heat exchanger, and
a second section of the third fin tube comprises at least part of the third heat exchanger.

12. The heat pump according to claim 11, wherein at least a part of the first section of the third fin tube is disposed above at least a part of the second section of the third fin tube when seen from a top view; and/or at least a part of the second section of the third fin tube is disposed on a bottom side of the third fin tube.

13. Method for operating a heat pump according to one of claims 1 to 12.

14. Method for operating a heat pump, the heat pump including a refrigeration cycle comprising in a heating mode:

a compressor,
an internal heat exchanger being configured to provide heat from a high pressure section in the refrigeration cycle of the heat pump to a low pressure section of the refrigeration cycle before the refrigerant gets to an input of the compressor in the low pressure section of the refrigeration cycle,
a third heat exchanger being configured to cool down the refrigerant before getting to a high pressure section of the internal heat exchanger,
a bypass of the third heat exchanger, and
a three-way valve being configured to control a flow rate to the third heat exchanger and a flow rate being bypassed of the third heat exchanger,
the method comprising in the heating mode the steps of:

capturing of one or more physical system parameters of the heat pump comprising one or more of the group: a pressure within the refrigeration cycle, a temperature within the refrigeration cycle, and an electrical power of an inverter of the heat pump;
controlling the three-way valve based on the captured one or more physical system parameters and one or more predetermined thresholds.

15. Method according to claim 14, the refrigeration cycle comprising in a cooling mode:

the compressor,
the internal heat exchanger being configured to

provide heat from the high pressure section in the refrigeration cycle of the heat pump to a low pressure section of the refrigeration cycle before the refrigerant gets to an input of the compressor in the low pressure section of the refrigeration cycle, and
a bypass of the high pressure section of the internal heat exchanger, the bypass comprising a bypass valve, the bypass valve being configured to control a flow rate of the refrigerant through the internal heat exchanger on the high pressure section in the refrigeration cycle of the heat pump and a flow rate of the refrigerant through the bypass of the high pressure section of the internal heat exchanger,
the method comprising in the cooling mode the steps of:

capturing of one or more physical system parameters of the heat pump comprising one or more of the group: a pressure within the refrigeration cycle, a temperature within the refrigeration cycle, and an electrical power of an inverter of the heat pump;
controlling the bypass valve based on the captured one or more physical system parameters and one or more predetermined thresholds.

