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(54) A HEAT PUMP LAUNDRY DRYING MACHINE AND A METHOD FOR OPERATING A HEAT PUMP LAUNDRY DRYING MACHINE

WÄRMEPUMPE FÜR EINE WÄSCHETROCKNUNGSMASCHINE UND VERFAHREN ZUM BETREIBEN EINER WÄSCHETROCKNUNGSMASCHINE MIT WÄRMEPUMPE

SÈCHE-LINGE À POMPE À CHALEUR ET PROCÉDÉ D'EXPLOITATION D'UN SÈCHE-LINGE À POMPE À CHALEUR

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(56) References cited:
EP-A1- 2 468 946
EP-A1- 2 489 775
EP-A1- 2 527 521
EP-A1- 2 551 401
DE-C1- 19 525 064
JP-A- 2000 028 284
JP-A- 2000 105 003
JP-A- 2012 095 718
US-A1- 2012 079 736

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EP 2 959 052 B1

Description

FIELD OF THE INVENTION

[0001] The present invention concerns the field of laundry drying machines equipped with a heat pump system comprising a refrigerant loop.

[0002] In particular, the present invention concerns the field of preventing and/or reducing the risks deriving from an abnormal working condition, in particular the risk caused by a refrigerant leakage.

[0003] The present invention refers also to a method for operating such laundry drying machine.

BACKGROUND ART

[0004] Laundry drying machines capable of carrying out a drying process on laundry, hereinafter simply indicated as laundry dryers, generally comprise a casing that houses a laundry container, like a rotating drum, where laundry to be treated is received. A closed air stream circuit carries out drying operation by circulating hot air through the laundry container containing the wet laundry.

[0005] In laundry dryers, the heat pump technology is the most efficient way to save energy during drying operation. In conventional heat pump laundry dryers a drying air stream flows in a close loop. The drying air stream is moved by a fan, passes the laundry drum and removes water from wet clothes. Then the drying air stream is cooled down and dehumidified and then heated up in a heat pump system and finally reinserted again into the laundry drum.

[0006] The heat pump system comprises a refrigerant flowing in a closed-loop refrigerant circuit realized with pipes and comprising a compressor, a condenser, an expansion device and an evaporator. The condenser heats up the drying air while the evaporator cools and dehumidifies the drying air leaving the drum. The refrigerant flows in the refrigerant circuit where it is compressed by the compressor, condensed in the condenser, expanded in the expansion device and then vaporized in the evaporator. The temperatures of the drying air stream and the refrigerant are strongly correlated to each other.

[0007] Refrigerants which are used or could be used in the refrigerant circuit comprise substances like as Hydro Fluoro Carbon (HFC), Hydro Fluoro Olefine (HFO), Hydro Carbon (HC). Common HFC refrigerants are R134a and R407c and common HC refrigerants are R290 and R600a. Carbon dioxide (CO_2), ammonia (NH_3) could be also.

[0008] A drawback of the known technique using a closed-loop refrigerant circuit derives from risks of leakage in case of failure of some components of the heat pump system, for example in the case that the condenser or the refrigerant pipes are damaged.

[0009] A laundry dryer belonging to the know technique implementing refrigerant leakage detecting means is disclosed in document US20120079736.

[0010] In this document, a laundry dryer capable of rapidly and easily detecting whether refrigerant leakage has occurred or not is disclosed.

[0011] If it is determined that refrigerant leakage has occurred, the compressor is stopped and an alarm may be displayed in a display apparatus disposed on a front surface of the machine.

[0012] However, the technique above described belonging to the known art still poses some drawbacks.

[0013] A drawback of this known technique derives from risks for people health in case of leakage due to the failure of some components of the heat pump system.

[0014] In laundry dryers of known type, in fact, an alarm is sent only after a failure is occurred. The refrigerant may therefore evaporate and its diffusion and interaction in the air may affect the environment.

[0015] Even if the compressor is stopped and/or an alarm is displayed, part or whole the refrigerant flowing in the refrigerant circuit may leak thus determining dangerous situation, like risk of exposure to toxic gases and/or fire and/or explosions of the refrigerant itself.

[0016] It is an object of the invention to implement a laundry drying machine equipped with a heat pump system where the risks due to refrigerant leakage are reduced compared to known laundry drying machines.

[0017] The heat pump laundry dryer of EP 2 527 521 A1 has an evaporator, a condenser, a compressor and an expansion device. The refrigerant to be used is CO_2 where after a heat-up phase during the stationary phase very high refrigerant pressures are achieved. Due to this high pressure, abnormal conditions may occur which may damage the heat pump circuit. It is suggested to use at least one valve by which a portion of the CO_2 can be isolated from the refrigerant circuit of the heat pump system as soon as the heat-up phase was sufficient as indicated by the refrigerant pressure and/or temperature. The isolated capture of the refrigerant is made in a refrigerant trap that is connected via the one or more valves to the refrigerant circuit. By this capture of CO_2 further built-up of pressure may be restricted or limited and a refrigerant leakage is prevented.

[0018] EP 2 489 775 A1 suggests a heat-pump laundry dryer in which the heat-up phase of the heat pump system is accelerated by using an additional evaporator during heat-up. Thus in the heat-up phase the drying air is only heated up by the condenser. After heating-up, the 3/2 way valves change the refrigerant flow from additional evaporator only to main evaporator only.

[0019] US 2012/0079736 A1 proposes to use a leak detector in a dryer for detecting refrigerant leakage.

DISCLOSURE OF INVENTION

[0020] The invention is defined in claims 1 and 10, respectively.

[0021] The applicant has found that by providing a laundry drying machine of the type comprising a heat

pump system having a refrigerant circuit for a refrigerant and comprising an air stream circuit for an air stream conveyable to a laundry drum suited to receive laundry to be dried, wherein the refrigerant circuit comprises: a first heat exchanger for a thermal coupling between the air stream circuit and the refrigerant circuit; a second heat exchanger for a further thermal coupling between the air stream circuit and the refrigerant circuit; a compressor arranged in the refrigerant circuit between the second heat exchanger and the first heat exchanger; a refrigerant expansion device arranged in the refrigerant circuit between the first heat exchanger and the second heat exchanger; and by providing two or more interrupting devices arranged along the refrigerant circuit suited to define one or more portions of the refrigerant circuit where the refrigerant may be confined, it is possible to reduce the risks due to refrigerant leakage.

[0022] The present invention relates to a laundry drying machine of the type comprising a heat pump system having a refrigerant circuit for a refrigerant and comprising an air stream circuit for an air stream conveyable to a laundry drum suited to receive laundry to be dried, said refrigerant circuit comprising:

- a first heat exchanger for a thermal coupling between said air stream circuit and said refrigerant circuit wherein the refrigerant is cooled down and said air stream is heated up;
- a second heat exchanger for a further thermal coupling between said air stream circuit and said refrigerant circuit wherein the refrigerant is heated up and said air stream is cooled down;
- a compressor arranged in said refrigerant circuit between said second heat exchanger and said first heat exchanger;
- a refrigerant expansion device arranged in said refrigerant circuit between said first heat exchanger and said second heat exchanger;

wherein the machine further comprises two or more interrupting devices arranged along said refrigerant circuit suited to define one or more portions of said refrigerant circuit where said refrigerant may be confined. The machine further comprises a leakage sensor, wherein the interrupting devices are activated when a refrigerant leakage is detected by said leakage sensor.

[0023] Preferably, the machine comprises a control unit for controlling the interrupting devices.

[0024] In a preferred embodiment of the invention, the interrupting devices comprise on/off valves.

[0025] More preferably, the on/off valves are normally closed valves so that the refrigerant is normally confined in said one or more portions when the on/off valves are deactivated or the machine is switch off.

[0026] Preferably, the refrigerant expansion device comprises an expansion valve and such expansion is one of the interrupting devices.

[0027] Opportunely, the refrigerant circuit comprises pipes connecting the compressor, the first heat exchanger, the expansion device and the second heat exchanger in a closed-loop configuration.

[0028] Preferably, the interrupting devices are arranged along one or more of the connecting pipes.

[0029] In a preferred embodiment of the invention, the interrupting devices are arranged in the high-pressure side of the refrigerant circuit.

[0030] The high-pressure side is defined as the portion of the refrigerant circuit comprised between the compressor outlet and the expansion device inlet.

[0031] More preferably, the interrupting devices are arranged in the high-pressure side of the refrigerant circuit, preferably in proximity of the first heat exchanger, so that the refrigerant may be confined therein when the interrupting devices are activated or deactivated.

[0032] In another preferred embodiment of the invention, the interrupting devices are arranged in the low-pressure side of the refrigerant circuit.

[0033] The low-pressure side is defined as the portion of the refrigerant circuit comprised between the expansion device outlet and the compressor inlet. Preferably, the refrigerant is one of the following types: Hydro Fluoro Carbon type (HFC), Hydro Fluoro Olefine type (HFO), Hydro Carbon type (HC), Carbon dioxide (CO_2), ammonia (NH_3).

[0034] In a further preferred embodiment of the invention, the machine further comprises absorber arranged in positions suited to allow absorption of refrigerant which may leak out from the refrigerant circuit.

[0035] Preferably, the absorber are arranged in a basement portion of the machine.

[0036] In a further aspect the present invention relates to a method for controlling a laundry drying machine of the type comprising a heat pump system having a refrigerant circuit for a refrigerant and comprising an air stream circuit for an air stream conveyable to a laundry drum suited to receive laundry to be dried, said refrigerant circuit comprising:

- a first heat exchanger for a thermal coupling between said air stream circuit and said refrigerant circuit wherein the refrigerant is cooled down and said air stream is heated up;
- a second heat exchanger for a further thermal coupling between said air stream circuit and said refrigerant circuit wherein the refrigerant is heated up and said air stream is cooled down;
- a compressor arranged in said refrigerant circuit between said second heat exchanger and said first heat exchanger;
- a refrigerant expansion device arranged in said refrigerant circuit between said first heat exchanger and said second heat exchanger;

wherein the method comprises the step of confining said refrigerant in one or more portions of said refrigerant circuit if an abnormal working condition of said refrigerant

circuit occurs. The abnormal working condition is a refrigerant leakage.

[0037] Preferably, the step of confining the refrigerant in one or more portions of the refrigerant circuit is carried out controlling two or more interrupting devices arranged along the refrigerant circuit so that activation or deactivation of the interrupting devices creates said one or more portions.

[0038] Preferably, the working parameters of the compressor comprise the current and/or the power absorption of the compressor itself.

[0039] In a preferred embodiment of the invention, the refrigerant leakage is detected by means of a leakage sensor.

[0040] In a further preferred embodiment of the invention, the refrigerant leakage is determined analyzing one or more functioning parameters of the laundry drying machine.

[0041] Preferably, the functioning parameters comprise one of the parameters selected from a group comprising: the air stream temperature upstream and/or downstream of said drum, the temperature measured from a surface of the first heat exchanger, the detected or calculated pressure and/or temperature of the refrigerant.

[0042] Opportunely, the method further comprises the step of emitting a warning alarm for the user.

