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(54) Laundry drying machine

(57) The present invention relates to a laundry drying machine (1) comprising a laundry chamber (9) suitable for receiving the laundry to be dried, an air stream circuit (10) for circulating an air stream through said laundry chamber (9) and a heat pump system (20; 120; 220; 320; 420). The heat pump system (20; 120; 220; 320; 420) comprises a first heat exchanger (21) for heating up the air stream conveyable into the laundry chamber (9) and a second heat exchanger (23) for dehumidifying the moist air of the air stream coming from the laundry chamber (9). The heat pump system (20; 120; 220; 320; 420) comprises a compressor (24) having an outlet (24b) connectable to the first heat exchanger (21) and an inlet (24a) connectable to the second heat exchanger (23) and an expansion device (22) having an outlet (22b) connectable to the second heat exchanger (23) and an inlet connectable to the first heat exchanger (21). The heat pump system (20; 120; 220; 320; 420) further comprises an auxiliary heat exchanger comprising a portion (31; 41; 51; 61; 150) of the heat pump system (20; 120; 220; 320; 420) arranged between the expansion device outlet (22b) and the compressor inlet (24a) and a cooling member (57; 77) associated to an electric and/or an electronic device (25) of the machine (1).

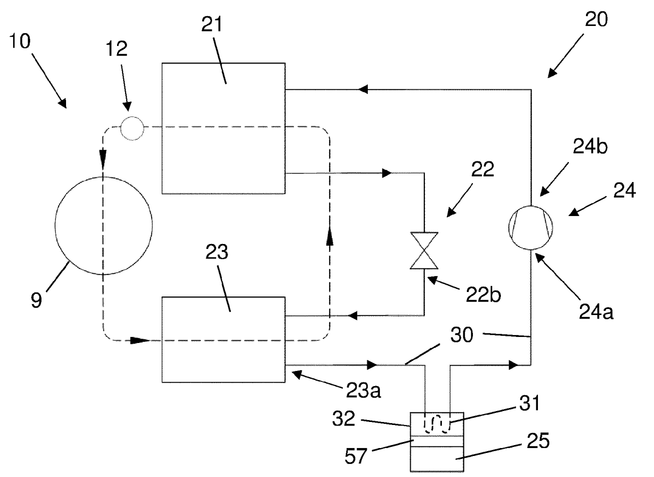

FIG. 9

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Description

FIELD OF THE INVENTION

[0001] The present invention concerns the technical field of laundry treating machines, especially laundry drying machines.

[0002] In particular, the present invention refers to laundry drying machines of the condenser type.

BACKGROUND ART

[0003] Laundry treating machines capable of carrying out a drying process on laundry generally comprise a casing that houses a laundry container, like a rotating drum, where laundry to be treated is received and a closed air stream circuit for carrying out drying operation by circulating hot air through the laundry container containing the wet laundry. The rotating drum is typically rotated by an electric motor which transmits the rotating motion to the drum, for example by means of a belt/pulley system.

[0004] A heating device for heating up the air stream is advantageously arranged upstream of the rotating drum.

[0005] An air circulating device, typically a fan, is provided in the air stream circuit for circulating the hot hair.

[0006] Known laundry drying machines, hereinafter referred simply as dryers, further comprise condensing means provided in the air stream circuit for removing moisture from warm humid air that leaves the drum. The warm humid air is both cooled down and dehumidified by the condensing means.

[0007] In dryers of known type the heating device and the condensing means are, respectively, the condenser and the evaporator of a heat pump system. In said heat pump system a compressor connects the evaporator outlet to the condenser inlet while expansion means, for example an expansion valve, connects the condenser outlet to the evaporator inlet. The compressor is typically powered by an electric motor.

[0008] The motor which drives the rotating drum and the motor of the compressor are typically speed controlled electric motors and are preferably controlled by respective inverter motor controls.

[0009] In operation, the inverters generate a large amount of heat which increases their working temperature. In order to keep the working temperatures of the inverters below a safety limit the inverters are usually provided with heat dissipators, for example finned sheet metal structures, directly mounted on the inverters. The heat is dissipated by conduction and natural convention.