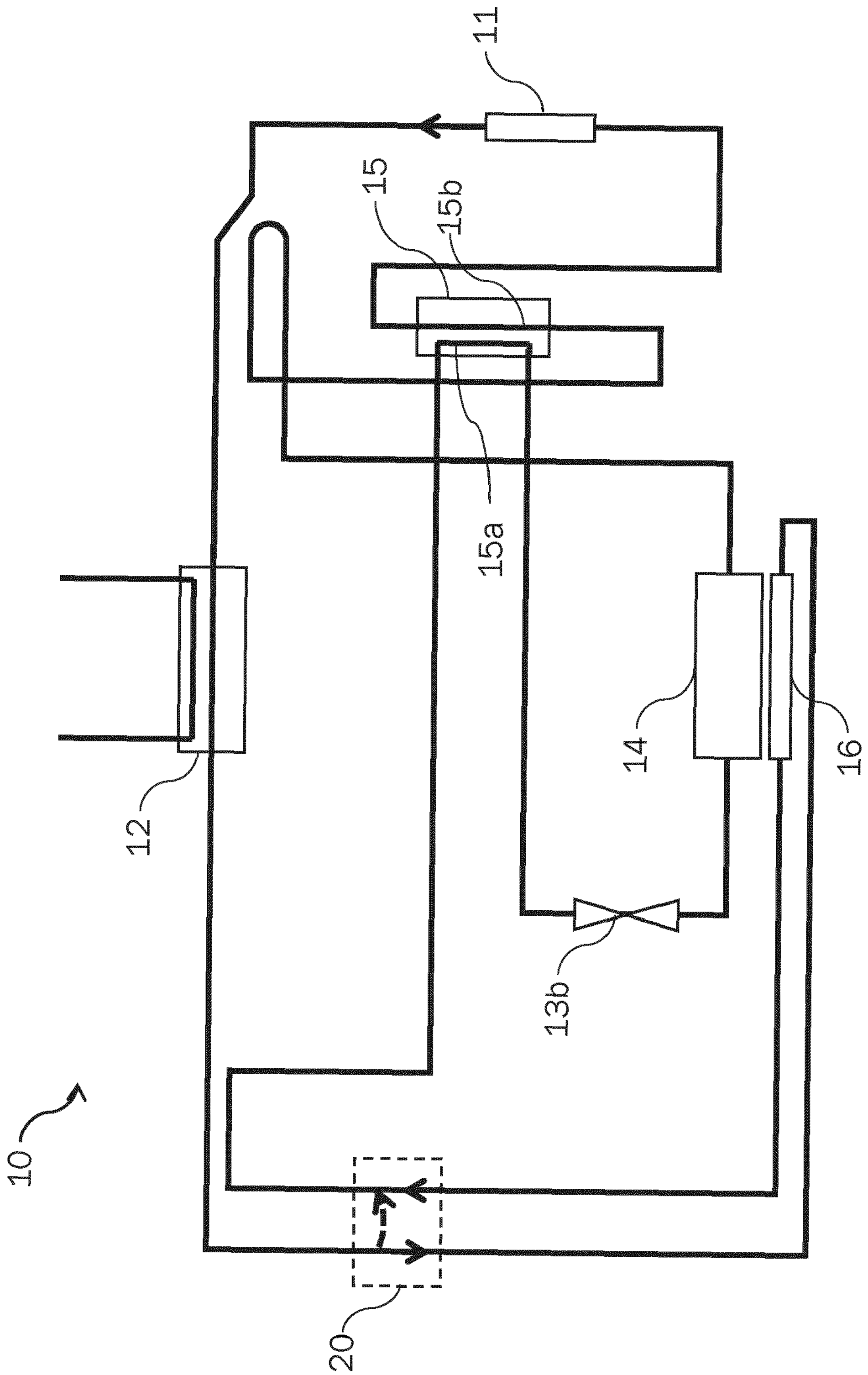

Fig. 1

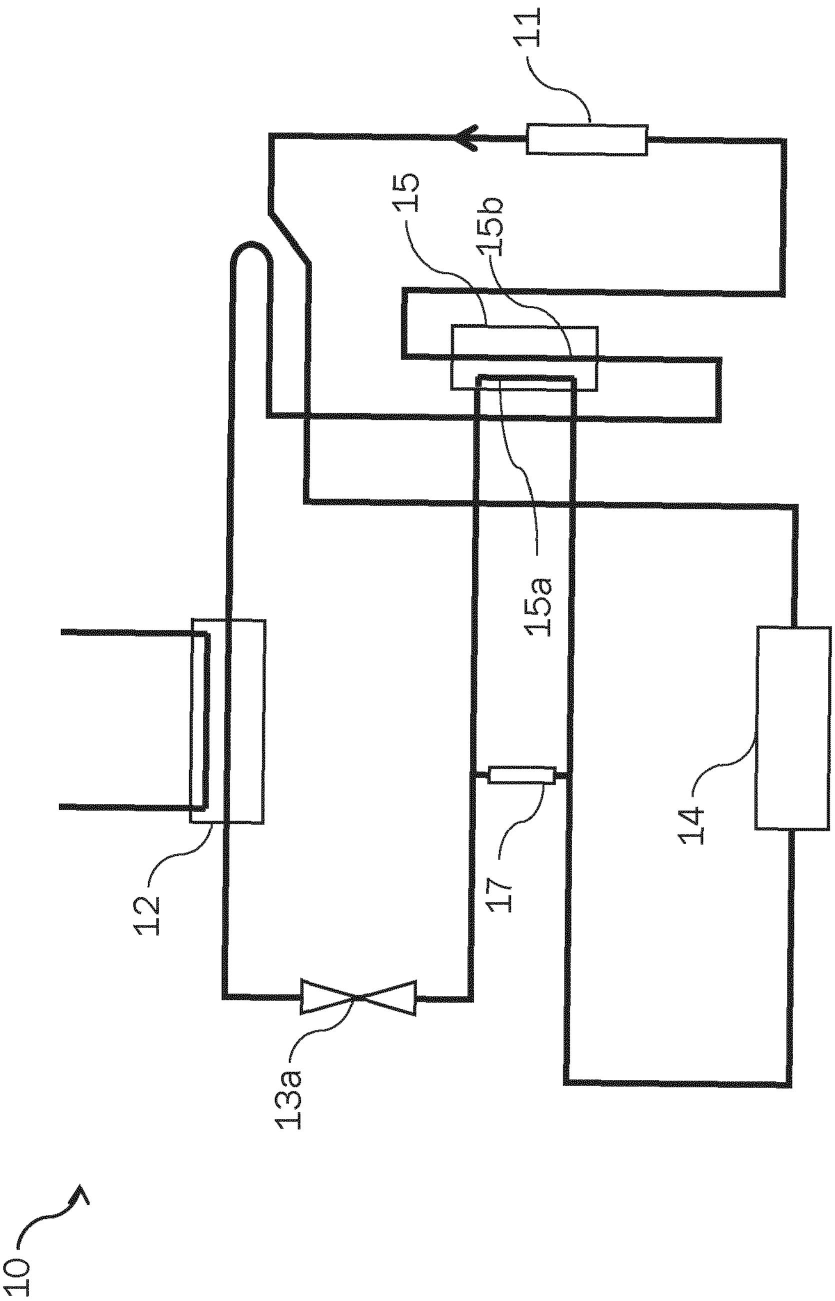

Fig. 2

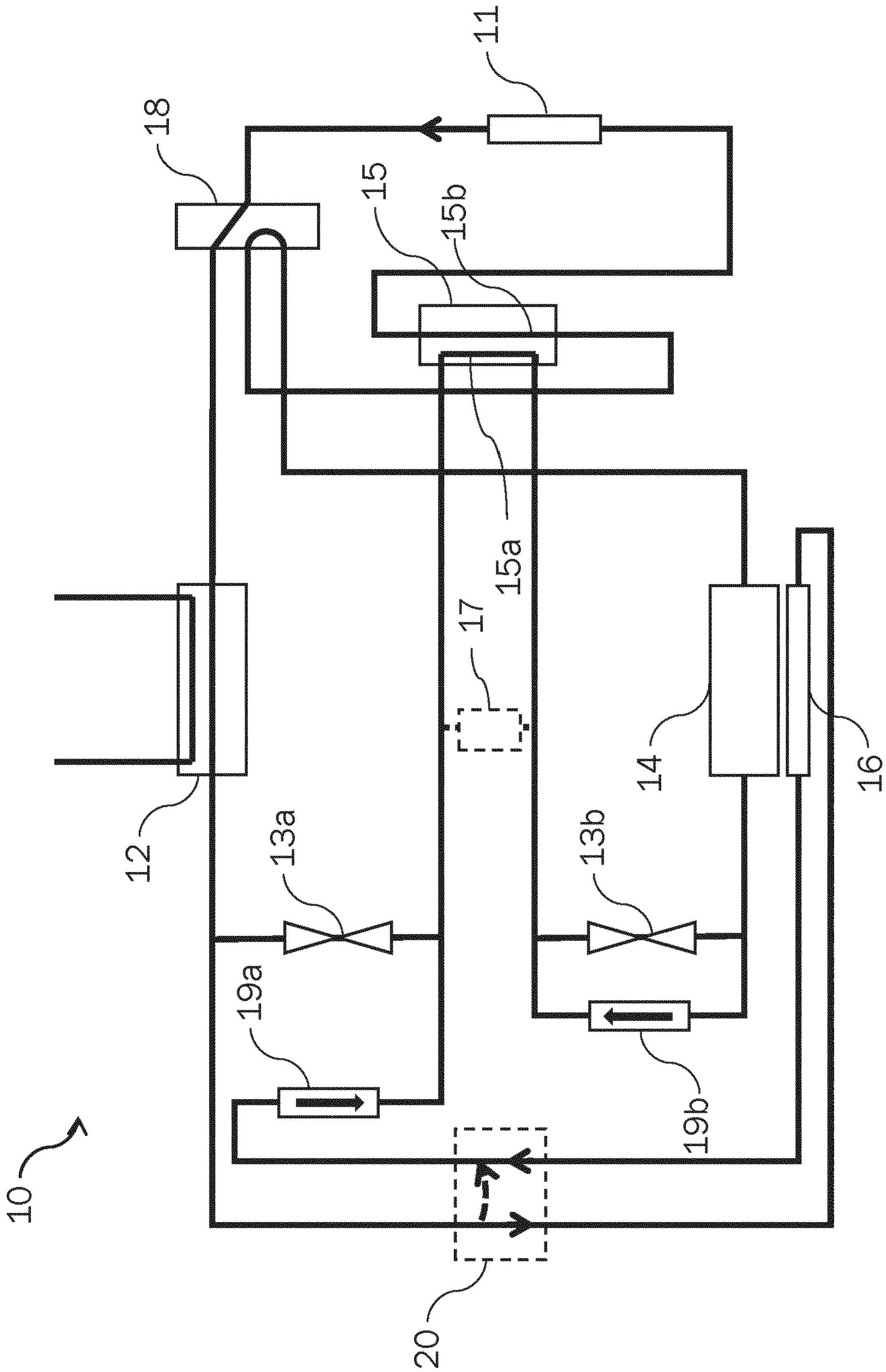

Fig. 3

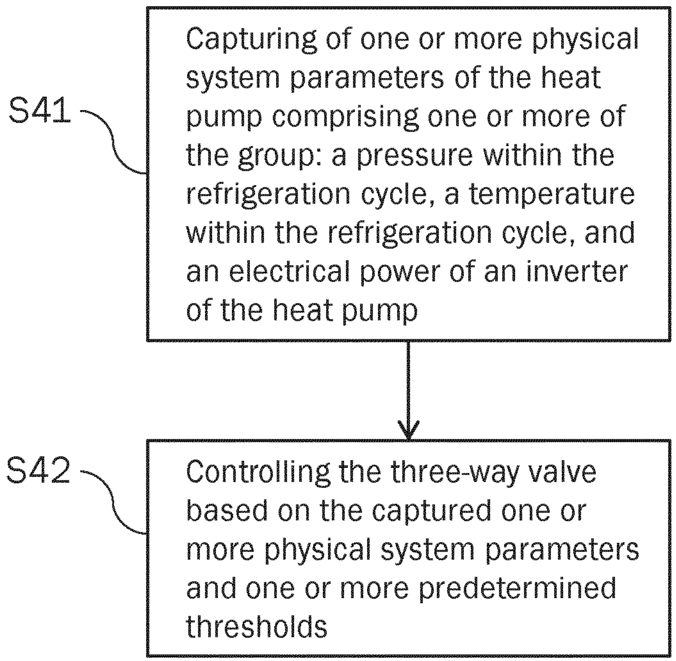
S41
Capturing of one or more physical system parameters of the heat pump comprising one or more of the group: a pressure within the refrigeration cycle, a temperature within the refrigeration cycle, and an electrical power of an inverter of the heat pump