[0043] Preferably, the method further comprises the step of deactivating the compressor if said abnormal working condition occurs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044] Further characteristics and advantages of the present invention will be highlighted in greater detail in the following detailed description of preferred embodiments of the invention, provided with reference to the enclosed drawings. In said drawings:

- Figure 1 shows a perspective view of a laundry drying machine with an upright side removed according to a preferred embodiment of the invention;
- Figure 2 illustrates a schematic diagram of the laundry drying machine of Figure 1;
- Figure 3 illustrates a schematic diagram of a laundry drying machine according to another preferred embodiment of the invention;
- Figure 4 illustrates a schematic diagram of a laundry drying machine according to a further preferred embodiment of the invention;
- Figure 5 shows a perspective view of the basement for a laundry drying machine realized according to the diagram of Figure 4;
- Figure 6 illustrates a schematic diagram of a laundry drying machine according to a further preferred embodiment of the invention;
- Figure 7 illustrates a schematic diagram of a laundry drying machine according to a further preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0045] The present invention has proved to be particularly successful when applied to a front-loading drying machine with a rotatable laundry container; however it is clear that the present invention can be applied as well to a top-loading drying machine and also to laundry drying machines of cabinet type, i.e. laundry drying machines where the laundry container does not rotate.

[0046] Furthermore, the present invention can be usefully applied to all the machines requiring a drying phase for wetted clothes, like as a combined laundry washing and drying machine.

[0047] In the present description the term "laundry drying machine" will refer to both simple laundry drying machines and laundry washing-drying machines.

[0048] Figures 1 and 2 illustrate a laundry drying machine 1, or laundry dryer, with a heat pump system 20 according to a first embodiment of the present invention.

[0049] The laundry dryer 1 preferably comprises, though not necessarily, a substantially parallelepiped-shaped outer boxlike casing 2 which is preferably structured for resting on the floor. A laundry container consisting of a rotatably drum 9 is provided within the casing 2. A front door 8, pivotally coupled to the front upright side wall 2a, is provided for allowing access to the drum interior region to place laundry to be dried therein.

[0050] The drum 9 is advantageously rotated by a drum motor, preferably an electric motor, which preferably transmits the rotating motion to the shaft of the drum 9, advantageously by means of a belt/pulley system. In a different embodiment of the invention, the drum motor can be directly associated with the shaft of the drum 9.

[0051] A user control interface 15 is preferably arranged on the top of the casing 2. The user control interface 15 is preferably accessible to the user for the selection of the drying cycle and insertion of other parameters, for example the type of fabric of the load, the degree of dryness, etc.. The user control interface 15 preferably displays machine working conditions, such as the remaining cycle time, alarm signals, etc. For this purpose the user control interface 15 preferably comprises a display 13.

[0052] In different embodiments, for example in a combined laundry washing and drying machine, the user may selects and inserts other types of parameters, for example the washing temperature, the spinning speed, etc..

[0053] In further embodiments, the user control interface may be differently realized, for example remotely arranged in case of a remote-control system.

[0054] The laundry dryer 1 is provided with an air stream circuit 10, as illustrated in Figure 2, which is structured to circulate inside the drum 9 a stream of hot air A. The hot air circulates over and through the laundry located inside the drum 9 to dry the laundry. The drum 9 itself is therefore part of the air stream circuit 10. The air stream

circuit 10 is also structured for drawing moist air from the drum 9, cooling down the moist air leaving the drum 9 so to extract and retain the surplus moisture. The dehumidified air is then heated up to a predetermined temperature preferably higher than that of the moist air arriving from the drum 9. Finally the heated, dehumidified air is conveyed again into the drum 9, where it flows over and through the laundry stored inside the rotatable drum 9 to rapidly dry the laundry, as said above.

[0055] The air stream circuit 10 forms therefore a closed-loop for the air A, as schematically illustrated with dashed line in Figure 2.

[0056] A fan 12 is preferably arranged along the circuit 10 for generating the air stream A, more preferably upstream of the drum 9. The fan 12 is adapted and designed for circulating the air within the air stream circuit 10.

[0057] Preferably, and more particularly, the air stream circuit 10 comprises a dehumidifying unit 23 arranged downstream of the drum 9 and a heater unit 21 arranged downstream of the dehumidifying unit 23 and upstream of the drum 9. It is underlined that in the present application the terms "upstream" and "downstream" are referred to the flowing direction of the air, heated air and/or moist air, during the standard functioning of the laundry dryer; for example saying that the fan is arranged upstream of the drum means that in the standard functioning of the laundry dryer the air firstly passes through the fan and then flows into the drum; saying that the dehumidifying unit is arranged downstream of the drum means that in the standard functioning of the laundry dryer the air firstly circulates inside the drum and then passes through the dehumidifying unit. In the dehumidifying unit 23 the moist air condenses and cools down and the water generated therein is preferably collected in a removable container, not illustrated, arranged below the dehumidifying unit 23.

[0058] In the preferred embodiment here described, the dehumidifying unit 23 is the evaporator of the heat pump system 20 and the heating unit 21 is the condenser of said heat pump system 20.

[0059] Therefore, the evaporator 23 dehumidifies the moist air coming from the drum 9 and then the condenser 21 heats up the dehumidified air coming from the evaporator 23. The heated air is then conveyed again into the drum 9.

[0060] In further embodiments, the air stream circuit may not form a closed-loop. In this case, for example, the air stream may be conveyed to a condenser from outside, then conveyed into the drum, from the drum conveyed to the evaporator and finally expelled to the outside.

[0061] The heat pump system 20 with its evaporator 23 and condenser 21, therefore, interacts with the air stream circuit 10. In fact, the air stream circuit 10 and the heat pump system 20 are thermally coupled by the condenser 21 and the evaporator 23.

[0062] In particular, the heat pump system 20 advantageously comprises a refrigerant circuit 30 forming a closed-loop circuit where a refrigerant flows.

[0063] The refrigerant circuit 30 comprises a compressor 24, a first heat exchanger 21, i.e. the condenser 21 in the preferred embodiment here described, an expansion device 22 and a second heat exchanger 23, i.e. the evaporator 23 in the preferred embodiment here described. The compressor 24, the condenser 21, the expansion device 22 and the evaporator 23 are connected in series to form said closed-loop circuit.

[0064] The refrigerant flows in the refrigerant circuit 30 wherein is compressed by the compressor 24, condensed in the condenser 21, expanded in the expansion device 22 and then vaporized in the evaporator 23.

[0065] The expansion device 22 preferably comprises a capillary tube, as visible in Figure 5. In different embodiments, the expansion device may comprise a controlled expansion valve, more preferably an electronic expansion valve, as will be illustrated below with reference to embodiment of Figure 7.

[0066] Refrigerants which may be used in the refrigerant circuit 30 comprise substances like as Hydro Fluoro Carbon (HFC), Hydro Fluoro Olefine (HFO) and Hydro Carbon (HC). Common HFC refrigerants are R134a and R407c and common HC refrigerants are R290 and R600a.

[0067] In different embodiments, the first heat exchanger may comprises a gas cooler (instead of the condenser) and the second heat exchanger may comprises a gas heater (instead of the evaporator). In this case the refrigerant is advantageously a gas, such as Carbon dioxide CO_2 or ammonia (NH_3), which maintains its gaseous state along all the closed-loop circuit, and in particular in the gas cooler and in the gas heater. In this type of heat pump system the gas temperature changes while passing through the gas cooler and the gas heater.

[0068] Generally, the first heat exchanger 21 defines a thermal coupling between the air stream circuit 10 and the refrigerant circuit 30 wherein the refrigerant is cooled down and the air stream A is heated up.

[0069] Analogously, the second heat exchanger 23 defines a further thermal coupling between the air stream circuit 10 and the refrigerant circuit 30 wherein the refrigerant is heated up and the air stream A is cooled down.

[0070] The portion of the refrigerant circuit 30 comprised between the compressor outlet 24b and the expansion device inlet 22a defines a high-pressure side wherein the refrigerant is compressed at a high pressure (for example 15-20 bars when the refrigerant used is R290).

[0071] On the other hand, the portion of the refrigerant circuit 30 comprised between the expansion device outlet 22b and the compressor inlet 24a defines a low-pressure side wherein the refrigerant is expanded at a low pressure (for example 6-10 bars when the refrigerant used is R290).

[0072] More preferably, the components of the refrigerant circuit 30 (i.e. the compressor 24, the condenser 21, the expansion device 22 and the evaporator 23) are

connected one to the other by means of respective pipes 61, 62, 63 and 64. More preferably, the first pipe 61 connects the compressor outlet 24b to the condenser inlet 21a, the second pipe 62 connects the condenser outlet 21b to the expansion device inlet 22a, the third pipe 63 connects the expansion device outlet 22b to the evaporator inlet 23a and the fourth pipe 64 connects the evaporator outlet 23b to the compressor inlet 24a.

[0073] Preferably said connections between pipes and components of the refrigerant circuit 30 are obtained by a welding process.

[0074] Further, the laundry dryer 1 may comprise several kinds of sensor elements, which are not shown in the figures. For example, the sensor elements may be provided for detecting the temperature, the relative humidity and/or the electrical impedance at suitable positions of the laundry dryer 1. Furthermore, the sensor element may preferably comprise a leakage sensor. The leakage sensor is preferably positioned in a bottom portion 14 of the laundry dryer 1. The leakage sensor preferably comprises: catalytic sensors, semiconductors sensors, electrochemical sensors, thermal conductivity sensors, infrared sensors. The type of sensor to use is selected in relation to the refrigerant fluid to detect. For example, when the refrigerant is CO_2 the infrared sensors are preferably used. Preferably, the sensor type has to be selected on the base of the level of sensibility determined by refrigerant fluid to detect.

[0075] The laundry dryer 1 further preferably comprises a central processing unit, not illustrated, advantageously connected to the various parts of laundry dryer 1, or peripheral units, in order to ensure its operation.

[0076] According to the preferred embodiment of the invention here illustrated, along the refrigerant circuit 30 are arranged two interrupting devices 71, 72. The two interrupting devices 71, 72 are preferably arranged in the high-pressure side of the refrigerant circuit 30.

[0077] The first interrupting device 71 is preferably arranged along the first pipe 61 and the second interrupting device 72 is preferably arranged along the second pipe 62.

[0078] The first interrupting device 71 divides the first pipe 61 into two portions 61a and 61b. The second interrupting device 72 divides the second pipe 62 into two portions 62a and 62b.

[0079] The interrupting devices 71, 72 are advantageously connected to a control unit 26. The control unit 26 controls the activation/deactivation of the interrupting devices 71, 72.

[0080] The control unit 26 for controlling the interrupting devices 71, 72 can be part of the central processing unit.

[0081] The interrupting devices 71, 72 preferably comprise on/off valves which control the flow of the refrigerant within the pipes 61 and 62, and therefore the flow of the refrigerant within the refrigerant circuit 30.

[0082] More preferably, the interrupting devices 71, 72 comprise solenoid operated valves.

[0083] In different embodiments, nevertheless, the interrupting devices may be of different types, like as step motor valves.

[0084] In the preferred embodiment here described, with "valve activated" it is meant that the valve is ON, or energized, and the refrigerant may flow (i.e. the valve is open). With "valve deactivated" it is meant that the valve is OFF, or de-energized, and the refrigerant may not flow (i.e. the valve is closed and the refrigerant flow is interrupted).

[0085] Still more preferably, the valves 71, 72 are normally-closed valves. In this case, when either the laundry dryer 1 or the control unit 26 is switch off, each valve 71, 72 is deactivated , or de-energized, and therefore in its closed condition. When the laundry dryer 1 and the control unit 26 are both switch on and ready to start a drying cycle, both the valves 71, 72 are activated by the control unit 26. The refrigerant may flow along the refrigerant circuit 30 and the drying cycle can be normally carried out until its completion.