[0010] Known dryers further comprise a control unit which is advantageously connected to the various parts of the dryer in order to ensure its operation. The control unit typically comprises a printed circuit board that supports the electric and/or electronic devices which assure functioning of the peripheral units. Such electric and/or electronic devices usually also generate heat and are therefore opportunely provided with proper designed heat dissipators.

[0011] However, the dryers above described belonging to the known art pose some drawbacks.

[0012] A first drawback posed by this known technique is constituted by the fact that the heat dissipators are bulky.

[0013] Another drawback posed by this known technique is constituted by the fact that increasing of temperature may cause failure of the inverters or of the other electric and/or electronic devices of the dryer.

[0014] A further drawback posed by this known technique is constituted by the fact that heat dissipation reduces the energy efficiency of the dryer. This causes, in turn, a higher power consumption and higher costs.

[0015] The main object of the present invention is therefore to overcome said drawbacks.

[0016] In particular, it is one object of the present invention to provide a laundry drying machine with a heat dissipation system which has a reduced constructional complexity with respect to the systems of known type.

[0017] Another object of the present invention is to provide a laundry drying machine with a lower failure rate with respect to the laundry drying machines of known type.

[0018] A further object of the present invention is to provide a laundry drying machine with reduced power consumption with respect to the laundry drying machines of known type.

[0019] Another object of the present invention is to provide a laundry drying machine with higher energy efficiency with respect to the laundry drying machines of known type.

[0020] Advantages, objects, and features of the invention will be set forth in part in the description and drawings which follow and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention.

DISCLOSURE OF INVENTION

[0021] The applicant has found that by providing a laundry drying machine comprising a laundry chamber suitable for receiving the laundry to be dried, an air stream circuit for circulating an air stream through said laundry chamber and provided with a heat pump system for heating up said air stream conveyable into said container and for dehumidifying the moist air of said air stream coming from said laundry chamber, wherein a portion of said heat pump system is subjected to a heat exchange with heat generated by an electric and/or electronic device of said machine it is possible to obtain a laundry drying machine having a reduced constructional complexity.

[0022] The present invention relates, therefore, to a laundry drying machine comprising a laundry chamber suitable for receiving the laundry to be dried, an air stream circuit for circulating an air stream through said laundry chamber and a heat pump system comprising:

- a first heat exchanger for heating up said air stream conveyable into said laundry chamber;
- a second heat exchanger for dehumidifying the moist air of said air stream coming from said laundry chamber;
- a compressor comprising an outlet connectable to said first heat exchanger and an inlet connectable to said second heat exchanger;
- an expansion device comprising an outlet connectable to said second heat exchanger and an inlet connectable to said first heat exchanger;

wherein the machine further comprises an auxiliary heat exchanger comprising a portion of said heat pump system arranged between said expansion device outlet and said compressor inlet and a cooling member associated to an electric and/or an electronic device of said machine.

[0023] Preferably the portion of the heat pump system and the cooling member are mutually arranged so that heat transfer between them takes place by conduction. In a first preferred embodiment of the invention, the portion comprises a portion of a pipe arranged between the second heat exchanger and the inlet compressor. In a second preferred embodiment of the invention, the portion comprises a portion of a pipe arranged between the expansion device outlet and said second heat exchanger.

[0024] Preferably the portion comprises a portion of a pipe connected in series to the second heat exchanger.

[0025] Alternatively, the portion comprises a portion of a pipe arranged in parallel to the second heat exchanger.

[0026] In a further preferred embodiment of the invention, the second heat exchanger comprises a pipe and the portion comprises a portion of such pipe.

[0027] Preferably, the portion comprises a serpentine pipe.

[0028] In a preferred embodiment of the invention, the auxiliary heat exchanger further comprises a support member for the portion of the pipe, the support member being suitable for fixing the portion to the cooling member and suitable for increasing the heat exchanging surface between the portion and the cooling member.

[0029] Advantageously the support member comprises a thermally conductive material. Advantageously the cooling member comprises a thermally conductive material. In a preferred embodiment of the invention, the cooling member comprises a metallic plate.