S42
Controlling the three-way valve based on the captured one or more physical system parameters and one or more predetermined thresholds

Fig. 4

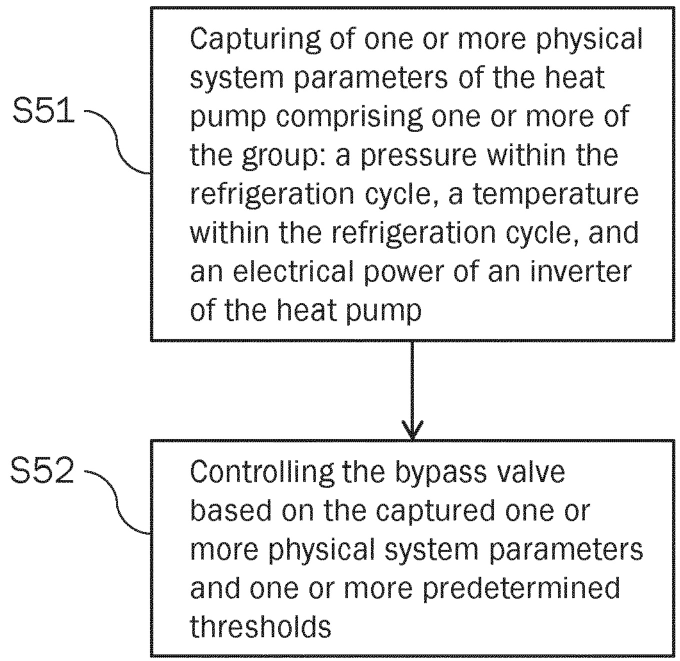
S51
Capturing of one or more physical system parameters of the heat pump comprising one or more of the group: a pressure within the refrigeration cycle, a temperature within the refrigeration cycle, and an electrical power of an inverter of the heat pump
S52
Controlling the bypass valve based on the captured one or more physical system parameters and one or more predetermined thresholds

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 23 15 0737

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F25B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	13 July 2023	Amous, Moez

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