[0086] In particular, the laundry to be dried is first placed inside the drum 9. By operating on the interface unit 15 the user selects the desired drying cycle depending, for example, on the type of laundry textile to dry or on the dryness degree of the laundry which is expected at the end of the cycle, for example totally dried or with residual moisture for a best ironing.

[0087] Once the user has selected the desired drying cycle, the central processing unit sets the laundry drying machine 1 so that it starts the drying cycle.

[0088] In a further embodiment, the selection of the desired drying cycle may be performed before placing the laundry into the drum 9.

[0089] In normal condition, the selected drying cycle is performed until its completion, as said above.

[0090] On the contrary, and according to the invention, if an abnormal condition of the refrigerant circuit 30 occurs, the valves 71, 72 are deactivated. Both the valves 71, 72 are closed and the refrigerant flow is being interrupted.

[0091] An abnormal condition may comprise one or more working conditions of the laundry dryer 1 which differ from the normal condition of the same.

[0092] Preferably, abnormal conditions may preferably comprise one of the following conditions which affect the refrigerant circuit 30.

[0093] In a first preferred embodiment, an abnormal condition is determined by working parameters of the compressor 24 which exceed pre-determined safety thresholds. Preferably, the working parameters of the compressor 24 comprise current and/or power absorption of the compressor 24 itself.

[0094] In further first preferred embodiment, an abnormal condition is determined by the refrigerant temperature or pressure which exceed pre-determined safety thresholds.

[0095] Furthermore, an abnormal condition is also determined by sudden changes of said parameters, for ex-

ample sudden changes of current and/or power absorption of the compressor 24 or sudden changes of the refrigerant temperature or pressure.

[0096] An abnormal condition may then preferably refer to a refrigerant leakage which is directly and advantageously detected by a leakage sensor, if present.

[0097] In different embodiments, detection of refrigerant leakage is determined analyzing one or more functioning parameters of the laundry dryer 1, for example analyzing the drying air temperature upstream and/or downstream of the drum 9, the temperature measured from the surface of the condenser 21, the detected or calculated pressure or temperature of the refrigerant. A method which uses said parameters for the detection of a refrigerant leakage is disclosed, for example, in the known document US20120079736.

[0098] In further different embodiments, it is considered quite probable that a refrigerant leakage occurs when the above mentioned parameters of the compressor exceed pre-determined safety thresholds and/or when the refrigerant temperature or pressure exceed pre-determined safety thresholds.

[0099] Furthermore, once the valves 71, 72 are deactivated the compressor 24 is also preferably deactivated.

[0100] The compressor 24 is preferably deactivated when the valves 71, 72 are deactivated or just after a short period of time. In different embodiments, the compressor 24 may be deactivated after a pre-determined lapse of time.

[0101] At the same time, preferably, a warning alarm is emitted for the user, for example a visual alarm at the display 13 or an acoustic alarm. More preferably, a message alarm to call the service is advantageously displayed.

[0102] According to the invention, therefore, when an abnormal condition of the refrigerant circuit 30 occurs the refrigerant is advantageously prevented from flowing along the refrigerant circuit 30 by the closed valves 71, 72.

[0103] More particularly, a first quantity of the refrigerant is confined by the closed valves 71, 72 in the path defined by the second portion 61b of the first pipe 61, the condenser 21 and the first portion 62a of the second pipe 62. The remaining second quantity of refrigerant is confined by the closed valves 71, 72 in the path defined by the second portion 62b of the second pipe 62, the expansion device 22, the third pipe 63, the evaporator 23, the fourth pipe 64, the compressor 24 and the first portion 61a of the first pipe 61.

[0104] Advantageously, if the abnormal condition is caused by a refrigerant leakage in a point of the refrigerant circuit 30, the quantity of refrigerant leaving the refrigerant circuit 30 is not the total amount of refrigerant contained in the refrigerant circuit 30 but rather only the first or the second quantity of the same, depending on the point in the refrigerant circuit 30 where the leakage occurs. For example, if a condenser failure causes a refrigerant leakage therein, only the second quantity of refrigerant confined by the closed valves 71, 72 leaves the refrigerant circuit 30. Analogously, if a failure in the fourth pipe 64 occurs thus causing a refrigerant leakage therein, only the first quantity of refrigerant confined by the closed valves 71, 72 leaves the refrigerant circuit 30.

[0105] According to the invention, therefore, the provision of two interrupting devices 71, 72 advantageously allows the reduction of the refrigerant which may leave the refrigerant circuit 30 when a leakage occurs. In other words, the provision of two interrupting devices 71, 72 advantageously prevents all the refrigerant leaking out the from the refrigerant circuit 30.

[0106] This, in turn, reduces the risks deriving from the refrigerant leaked out from the refrigerant circuit 30, like the risk of exposure to toxic gases, fire and/or explosions of the refrigerant.

[0107] This is particularly advantageous if Hydro Carbon (HC) is used as refrigerant. Hydro Carbon (HC), in fact, is a substance particularly toxic and flammable.

[0108] Nevertheless, even when other refrigerants less dangerous are used, like as Hydro Fluoro Carbon (HFC), Hydro Fluoro Olefine (HFO), Carbon dioxide CO_2 or ammonia (NH_3), the provision of two interrupting devices 71, 72 advantageously allows the reduction of the refrigerant which may leave the refrigerant circuit 30 when a leakage occurs.

[0109] Furthermore, the remaining refrigerant confined in the refrigerant circuit 30 between the interrupting devices 71, 72 may be advantageously recycled and/or subjected to a disposal process.

[0110] Evaporation and diffusion of the refrigerant in the air is therefore advantageously avoided.

[0111] Furthermore, even when a refrigerant leakage has not yet occurred, the deactivation of the two interrupting devices 71, 72 as a consequence of an abnormal working condition, for example a compressor failure and/or a high temperature of the refrigerant, creates two confined portions for the refrigerant inside the refrigerant circuit 30. This is a favourable configuration which may reduce the risks for imminent or future damaging that may occur as consequence of said abnormal working condition. A risk prevention is therefore performed. As a consequence of what described above, it follows that the more the interrupting devices arranged along the refrigerant circuit are, the less the quantity of refrigerant which may leak out from the refrigerant circuit is. Preferably, as said above, the interrupting devices are placed in the high-pressure side of the refrigerant circuit. In fact, due to the high pressure of the refrigerant, this side comprises the most relevant quantity of the refrigerant. In particular, the condenser 21 contains a high percentage of the refrigerant, typically more than 50% of the total amount.

[0112] For this reason, preferably, the interrupting devices are arranged in the high-pressure side of the refrigerant circuit in proximity of the condenser, so that more than 50% of the refrigerant may be confined therein when the interrupting devices are activated.

[0113] A further embodiment of the heat pump system

120 according to the invention which utilizes more than two interrupting devices 71, 72 is shown in figure 3.

[0114] Here, further the two interrupting devices 71, 72 as previously disclosed, a third interrupting device 171 and a fourth interrupting device 172 are arranged along the refrigerant circuit 130. The two interrupting devices 171, 172 are arranged in the low-pressure side of the refrigerant circuit 130.

[0115] The third interrupting device 171 is preferably arranged along the third pipe 63 and the fourth interrupting device 172 is preferably arranged along the fourth pipe 64.

[0116] The third interrupting device 171 divides the third pipe 63 into two portions 63a and 63b. The fourth interrupting device 172 divides the fourth pipe 64 into two portions 64a and 64b.

[0117] The interrupting devices 171, 172 are advantageously connected to the control unit 26 which controls the activation/deactivation of the same.

[0118] The interrupting devices 171, 172 preferably comprise on/off valves.

[0119] In this embodiment and analogously to the first embodiment previously described, if an abnormal condition occurs, the valves 71, 72, 171, 172 are deactivated. The valves 71, 72, 171, 172 are closed and the refrigerant flow is being interrupted.

[0120] More particularly, the refrigerant is now confined by the closed valves 71, 72, 171, 172 in respective four portions. Each portion may contain, for example, a fourth of the total amount of refrigerant.

[0121] Advantageously, if a refrigerant leakage in a point of the refrigerant circuit 130 occurs, the quantity of refrigerant which may leave the refrigerant circuit 130 is less than the total amount of refrigerant contained in the refrigerant circuit 130, and in particular only a quarter of the total amount.

[0122] For example, if a condenser failure causes a refrigerant leakage therein, only the quantity (one fourth of the total) of refrigerant confined by the closed valves 71, 72 leaves the refrigerant circuit 130.

[0123] According to the invention, therefore, the provision of interrupting devices 71, 72, 172, 172 advantageously allows the reduction of the refrigerant which may leave the refrigerant circuit 130 when a leakage occurs.

[0124] This, in turn, reduces the risks deriving from the refrigerant leaked out from the refrigerant circuit 130, like the risk of exposure to toxic gases, fire and/or explosions of the refrigerant.

[0125] The remaining refrigerant confined in the refrigerant circuit 130 between the interrupting devices 71, 72, 172, 172, then, may be advantageously recycled and/or subjected to a disposal process.

[0126] Furthermore, when a refrigerant leakage has not yet occurred, the deactivation of the interrupting devices 71, 72, 171, 172 as a consequence of an abnormal working condition, for example a compressor failure and/or a high temperature of the refrigerant, creates four confined portions for the refrigerant inside the refrigerant circuit 130. This is a favourable configuration which may reduce the risks for imminent or future damaging that may occur as consequence of said abnormal working condition. A risk prevention is therefore performed.

[0127] A further embodiment of the present invention is described with reference to figures 4 and 5.

[0128] Figure 4 shows a schematic diagram of a laundry dyer 1 with a heat pump system 220 according to this embodiment.

[0129] Almost all the components of the laundry dryer 1 here illustrated are the same described and illustrated in the previous embodiments.

[0130] The laundry dryer 1 comprises an air stream circuit 10. The air stream circuit 10 is a closed-loop air stream circuit 10 structured to circulate inside the drum 9 a stream of hot air A.

[0131] A fan 12 is preferably arranged along the circuit 10. The air stream circuit 10 then comprises a dehumidifying unit 23 (evaporator) arranged downstream of the drum 9 and a heater unit 21 (condenser) arranged downstream of the dehumidifying unit 23 and upstream of the drum 9.

[0132] In further embodiments, the air stream circuit may not form a closed-loop. In this case, for example, the air stream may be conveyed to a condenser from outside, then conveyed into the drum, from the drum conveyed to the evaporator and finally expelled to the outside.

[0133] The heat pump system 220 with its evaporator 23 and condenser 21, therefore, interacts with the air stream circuit 10. In fact, the air stream circuit 10 and the heat pump system 220 are thermally coupled by the condenser 21 and the evaporator 23.

[0134] In particular, the heat pump system 220 advantageously comprises a refrigerant circuit 230 forming a closed-loop circuit where a refrigerant flows.

[0135] The refrigerant circuit 230 comprises a compressor 24, a first heat exchanger 21, i.e. the condenser 21 in the preferred embodiment here described, an expansion device 22 and a second heat exchanger 23, i.e. the evaporator 23 in the preferred embodiment here described. The compressor 24, the condenser 21, the expansion device 22 and the evaporator 23 are connected in series to form said closed-loop circuit.

[0136] The refrigerant flows in the refrigerant circuit 230 wherein is compressed by the compressor 24, condensed in the condenser 21, expanded in the expansion device 22 and then vaporized in the evaporator 23.

[0137] Refrigerants which may be used in the refrigerant circuit 230 comprise substances like as Hydro Fluoro Carbon (HFC), Hydro Fluoro Olefine (HFO) and Hydro Carbon (HC). Common HFC refrigerants are R134a and R407c and common HC refrigerants are R290 and R600a.