[0030] Preferably the system further comprises a thermal conducting paste arranged between the support member and the cooling member.

[0031] According to a preferred embodiment of the invention, the electric and/or electronic device comprises an inverter motor control.

[0032] In a first preferred embodiment of the invention, the inverter motor control controls the speed of a motor of the compressor.

[0033] Preferably the laundry chamber is a rotatable laundry container and the inverter motor control controls the speed of a motor suitable for rotating the rotatable laundry container.

[0034] According to a preferred embodiment of the invention, the first heat exchanger is a condenser or a gas cooler.

[0035] In a similar way, the second heat exchanger is an evaporator or a gas heater. Preferably, the dehumidified air coming from the second heat exchanger is conveyed again to the first heat exchanger so as to create a closed loop air stream circuit.

[0036] Opportunely, the heat pump system is received in a basement portion of the machine.

[0037] Advantageously, the basement comprises a first area suitable for receiving the first heat exchanger and the second heat exchanger and at least a second area, separated from the first area, suitable for receiving at least the compressor and the expansion device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate possible embodiments of the invention and together with the description serve to explain the principles of the invention. In the drawings, corresponding characteristics and/or components are identified by the same reference numbers. In particular:

- Figure 1 shows a perspective view of a laundry drying machine according to a first embodiment of the invention with an upright side wall removed;
- Figure 2 shows a perspective view of the basement of the laundry drying machine of Figure 1;
- Figure 3 shows the basement of Figure 2 with the upper shell removed;
- Figure 4 shows a perspective view of a particular of Figure 2;
- Figure 5 shows an exploded view of the particular of Figure 3;
- Figure 6 shows a perspective view of a particular of Figure 4;
- Figure 7 shows the particular of Figure 4 from another point of view with the cover member removed;
- Figure 8 shows a sectional view taken along line VIII-VIII of Figure 4;
- Figure 9 shows a schematic diagram of the heat pump system of the laundry drying machine of Figure 1;
- Figure 10 shows a schematic diagram of a heat pump system for a laundry drying machine according to a second embodiment of the present invention;
- Figure 11 shows a schematic diagram of a heat pump system for a laundry drying machine according to a third embodiment of the present invention;
- Figure 12 shows a schematic diagram of a heat pump

system for a laundry drying machine according to a fourth embodiment of the present invention;

- Figure 13 shows a schematic diagram of a heat pump system for a laundry drying machine according to a fifth embodiment of the present invention;
- Figure 14 shows a perspective view of the heat pump system according to the schematic diagram of Figure 13;
- Figure 15 shows the heat pump of Figure 14 with a part removed;
- Figure 16 shows a partial perspective view of the heat pump system of Figure 11 from another point of view.

DETAILED DESCRIPTION OF THE INVENTION

[0039] 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.

[0040] With reference to Figure 1, reference number 1 indicates as a whole a laundry drying machine 1, or dryer, according to the present invention.

[0041] The dryer 1 preferably comprises, though not necessarily, a substantially parallelepiped-shaped outer boxlike casing 2 which is preferably structured for resting on the floor and a preferably, though not necessarily, substantially cylindrical rotatable drum 9 which is structured for housing the laundry to be dried. The drum 9 preferably has its front opening or mouth directly facing a laundry loading/unloading pass-through opening provided in the front wall 2a of the boxlike 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.

[0042] The dryer 1 preferably furthermore comprises an electric motor assembly 11 which is structured for driving into rotation the rotatable drum 9 about its longitudinal reference axis, preferably by means of a belt/pulley system.

[0043] The electric motor assembly 11 preferably comprises an electric motor M1 and an inverter motor control so that the speed of the electric motor M1, and therefore the rotational speed of the drum 9, may be controlled.

[0044] The dryer 1 is provided with an air stream circuit 10, schematically illustrated with dashed line in Figure 9, which is structured to circulate inside the drum 9 a stream of hot air having a low moisture content. The hot air circulates over and through the laundry located inside the drum 9 to dry the laundry.

[0045] 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 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 the laundry stored inside the rotatable drum 9 to rapidly dry the laundry, as said above.

[0046] The air stream circuit 10 forms therefore a closed loop.

[0047] A fan 12 is preferably arranged along the circuit 10 for generating the air stream, more preferably upstream of the drum 9.

[0048] The dryer 1 is preferably provided with a heat pump system 20 interacting with the air stream circuit 10.

[0049] The heat pump system 20 advantageously comprises a condenser 21, an expansion device 22, an evaporator 23 and a compressor 24. The heat pump system 20 forms also a closed loop.

[0050] The expansion device 22 preferably comprises a capillary tube. In different embodiments the expansion device may be of different type, for example an expansion valve.

[0051] The compressor 24 preferably comprises a variable speed electric motor M2, not visible in the figures. The compressor motor M2 is advantageously arranged inside the compressor casing 124. The compressor 24 also preferably comprises an inverter motor control 25 so that the speed of the compressor motor M2 may be controlled.

[0052] In further embodiments, different electric and/or electronic devices may be provided for controlling the speed of the compressor motor M2.

[0053] The condenser 21 and the evaporator 23 are heat exchangers. Preferably such heat exchangers are of the serpentine type, as illustrated in Figure 3, comprising respective pipe 150, 151 corrugated in a zigzag pattern.

[0054] The air stream circuit 10 and the heat pump system 20 are thermally coupled by the condenser 21 and the evaporator 23.

[0055] An evaporating and condensing fluid, known as refrigerant, flows in the heat pump system 20. In the heat pump system 20 schematically illustrated in Figure 6 the refrigerant flows counter-clockwise in a closed loop.

[0056] The refrigerant is compressed and heated by the compressor 24. From the compressor outlet 24b the heated refrigerant in its gaseous state reaches the condenser 21. In the condenser 21 the refrigerant condenses and cools down while the air stream of the air stream circuit 10 which is blown across the condenser 21 is heated up. The condensed refrigerant then passes through the expansion device 22 where its pressure abruptly decreases and resulting in a mixture of liquid and vapour at a lower temperature and pressure. The cold liquid-vapour mixture from the expansion device outlet 22b then travels through the evaporator pipe 150 of the evaporator 23 and here is heated up and partially, or totally, vaporized. This is obtained thanks to the warm moist air of the air stream circuit 10 coming from the drum 9 which is blown across the evaporator pipe 150. The moist air coming from the drum 9 at the same time is cooled down and dehumidified. The resulting refrigerant vapour, or the mixture of liquid and vapour, is then conveyed from the evaporator outlet 23a to the compressor inlet 24a and compressed and heated again by the compressor 24.

[0057] In different embodiment, the first heat exchanger may comprises a gas cooler and the second heat exchanger may comprises a gas heater. In this case the refrigerant is advantageously a gas, such as CO_2, 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.

[0058] Preferably, most of the components of the air stream circuit 10 and of the heat pump system 20 are arranged in a bottom portion 14 of dryer 1, or basement, as illustrated in Figures 2 and 3. The basement 14 is preferably made of polymeric material.

[0059] The basement 14 preferably comprises a lower shell 54, as better visible in Figure 3, and an upper shell 55, opportunely coupled one to the other, as visible in Figure 2.

[0060] In particular, the basement 14 of the dryer 1 receives the connecting pipes of the heat pump system 12 which connect the condenser 21, the expansion device 22, the evaporator 23 and the compressor 24.

[0061] The basement 14 also preferably receives a cooling-air fan 45, visible in Figure 3, which advantageously conveys a cooling air stream inside the basement 14, and in particular an air stream for cooling the compressor 24.

[0062] 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. For this purpose, as illustrated in Figure 2, the lower shell 54 and the upper shell 55 are coupled so as to create a channel 56 for the air crossing the evaporator 23 and the condenser 21. The air stream, and in particular the moist air reaching the evaporator 23, is therefore advantageously confined inside the channel 56 and does not reach other part of the machine 1.