[0138] In different embodiments, the first heat exchanger may comprises a gas cooler (instead of the condenser) and the second heat exchanger may comprises a gas heater (instead of the evaporator). In this case the

refrigerant is advantageously a gas, such as Carbon dioxide CO_2 or ammonia (NH_3), which maintains its gaseous state along all the closed-loop circuit, and in particular in the gas cooler and in the gas heater. In this type of heat pump system the gas temperature changes while passing through the gas cooler and the gas heater.

[0139] Generally, the first heat exchanger 21 defines a thermal coupling between the air stream circuit 10 and the refrigerant circuit 230 wherein the refrigerant is cooled down and the air stream A is heated up.

[0140] Analogously, the second heat exchanger 23 defines a further thermal coupling between the air stream circuit 10 and the refrigerant circuit 230 wherein the refrigerant is heated up and the air stream A is cooled down.

[0141] According to the invention, the laundry dryer 1 comprises absorbers, schematically shown with the grey square 500 surrounding the refrigerant circuit 230 in Figure 4 .

[0142] The absorbers 500 are opportunely arranged in the laundry dryer 1 to absorb the major quantity of refrigerant which may leak out from the refrigerant circuit 230. The absorbers 500 are preferably arranged to cover and/or surround the most critical part or the potential source of leakages of the laundry dryer 1.

[0143] In a preferred embodiment, the absorbers 500 are arranged in close proximity to the heat exchangers 21, 23, more preferably around the first heat exchanger 21. In a further preferred embodiment, the absorbers 500 are arranged in close proximity to the pipe connections, in particular at welded joints thereof.

[0144] In another preferred embodiment, the absorbers 500 are arranged at the compressor outlet 24a where the refrigerant pressure along the refrigerant circuit 30 is typically at its maximum value and therefore a critical point.

[0145] In preferred embodiments, the absorbers 500 are preferably placed into one or more side walls of the casing 2 or into the basement 14. In other embodiments, the absorbers may be preferably placed in the opening of the laundry dryer 1 where air is exchange with the environment.

[0146] The absorbers 500 are preferably made with active carbon, or synthetic absorbers or inorganic absorber materials or polymers absorbers.

[0147] The absorbers 500 preferably may are in the form of a sheet or a cartridges or sponges, etc.

[0148] To avoid flammability or explosion problems related to the accumulation of the leaked refrigerant in the absorbers 500, the absorbers 500 are preferably at least partially filled with fireproof compounds. Alternatively, the absorption capacity (dimension and internal shape) of the absorbers 500 is maintained under a prefixed value so that to maintain it safe from flammability or explosion.

[0149] If a refrigerant leakage occurs, part or all the leaked refrigerant is advantageously absorbed by the absorbers 500.

[0150] At the same time, preferably, a warning alarm is emitted for the user, for example a visual alarm at the display 13 or an acoustic alarm. More preferably, intervention of the service is necessary.

[0151] Advantageously the absorbers 500 will be regenerated or replaced by the service. Regeneration of the absorbers 500 could be easily done by heating. Replacement operations of the absorbers 500 may therefore be simple and fast.

[0152] Figure 5 illustrates preferred positions P where the absorbers 500 (sheet, sponges, cartridges, etc) may be arranged.

[0153] In the figure, the basement 14 of the laundry drier 1 is illustrated removed from the rest.

[0154] Most of the components of the air stream circuit 10 and of the heat pump system 220 are arranged in basement 14. The basement 14 is preferably made of polymeric material.

[0155] The basement 14 preferably comprises a lower shell 54 and an upper shell 55, opportunely coupled one to the other.

[0156] In particular, the basement 14 receives the condenser 21, the expansion device 22 (capillary tube), the evaporator 23, the compressor 24 and the connecting pipes. The basement 14 also preferably receives the fan 12, not visible, in a seat 12a. The basement 14 then also preferably receives a cooling-air fan, not visible, which advantageously conveys a cooling air stream inside the basement 14, and in particular an air stream for cooling the compressor 24.

[0157] The basement 14 of the dryer 1 is also opportunely shaped to form air paths for the air stream circuit 10. Such air paths opportunely convey the air across the heat exchangers, i.e. the condenser 21 and the evaporator 23.

[0158] Positions P are preferred places where the absorbers according to the invention may be placed.

[0159] Preferably, the absorbers are arranged in the lower shell 54 of the basement, more preferably around the heat exchangers 21, 23 and the compressor 24.

[0160] Figure 6 shows a schematic diagram of a laundry dyer 1 according to a further embodiment of the invention.

[0161] This embodiment shows a combination of the previous embodiment described with reference to figure 3 and the embodiment described with reference to Figure 4. The laundry dryer 1 hence comprises both the interrupting devices 71, 72, 171, 172 and the absorbers 500.

[0162] Advantageously, the provision of interrupting devices 71, 72, 171, 172 advantageously allows the reduction of the refrigerant which may leave the refrigerant circuit 130 when a leakage occurs and, furthermore, part or all the leaked refrigerant is advantageously absorbed by the absorbers 500.

[0163] A further embodiment of the heat pump system 320 according to the invention is shown in figure 7.

[0164] This embodiment differs from the first embodiment illustrated in Figure 2 for the fact that the expansion device 122 comprises a controlled expansion valve instead of a capillary tube and the second interrupting de-

vice 72 is omitted. The expansion valve 122 preferably comprises an electronic valve.

[0165] The control unit 26 drives the expansion valve 122 and may modulate therefore the refrigerant flowing in the refrigerant circuit 330.

[0166] The control unit 26 may also drive the expansion valve 122 until its closure, i.e. until the refrigerant is prevented from flowing in the in the refrigerant circuit 330.

[0167] In this particular working condition, the expansion valve 122 acts as an interrupting device.

[0168] In this embodiment, therefore, the interrupting function for the refrigerant flowing in the refrigerant circuit 330 according to the invention is carried out by the first interrupting device 71 and the expansion valve 122, which performs therefore the function of the second interrupting device 72 previously described. It has thus been shown that the present invention allows the set objects to be achieved. In particular, it makes it possible to obtain a laundry drying machine having reduced risks due to refrigerant leakage with respect to the systems of known type.

[0169] Although illustrative embodiments of the present invention have been described herein with reference to the accompanying drawings, it is to be understood that the present invention is not limited to those precise embodiments, and that various other changes and modifications may be affected therein by one skilled in the art. For example, the laundry dryer may comprise further auxiliary heat exchangers associated to the heat pump system. All such changes and modifications are intended to be included within the scope of the invention as defined by the appended claims.

Claims

1. A laundry drying machine (1) of the type comprising a heat pump system (20; 120; 220; 320) having a refrigerant circuit (30; 130; 230; 330) for a refrigerant and comprising an air stream circuit (10) for an air stream (A) conveyable to a laundry drum (9) suited to receive laundry to be dried, said refrigerant circuit (30; 130; 230; 330) comprising:

   - a first heat exchanger (21) for a thermal coupling between said air stream circuit (10) and said refrigerant circuit (30; 130; 230; 330) wherein the refrigerant is cooled down and said air stream (A) is heated up;
   - a second heat exchanger (23) for a further thermal coupling between said air stream circuit (10) and said refrigerant circuit (30; 130; 230; 330) wherein the refrigerant is heated up and said air stream (A) is cooled down;
   - a compressor (24) arranged in said refrigerant circuit (30; 130; 230; 330) between said second heat exchanger (23) and said first heat exchanger (21);
   - a refrigerant expansion device (22; 122) arranged in said refrigerant circuit (30; 130; 230; 330) between said first heat exchanger (21) and said second heat exchanger (23); and

   two or more interrupting devices (71, 72; 171, 172; 122) arranged along said refrigerant circuit (30; 130; 230; 330) suited to define one or more portions of said refrigerant circuit (30; 130; 230; 330) where said refrigerant may be confined; **cha racterized by**
   a leakage sensor,
   wherein said interrupting devices (71, 72; 171, 172; 122) are closed when a refrigerant leakage is detected by said leakage sensor.

2. A machine (1) according to claim 1, **characterized in that** it comprises a control unit (26) for controlling said interrupting devices (71, 72; 171, 172; 122).

3. A machine (1) according to claim 1 or 2, **characterized in that** said two or more interrupting devices (71, 72; 171, 172) comprise on/off valves.

4. A machine (1) according to claim 3, **characterized in that** said on/off valves are normally closed valves (71, 72; 171, 172) so that said refrigerant is confined in said one or more portions when said on/off valves (71, 72; 171, 172) are deactivated or said machine (1) is switch off.

5. A machine (1) according to any preceding claim, **characterized in that** said refrigerant expansion device (122) comprises an expansion valve, said expansion valve being one of said interrupting devices (71, 72; 171, 172; 122).

6. A machine (1) according to any preceding claim, **characterized in that** said refrigerant circuit (30; 130; 230; 330) comprises pipes (61, 62, 63, 64) connecting said compressor (24), said first heat exchanger (21), said expansion device (22; 122) and said second heat exchanger (23) in a closed-loop configuration and **in that** said interrupting devices (71, 72; 171, 172) are arranged along one or more of said connecting pipes (61, 62, 63, 64).

7. A machine (1) according to any preceding claim, **characterized in that** said interrupting devices (71, 72; 122) are arranged in the high-pressure side of said refrigerant circuit (30; 230; 330).

8. A machine (1) according to claim 7, **characterized in that** said interrupting devices (71, 72; 122) are arranged in said high-pressure side of said refrigerant circuit (30; 230; 330), so that said refrigerant may be confined in said first heat exchanger (21).

9. A machine (1) according to any preceding claim, **characterized in that** said refrigerant is one of the following types: Hydro Fluoro Carbon type (HFC), Hydro Fluoro Olefine type (HFO), Hydro Carbon type (HC), Carbon dioxide (CO_2), ammonia (NH_3).

10. A method for controlling a laundry drying machine (1) of the type comprising a heat pump system (20; 120; 220; 320) having a refrigerant circuit (30; 130; 230; 330) for a refrigerant and comprising an air stream circuit (10) for an air stream (A) conveyable to a laundry drum (9) suited to receive laundry to be dried, said refrigerant circuit (30; 130; 230; 330) comprising:

- a first heat exchanger (21) for a thermal coupling between said air stream circuit (10) and said refrigerant circuit (30; 130; 230; 330) wherein the refrigerant is cooled down and said air stream (A) is heated up;
- a second heat exchanger (23) for a further thermal coupling between said air stream circuit (10) and said refrigerant circuit (30; 130; 230; 330) wherein the refrigerant is heated up and said air stream (A) is cooled down;
- a compressor (24) arranged in said refrigerant circuit (30; 130; 230; 330) between said second heat exchanger (23) and said first heat exchanger (21);
- a refrigerant expansion device (22; 122) arranged in said refrigerant circuit (30; 130; 230; 330) between said first heat exchanger (21) and said second heat exchanger (23);

characterized in that
said method comprises the step of confining said refrigerant in one or more portions of said refrigerant circuit (30; 130; 230; 330) if an abnormal working condition of said refrigerant circuit (30; 130; 230; 330) occurs,
wherein said abnormal working condition is a refrigerant leakage

11. The method according to claim 10, **characterized in that** said step of confining said refrigerant in one or more portions of said refrigerant circuit (30; 130; 230; 330) is carried out controlling two or more interrupting devices (71, 72; 171, 172; 122) arranged along said refrigerant circuit (30; 130; 230; 330) so that activation or deactivation of said interrupting devices (71, 72; 171, 172; 122) creates said one or more portions.