[0063] The basement 14, therefore, substantially defines a first area for receiving the evaporator 23 and the condenser 21 which are crossed by the air stream and a second separated area for other parts of the machine 1, such as the compressor 24, the expansion device 22, the inverter motor control 25, etc..

[0064] Further, the basement 14 may preferably receive other operational devices of the dryer 1, like the air stream fan 12, the drum- rotating electric motor M1 and other functional devices. In particular the basement 14 may receive one or more printed circuit board with electric and/or electronic devices mounted thereon. Still advantageously, these devices are not reached by the moist air of the air stream which is confined inside the channel 56.

[0065] The inverter motor control 25 preferably comprises a first printed board 27 on which the inverter motor control devices 58 are mounted, as illustrated in Figures 8 and 9.

[0066] A thermally conductive member 57, or cooling member, is associated to the inverter motor control devices 58. The thermally conductive member 57 preferably comprises a thermally conductive metallic plate, such as an alloy plate.

[0067] The thermally conductive member 57 is preferably in contact with a component 59 of the inverter motor control devices 58 which is subjected to the highest heating, such as an electronic switch, or IGBT, as illustrated in Figure 8.

[0068] The heat produced by inverter motor control devices 58 is transferred to the cooling member 57.

[0069] A cover 26 advantageously protects the devices 58 mounted of the first printed board 27.

[0070] An analogue separated printed circuit board, not visible in the figures, preferably receives the inverter motor control of the drum-rotating electric motor M1.

[0071] In further embodiments, the two inverter motor controls may be advantageously both mounted on a common single printed circuit board.

[0072] According to the invention, a portion 31 of the pipe 30 connecting the evaporator outlet 23a to the compressor inlet 24a is thermally coupled to the inverter motor control 25 of the compressor electric motor M2.

[0073] Preferably the portion 31 of the pipe 30 is thermally coupled to the inverter motor control 25 so that the heat between the two parts is transferred by heat conduction.

[0074] Preferably the portion 31 of the pipe 30 is corrugated in a zigzag pattern forming a serpentine type portion. The portion 31 of the pipe 30 is preferably embedded in a box-like support member 32. The support member 32 is advantageously made by a thermally conductive material, such as alloy or a metal. The support member 32 and the portion 31 may be advantageously obtained by die-casting and advantageously form an integral unit.

[0075] The support member 32 preferably comprises holes 34 for receiving fixing means, such as screws, used for fixing the support member 32 to the cooling member 57 of the inverter motor control 25. An interface element 33 is preferably interposed between the support member 32 and the cooling member 57. The interface element 33 may be, for example, a thermal conductive plate or a thermal conducting paste.

[0076] The support member 32 is advantageously made by a thermally conductive material, such as alloy. Also the interface element 33 is advantageously made by a thermally conductive material, such as alloy.

[0077] The portion 31 of the pipe 30 and the cooling member 57 substantially form an auxiliary exchanger disposed downstream of the main evaporator 23 of the heat pump system 20. The main evaporator 23 and the auxiliary exchanger are, therefore, connected in series.

[0078] As said above, the portion 31 of the pipe 30 is thermally coupled to the inverter motor control 25 so that the heat between the two parts is transferred by heat conduction. In particular the heat is transferred by conduction from the cooling member 57 to the interface element 33, the support member 32 and finally to the portion 31 of the pipe 30.

[0079] In different embodiments the heat transfer may be obtained by arranging differently the portion 31 of the pipe 30. For example, the portion 31 of the pipe 30 may be arranged directly in contact with the cooling member 57.

[0080] In the preferred embodiment here described, nevertheless, the thermal conductivity between the portion 31 and the cooling member 57 is enhanced by the support member 32 which increases the thermal transfer surface.

[0081] In operation, the inverter motor control 25 generates a large amount of heat and, according to the invention, such a heat is the transferred to the cooling member 57 and from there removed by the auxiliary exchanger. This implies a heat exchange between the inverter motor control 25 and the refrigerant of the heat pump system 20. The dimensions of the cooling member 57 may, therefore, be kept at low values.

[0082] Advantageously, dissipation of the heat generated by the inverter motor control 25 does not require any bulky dissipator, such as the finned metal dissipator of the known systems.