12. The method according to claim 10 or 11, **characterized in that** said refrigerant leakage is detected by means of a leakage sensor.

13. The method according to claim 10, 11 or 12, **characterized in that** said refrigerant leakage is determined analyzing one or more functioning parameters of said laundry drying machine (1).

14. The method according to claim 13, **characterized in that** said one or more functioning parameters comprise one of the parameters selected from a group comprising: the air stream temperature upstream and/or downstream of said drum (9), the temperature measured from a surface of said first heat exchanger (21), the detected or calculated pressure and/or temperature of said refrigerant.

15. The method according to any preceding claims from 10 to 14, wherein said refrigerant leakage occurs when
one or more working parameters of said compressor (24) exceed pre-determined safety thresholds, and/or
the refrigerant temperature and/or the refrigerant pressure exceeds pre-determined safety thresholds.

16. The method according to claim 15, **characterized in that** said working parameters of said compressor comprise the current and/or the power absorption of said compressor (24).

17. The method according to any preceding claim from 10 to 16, **characterized in that** it further comprises the step of emitting a warning alarm for the user.

18. The method according to any preceding claim from 10 to 17, **characterized in that** it further comprises the step of deactivating said compressor if said abnormal working condition occurs.

Patentansprüche

1. Wäschetrocknungsmaschine (1) des Typs, der ein Wärmepumpensystem (20; 120; 220; 320) umfasst, das einen Kühlkreislauf (30; 130; 230; 330) für ein Kühlmittel aufweist und einen Luftströmungskreislauf (10) für eine Luftströmung (A), die einer Wäschetrommel (9), die zu trocknende Wäsche aufnehmen kann, zugeführt werden kann, umfasst, wobei der Kühlkreislauf (30; 130; 230; 330) Folgendes umfasst:

- einen ersten Wärmetauscher (21) für eine Wärmekopplung zwischen dem Luftströmungskreislauf (10) und dem Kühlkreislauf (30; 130; 230; 330), wobei das Kühlmittel herabgekühlt wird und die Luftströmung (A) aufgeheizt wird;
- einen zweiten Wärmetauscher (23) für eine weitere Wärmekopplung zwischen dem Luftströmungskreislauf (10) und dem Kühlkreislauf (30; 130; 230; 330), wobei das Kühlmittel auf-

geheizt wird und die Luftströmung (A) herabgekühlt wird;
- einen Kompressor (24), der in dem Kühlkreislauf (30; 130; 230; 330) zwischen dem zweiten Wärmetauscher (23) und dem ersten Wärmetauscher (21) angeordnet ist;
- eine Kühlmittel-Expansionsvorrichtung (22; 122), die in dem Kühlkreislauf (30; 130; 230; 330) zwischen dem ersten Wärmetauscher (21) und dem zweiten Wärmetauscher (23) angeordnet ist; und
- zwei oder mehrere Unterbrechungsvorrichtungen (71, 72; 171, 172; 122), die entlang des Kühlkreislaufs (30; 130; 230; 330) angeordnet sind und einen oder mehrere Abschnitte des Kühlkreislaufs (30; 130; 230; 330), in denen Kühlmittel eingeschlossen werden kann, definieren;

gekennzeichnet durch
einen Lecksensor,
wobei die Unterbrechungsvorrichtungen (71, 72; 171, 172; 122) geschlossen sind, wenn **durch** den Lecksensor ein Kühlmittelleck detektiert wird.

2. Maschine (1) nach Anspruch 1, **dadurch gekennzeichnet, dass** sie eine Steuerung (26) zum Steuern der Unterbrechungsvorrichtungen (71, 72; 171, 172; 122) umfasst.

3. Maschine (1) nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** zwei oder mehrere Unterbrechungsvorrichtungen (71, 72; 171, 172) Ein/Aus-Ventile umfassen.

4. Maschine (1) nach Anspruch 3, **dadurch gekennzeichnet, dass** die Ein/Aus-Ventile normalerweise geschlossene Ventile (71, 72; 171, 172) sind, so dass das Kühlmittel in dem einen oder den mehreren Abschnitten eingeschlossen ist, wenn die Ein/Aus-Ventile (71, 72; 171, 172) deaktiviert sind oder die Maschine (1) ausgeschaltet ist.

5. Maschine (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Kühlmittel-Expansionsvorrichtung (122) ein Expansionsventil umfasst, wobei das Expansionsventil eine der Unterbrechungsvorrichtungen (71, 72; 171, 172; 122) ist.

6. Maschine (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Kühlkreislauf (30; 130; 230; 330) eine Leitung (61, 62, 63, 64) umfasst, die den Kompressor (24), den ersten Wärmetauscher (21), die Expansionsvorrichtung (22; 122) und den zweiten Wärmetauscher (23) in einer Konfiguration eines geschlossenen Kreislaufs verbindet, und dass die Unterbrechungsvorrichtungen (71, 72; 171, 172) entlang einer oder mehrerer der Verbindungsleitungen (61, 62, 63, 64) angeordnet sind.

7. Maschine (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Unterbrechungsvorrichtungen (71, 72; 122) auf der Hochdruckseite des Kühlkreislaufs (30; 230; 330) angeordnet sind.

8. Maschine (1) nach Anspruch 7, **dadurch gekennzeichnet, dass** die Unterbrechungsvorrichtungen (71, 72; 122) auf der Hochdruckseite des Kühlkreislaufs (30; 230; 330) angeordnet sind, so dass das Kühlmittel in dem ersten Wärmetauscher (21) eingeschlossen ist.

9. Maschine (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Kühlmittel von einem der folgenden Typen ist: Hydrofluorcarbonat (HFC); Hydrofluorolefin (HFO); Hydrocarbonat (HC), Kohlenstoffdioxid (CO_2), Ammoniak (NH_3) .

10. Verfahren zum Steuern einer Wäschetrocknungsmaschine (1) des Typs, der ein Wärmepumpensystem (20; 120; 220; 320) umfasst, das einen Kühlkreislauf (30; 130; 230; 330) für ein Kühlmittel aufweist und einen Luftströmungskreislauf (10) für eine Luftströmung (A), die einer Wäschetrommel (9), die geeignet ist, zu trocknende Wäsche aufzunehmen, zugeführt werden kann, umfasst, wobei der Kühlkreislauf (30; 130; 230; 330) Folgendes umfasst:

- einen ersten Wärmetauscher (21) für eine Wärmekopplung zwischen dem Luftströmungskreislauf (10) und dem Kühlkreislauf (30; 130; 230; 330), wobei das Kühlmittel herabgekühlt wird und die Luftströmung (A) aufgeheizt wird;
- einen zweiten Wärmetauscher (23) für eine weitere Wärmekopplung zwischen dem Luftströmungskreislauf (10) und dem Kühlkreislauf (30; 130; 230; 330), wobei das Kühlmittel aufgeheizt wird und die Luftströmung (A) herabgekühlt wird;
- einen Kompressor (24), der in dem Kühlkreislauf (30; 130; 230; 330) zwischen dem zweiten Wärmetauscher (23) und dem ersten Wärmetauscher (21) angeordnet ist;
- eine Kühlmittel-Expansionsvorrichtung (22; 122), die in dem Kühlkreislauf (30; 130; 230; 330) zwischen dem ersten Wärmetauscher (21) und dem zweiten Wärmetauscher (23) angeordnet ist;

dadurch gekennzeichnet, dass
das Verfahren den Schritt des Einschließens des Kühlmittels in einem oder mehreren Abschnitten des

Kühlkreislaufs (30; 130; 230; 330) umfasst, falls eine abweichende Betriebsbedingung des Kühlkreislaufs (30; 130; 230; 330) eintritt,
wobei eine abweichende Betriebsbedingung ein Kühlmittelleck ist.

11. Verfahren nach Anspruch 10, **dadurch gekennzeichnet, dass** der Schritt des Einschließens des Kühlmittels in einem oder mehreren Abschnitten des Kühlkreislaufs (30; 130; 230; 330) ausgeführt wird, indem zwei oder mehrere Unterbrechungsvorrichtungen (71, 72; 171, 172; 122) entlang des Kühlkreislaufs (30; 130; 230; 330) so gesteuert werden, dass eine Aktivierung oder Deaktivierung der Unterbrechungsvorrichtungen (71, 72; 171, 172; 122) den einen oder die mehreren Abschnitte erzeugt.

12. Verfahren nach Anspruch 10 oder 11, **dadurch gekennzeichnet, dass** das Kühlmittelleck mittels eines Lecksensors detektiert wird.

13. Verfahren nach Anspruch 10, 11 oder 12, **dadurch gekennzeichnet, dass** das Kühlmittelleck festgestellt wird, indem ein oder mehrere Funktionsparameter der Wäschetrocknungsmaschine (1) analysiert werden.

14. Verfahren nach Anspruch 13, **dadurch gekennzeichnet, dass** der eine oder die mehreren Funktionsparameter einen Parameter umfassen, der aus einer Gruppe ausgewählt wird, die Folgendes umfasst: die Luftströmungstemperatur stromaufwärts und/oder stromabwärts der Trommel (9), die Temperatur, die an einer Oberfläche des ersten Wärmetauschers (21) gemessen wird, der detektierte oder berechnete Druck und/oder die Temperatur des Kühlmittels.

15. Verfahren nach einem der vorhergehenden Ansprüche 10 bis 14, wobei das Kühlmittelleck eintritt, wenn ein oder mehrere Betriebsparameter des Kompressors (24) festgelegte Sicherheitsschwellenwerte überschreiten, und/oder
die Kühlmitteltemperatur und/oder der Kühlmitteldruck festgelegte Sicherheitsschwellenwerte überschreiten.

16. Verfahren nach Anspruch 15, **dadurch gekennzeichnet, dass** die Betriebsparameter des Kompressors die Strom- und/oder Leistungsaufnahme des Kompressors (24) umfassen.

17. Verfahren nach einem der vorhergehenden Ansprüche 10 bis 16, **dadurch gekennzeichnet, dass** es ferner den Schritt des Ausgebens eines Warnalarms für den Benutzer umfasst.

18. Verfahren nach einem der vorhergehenden Ansprüche 10 bis 17, **dadurch gekennzeichnet, dass** es ferner den Schritt des Deaktivierens des Kompressors umfasst, falls eine abweichende Betriebsbedingung eintritt.

Revendications

1. Machine à sécher le linge (1) du type comprenant un système de pompe à chaleur (20 ; 120 ; 220 ; 320) ayant un circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) pour un fluide frigorigène et comprenant un circuit de flux d'air (10) pour un flux d'air (A) pouvant être acheminé vers un tambour à linge (9) approprié pour recevoir du linge à sécher, ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) comprenant :

- un premier échangeur de chaleur (21) pour un accouplement thermique entre ledit circuit de flux d'air (10) et ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330), le fluide frigorigène étant refroidi et ledit flux d'air (A) étant chauffé ;
- un second échangeur de chaleur (23) pour un autre accouplement thermique entre ledit circuit de flux d'air (10) et ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330), le fluide frigorigène étant chauffé et ledit flux d'air (A) étant refroidi ;
- un compresseur (24) agencé dans ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) entre ledit second échangeur de chaleur (23) et ledit premier échangeur de chaleur (21) ;
- un dispositif de dilatation de fluide frigorigène (22 ; 122) agencé dans ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) entre ledit premier échangeur de chaleur (21) et ledit second échangeur de chaleur (23) ; et

au moins deux dispositifs d'interruption (71, 72 ; 171, 172 ; 122) agencés le long dudit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) et appropriés pour définir une ou plusieurs sections dudit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) où ledit fluide frigorigène peut être confiné ; **caractérisé par** :

un capteur de fuite,
lesdits dispositifs d'interruption (71, 72 ; 171, 172 ; 122) étant fermés quand une fuite de fluide frigorigène est détectée par ledit capteur de fuite.

2. Machine (1) selon la revendication 1, **caractérisée en ce qu'**elle comprend une unité de contrôle (26) pour contrôler lesdits dispositifs d'interruption (71, 72 ; 171, 172 ; 122).

3. Machine (1) selon la revendication 1 ou 2, **caractérisée en ce que** les au moins deux dispositifs d'in-

terruption (71, 72 ; 171, 172) comprennent des vannes d'ouverture/fermeture.

4. Machine (1) selon la revendication 3, **caractérisée en ce que** lesdites vannes d'ouverture/fermeture sont des vannes normalement fermées (71, 72 ; 171, 172) de sorte que ledit fluide frigorigène soit confiné dans ladite ou lesdites sections quand lesdites vannes d'ouverture/fermeture (71, 72 ; 171, 172) sont désactivées ou quand ladite machine (1) est éteinte.

5. Machine (1) selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ledit dispositif de dilatation de fluide frigorigène (122) comprend un détendeur, ledit détendeur étant un desdits dispositifs d'interruption (71, 72 ; 171, 172 ; 122).

6. Machine (1) selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) comprend des tuyaux (61, 62, 63, 64) raccordant ledit compresseur (24), ledit premier échangeur de chaleur (21), ledit dispositif de dilatation (22 ; 122) et ledit second échangeur de chaleur (23) en une configuration en boucle fermée et **en ce que** lesdits dispositifs d'interruption (71, 72 ; 171, 172) sont agencés le long d'un ou plusieurs desdits tuyaux de raccord (61, 62, 63, 64).

7. Machine (1) selon l'une quelconque des revendications précédentes, **caractérisée en ce que** lesdits dispositifs d'interruption (71, 72 ; 122) sont agencés du côté haute pression dudit circuit de fluide frigorigène (30 ; 230 ; 330).

8. Machine (1) selon la revendication 7, **caractérisée en ce que** lesdits dispositifs d'interruption (71, 72 ; 122) sont agencés dudit côté haute pression dudit circuit de fluide frigorigène (30 ; 230 ; 330), de sorte que ledit fluide frigorigène puisse être confiné dans ledit premier échangeur de chaleur (21).

9. Machine (1) selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ledit fluide frigorigène est un des types suivants : de type hydrofluorocarboné (HFC), de type hydrofluoroléfine (HFO), de type hydrocarbure (HC), du dioxyde de carbone (CO_2) et de l'ammoniac (NH_3) .

10. Procédé de contrôle d'une machine à sécher le linge (1) du type comprenant un système de pompe à chaleur (20 ; 120 ; 220 ; 320) ayant un circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) pour un fluide frigorigène et comprenant un circuit de flux d'air (10) pour un flux d'air (A) pouvant être acheminé vers un tambour à linge (9) approprié pour recevoir du linge à sécher, ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) comprenant :

- un premier échangeur de chaleur (21) pour un accouplement thermique entre ledit circuit de flux d'air (10) et ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330), le fluide frigorigène étant refroidi et ledit flux d'air (A) étant chauffé ;
- un second échangeur de chaleur (23) pour un autre accouplement thermique entre ledit circuit de flux d'air (10) et ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) le fluide frigorigène étant chauffé et ledit flux d'air (A) étant refroidi ;
- un compresseur (24) agencé dans ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) entre ledit second échangeur de chaleur (23) et ledit premier échangeur de chaleur (21) ;
- un dispositif de dilatation de fluide frigorigène (22 ; 122) agencé dans ledit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) entre ledit premier échangeur de chaleur (21) et ledit second échangeur de chaleur (23) ;

caractérisé en ce que :

ledit procédé comprend l'étape consistant à confiner ledit fluide frigorigène dans une ou plusieurs sections dudit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) si une condition de travail anormale dudit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) survient,
ladite condition de travail anormale étant une fuie de fluide frigorigène.

11. Procédé selon la revendication 10, **caractérisé en ce que** ladite étape de confinement dudit fluide frigorigène dans une ou plusieurs sections dudit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) est réalisée en contrôlant au moins deux dispositifs d'interruption (71, 72 ; 171, 172 ; 122) agencés le long dudit circuit de fluide frigorigène (30 ; 130 ; 230 ; 330) de sorte que l'activation ou la désactivation desdits dispositifs d'interruption (71, 72 ; 171, 172 ; 122) crée ladite ou lesdites sections.

12. Procédé selon la revendication 10 ou 11, **caractérisé en ce que** ladite fuite de fluide frigorigène est détectée au moyen d'un capteur de fuite.

13. Procédé selon la revendication 10, 11 ou 12, **caractérisé en ce que** ladite fuite de fluide frigorigène est déterminée en analysant un ou plusieurs paramètres de fonctionnement de ladite machine à laver le linge (1).

14. Procédé selon la revendication 13, **caractérisé en ce que** ledit ou lesdits paramètres de fonctionnement comprennent un des paramètres sélectionnés dans un groupe comprenant : la température de flux d'air en amont et/ou en aval dudit tambour (9), la température mesurée depuis une surface dudit pre-

mier échangeur de chaleur (21) et la pression et/ou la température détectées ou calculées dudit fluide frigorigène.

15. Procédé selon l'une quelconque des revendications précédentes 10 à 14, dans lequel ladite fuite de fluide frigorigène survient quand :

un ou plusieurs paramètres de travail dudit compresseur (24) dépassent des seuils de sécurité prédéterminés, et/ou
la température de fluide frigorigène et/ou la pression de fluide frigorigène dépassent des seuils de sécurité prédéterminés.

16. Procédé selon la revendication 15, **caractérisé en ce que** lesdits paramètres de travail dudit compresseur comprennent le courant et/ou l'absorption de puissance dudit compresseur (24).

17. Procédé selon l'une quelconque des revendications précédentes 10 à 16, **caractérisé en ce qu'**il comprend en outre l'étape consistant à émettre une alarme d'avertissement pour l'utilisateur.

18. Procédé selon l'une quelconque des revendications précédentes 10 à 17, **caractérisé en ce qu'**il comprend en outre l'étape consistant à désactiver ledit compresseur si ladite condition de travail anormale survient.

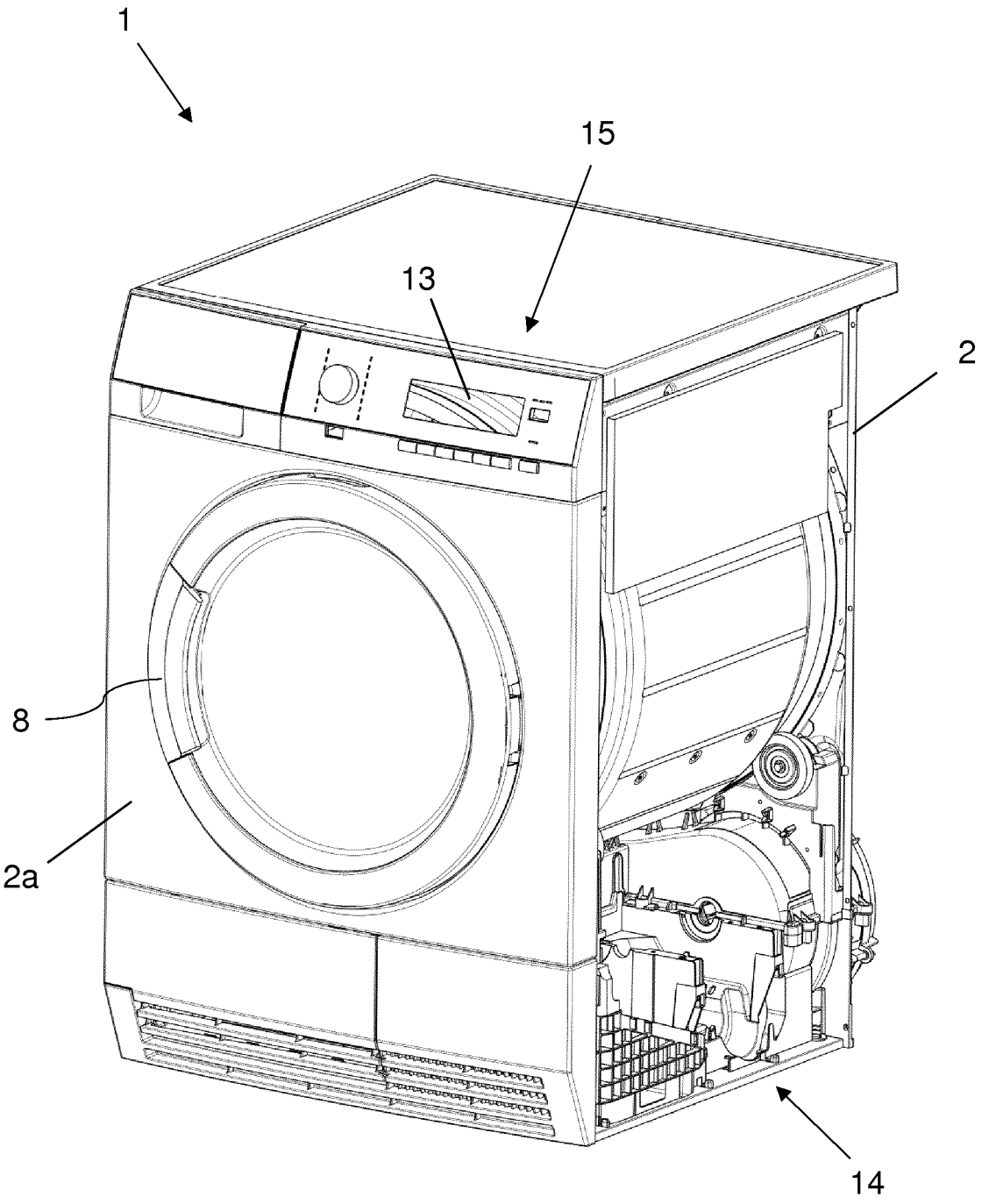


FIG. 1

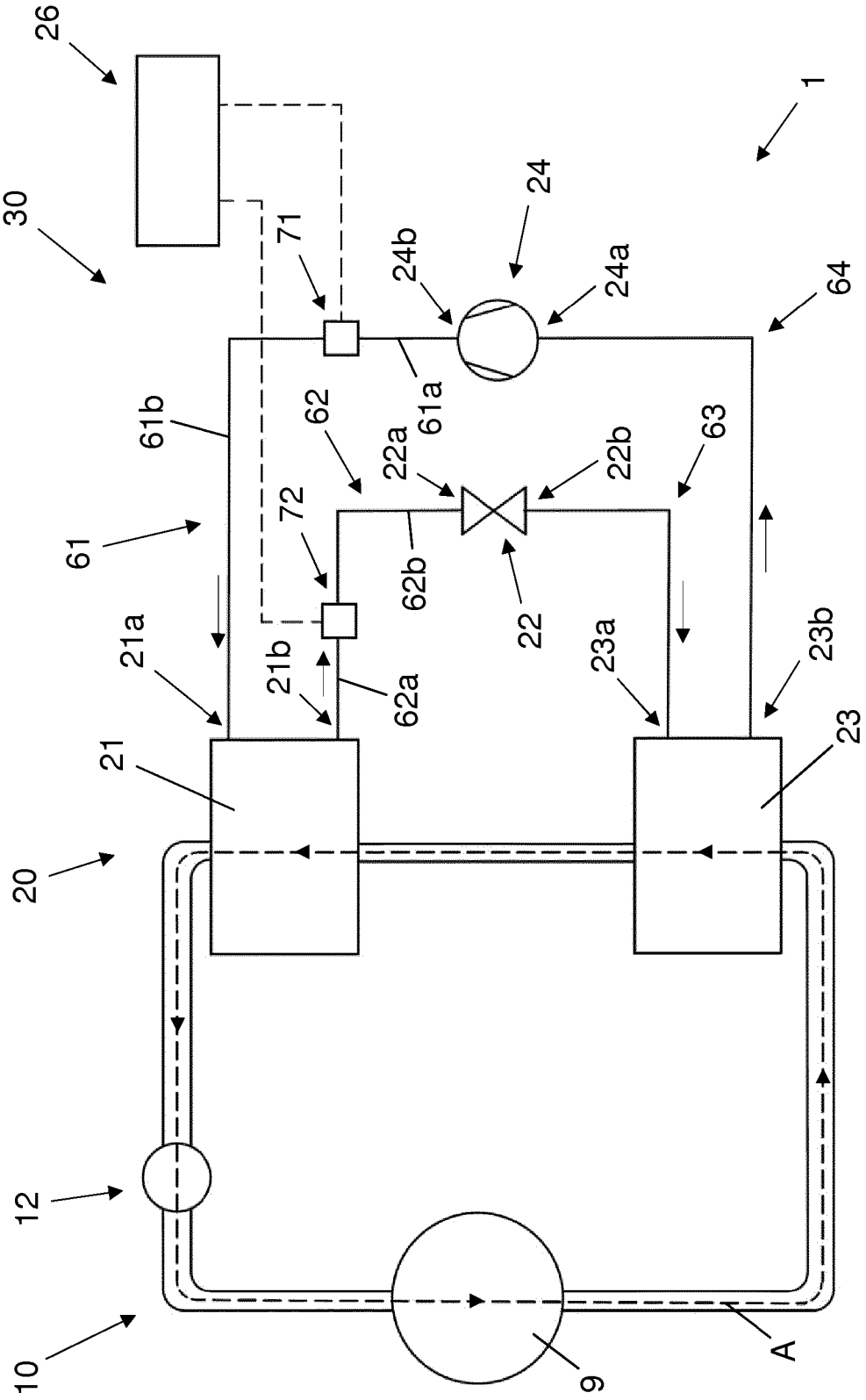

26
30
1
71
24
24b
24a
64
61b
62
61a
22a
22b
63
72
61
62b
22
21a
21b
62a
23a
23b
21
23
20
12
10
9
A

FIG. 2

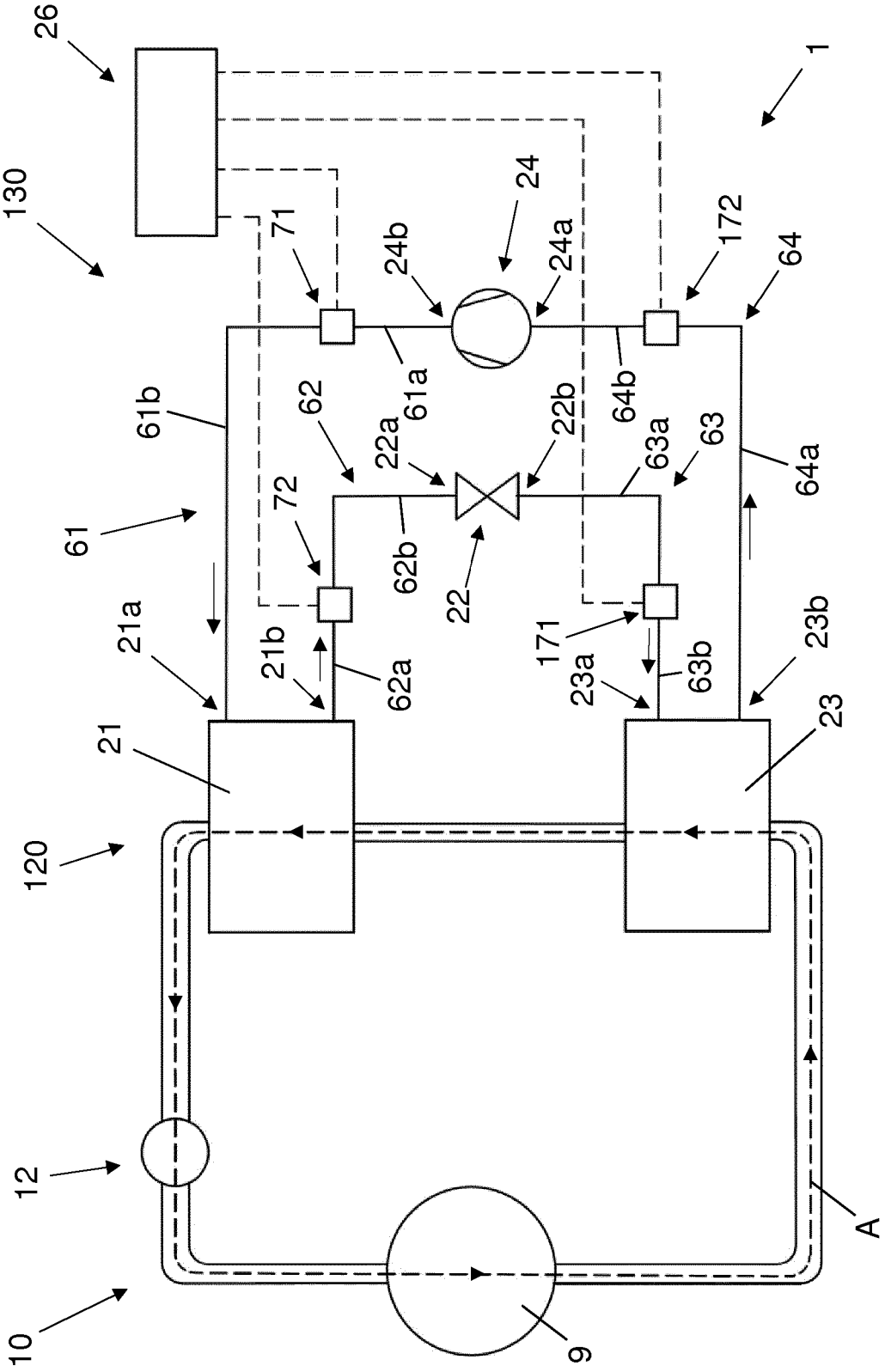

26
1
130
71
24
24b
24a
172
64
61b
62
61a
22a
22b
64b
63
63a
64a
72
61
62b
22
21a
21b
62a
171
63b
23b
23a
21
23
120
12
A
10
9

FIG. 3

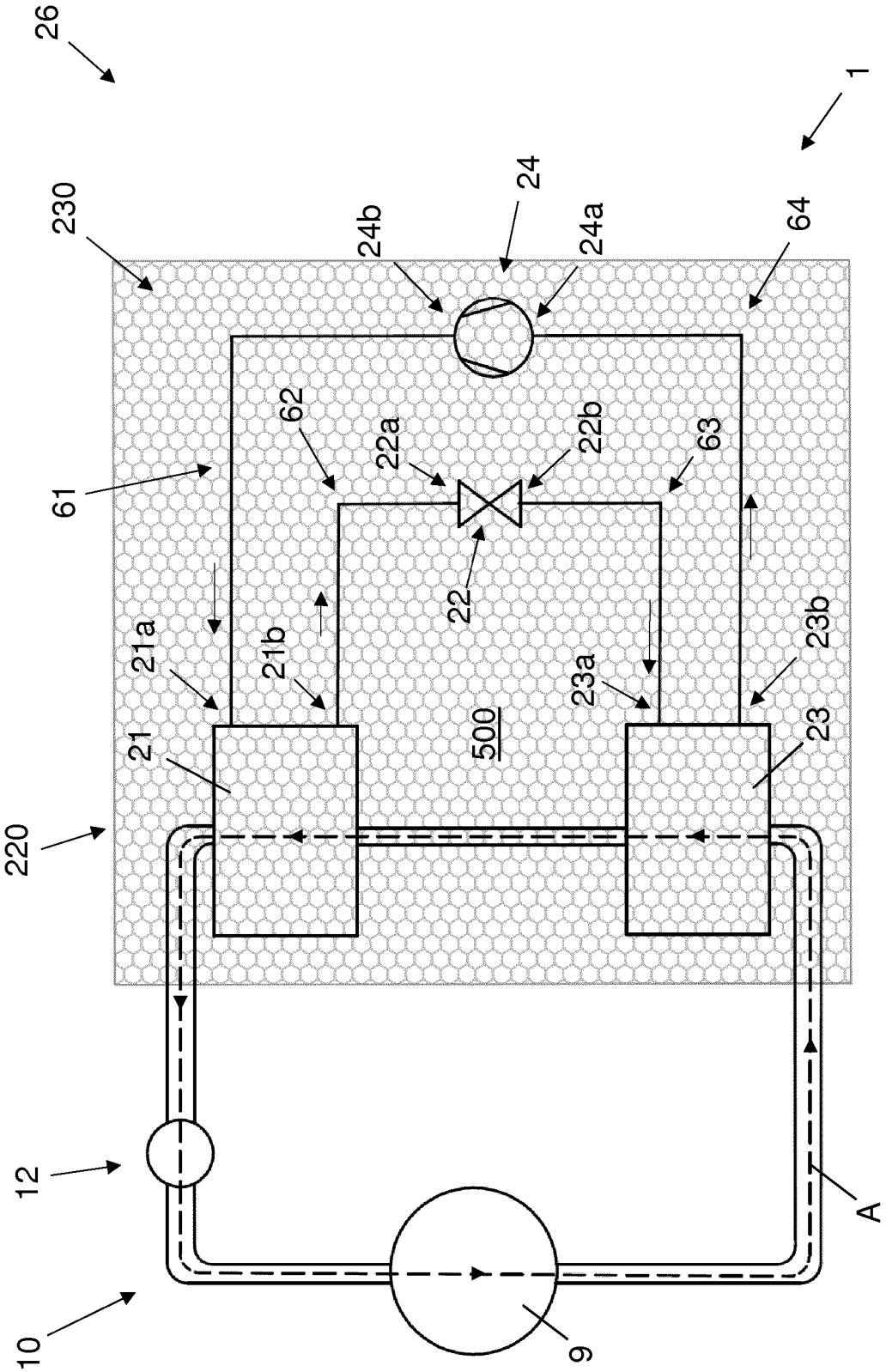

26
1
230
24
24b
24a
64
62
22a
22b
63
61
22
21a
21b
23b
23a
500
21
23
220
12
A
10
9

FIG. 4

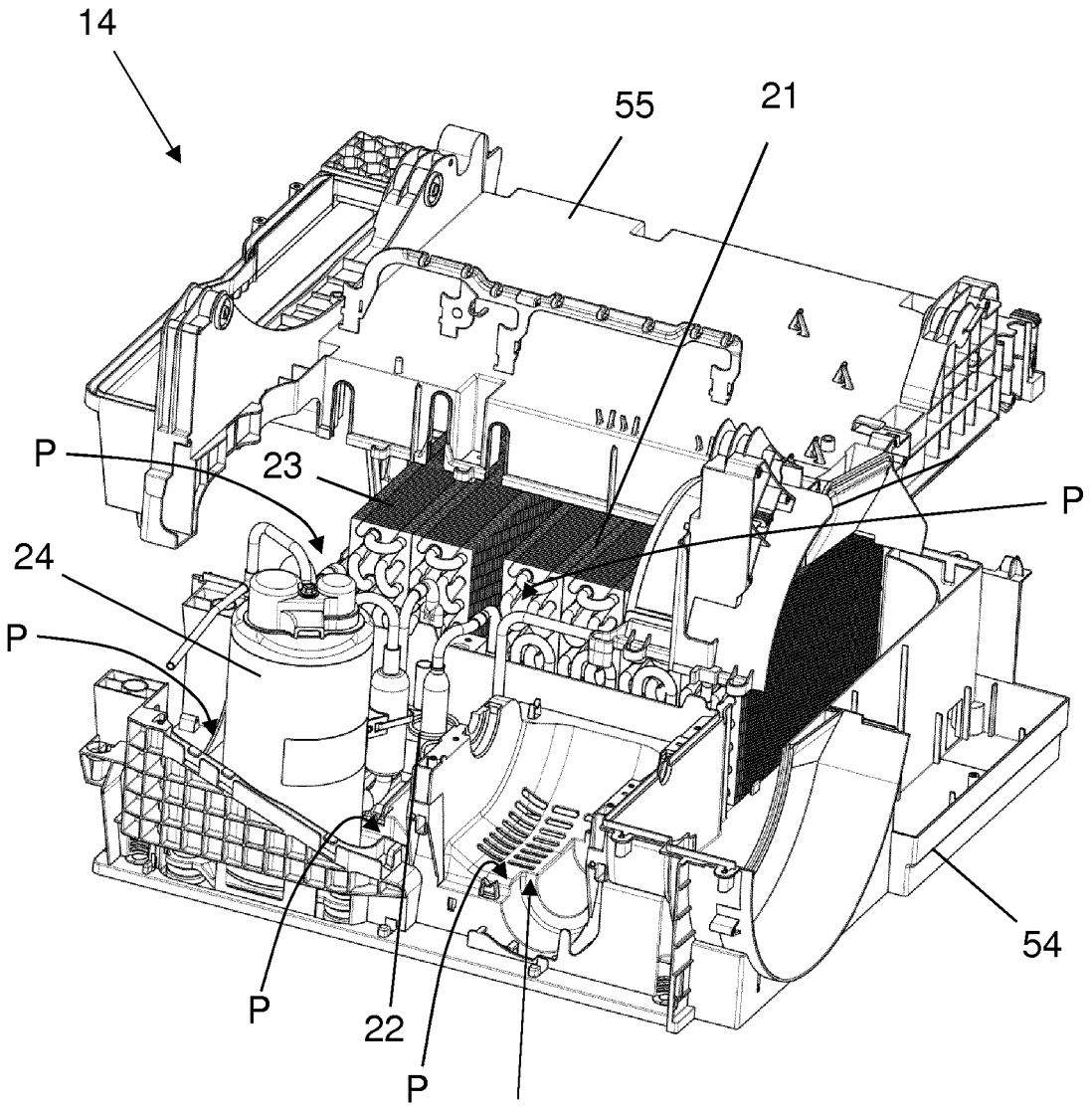


FIG. 5

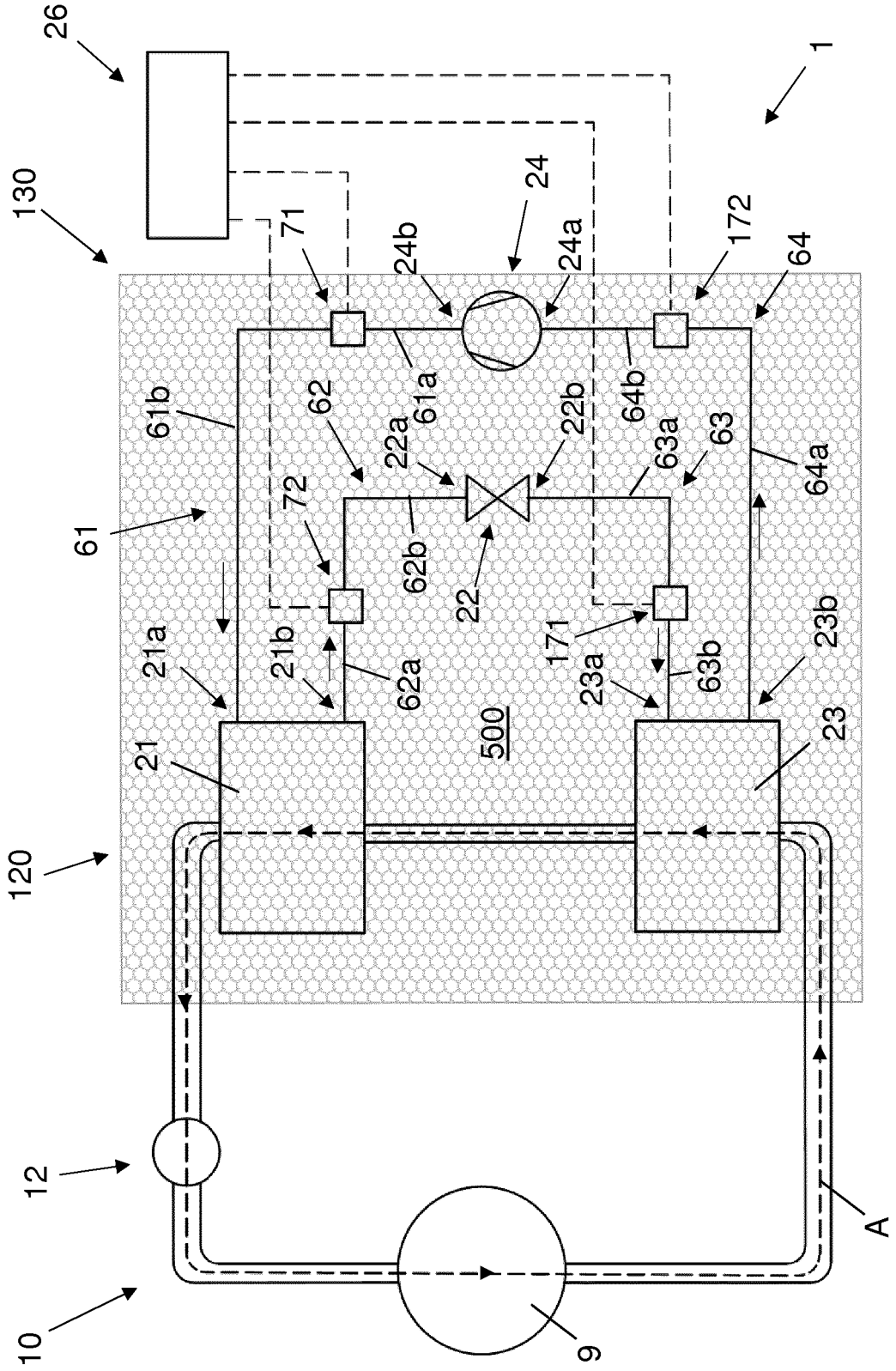

26
1
130
71
24b
24
24a
172
64
61b
62
61a
22a
22b
64b
63a
63
64a
72
61
62b
22
171
21a
21b
62a
500
23a
63b
23b
23
21
120
12
A
10
9

FIG. 6

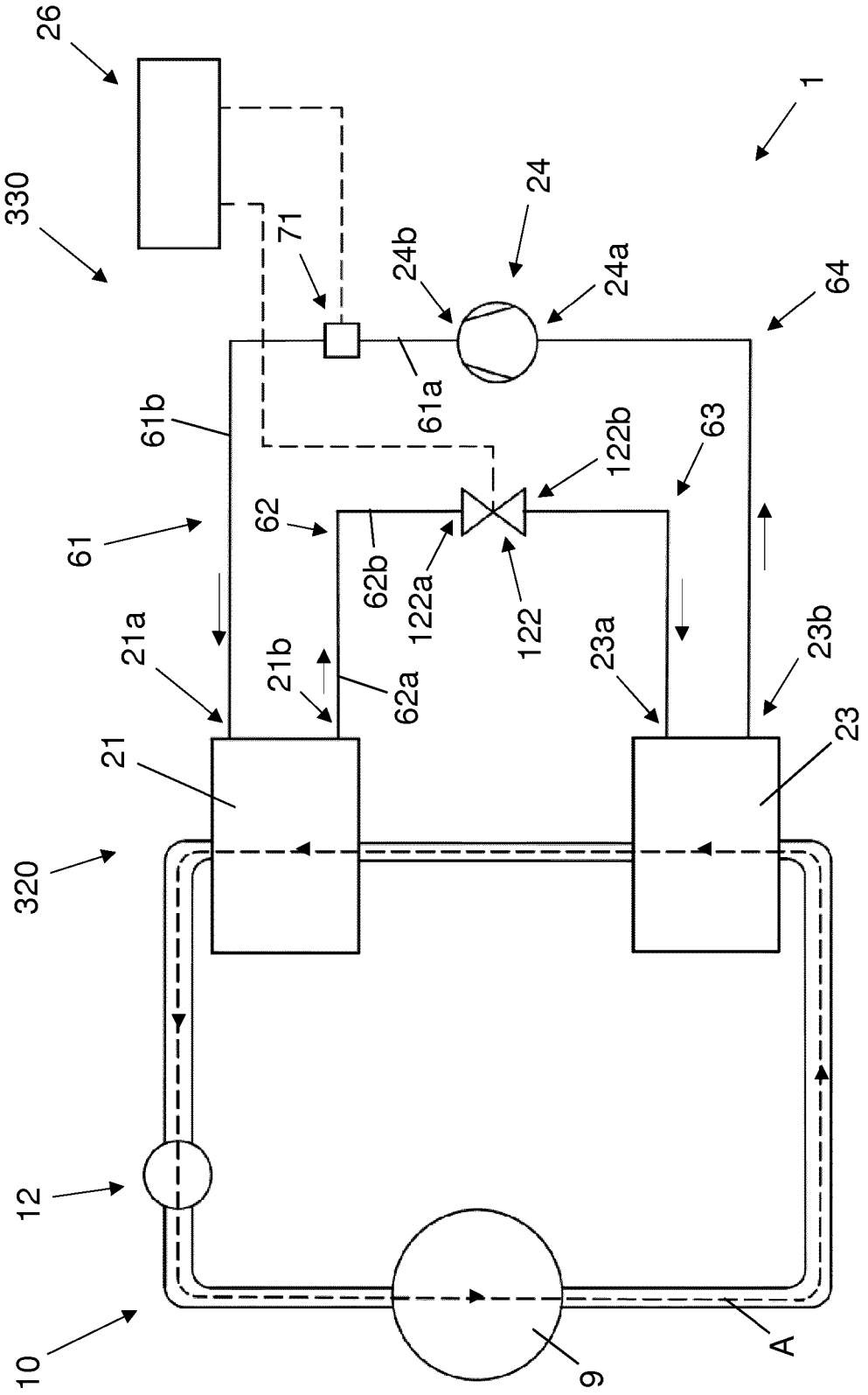

26
330
71
24
24b
24a
1
64
61b
61a
63
122b
62
61
62b
122a
122
23a
23b
21a
21b
62a
23
21
320
12
10
9
A

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20120079736 A **[0009] [0097]**
- EP 2527521 A1 **[0017]**
- EP 2489775 A1 **[0018]**
- US 20120079736 A1 **[0019]**