[0083] The heat dissipation system of the present invention has therefore a reduced constructional complexity with respect to the systems of known type. Furthermore, the efficient removing of the heat allows the layout optimization of the devices 58. Therefore, the overall size of the inverter motor control 25 may be reduced with respect to the inverter of the known type.

[0084] Furthermore, the heat removed from the inverter motor control 25 is advantageously transferred to the heat pump system 20 thus increasing its efficiency.

[0085] In fact, the heat removed from the inverter motor control 25 is advantageously transferred to the refrigerant coming from the evaporator 23 and conveyed to the compressor 24.

[0086] More preferably the temperature of the refrigerant at the evaporator outlet 23a may be kept lower than the temperature of the known heat pump systems, which is close to the dew point of the refrigerant, so that the efficiency of the evaporator 23 and of the overall heat pump system 20 is increased.

[0087] In this case, in fact, the evaporator 23 may work more efficiently with the refrigerant inside it which is maintained at least partially liquid. This increases the heat exchange efficiency between the evaporator 23 and the warm moist air stream.

[0088] The complete vaporization of the refrigerant leaving the evaporator 23, which is in fact partially liquid as said above, is then advantageously carried out by the auxiliary exchanger before the refrigerant reaches the compressor 24.

[0089] Still advantageously, then, the heat transferred from the inverter motor control 25 to the refrigerant by the auxiliary exchanger assures the absence of liquid in the refrigerant before it reaches the compressor 24. This ensure the correct functioning of the compressor 24 with a consequent increase of system reliability and lifetime.

[0090] In a further preferred functioning mode of the heat pump system 20, the evaporator 23 may normally work so that at the evaporator outlet 23a the refrigerant is completely vaporized, as in the heat pump systems of the known type. In this case the auxiliary exchanger will further heat the vaporized refrigerant thus assuring the absence of liquid in the refrigerant before it reaches the compressor 24. This guarantees the correct functioning of the compressor 24 with a consequent increase of system reliability and lifetime.

[0091] It should be noted that the above mentioned advantages may be reached also by providing a heat transfer by conduction between any cooling member of an electric and/or an electronic device of the dryer which generates heat and a portion of the pipe 30 which connects the evaporator 23 to the compressor 24. In particular such an arrangement may be provided for the inverter motor control of the drum-rotating electric motor M1.

[0092] With reference to Figure 10 a second construction variant of the heat pump system 120 for a laundry drying machine is described.

[0093] In the heat pump system 120 shown in Figure 10 a portion 41 of the pipe 40 connecting the expansion device 22 to the evaporator inlet 23b is thermally coupled to the inverter motor control 25 of the compressor electric motor M2. Preferably the portion 41 of the pipe 40 is corrugated in a zigzag pattern forming a serpentine type portion. The portion 41 is preferably surrounded by a box-like support member 32, as described above with reference to the first embodiment. The portion 41 of the pipe 40 is thermally coupled to the inverter motor control 25 so that the heat between the two parts is transferred by heat conduction, as explained above with reference to the first preferred embodiment.

[0094] The portion 41 of the pipe 40 and the cooling member 57 substantially form an auxiliary exchanger disposed upstream of the main evaporator 23 of the heat pump system 120. The main evaporator 23 and the auxiliary exchanger are, therefore, connected in series.

[0095] According to the invention, the heat generated by the inverter motor control devices 58 is removed by the auxiliary exchanger. This implies a heat exchange between the inverter motor control 25 and the refrigerant of the heat pump system 120.

[0096] Advantageously, dissipation of the heat generated by the inverter motor control 25 does not require any bulky dissipator, such as a finned metal dissipator of the known systems.

[0097] The heat dissipation system of the present invention has therefore a reduced constructional complexity with respect to the systems of known type. Furthermore, the efficient removing of the heat allows the layout optimization of the devices 58. Therefore, the overall size of the inverter motor control 25 may be reduced with respect to the inverter of the known type.

[0098] It should be noted that the above mentioned advantages may be reached also by providing a heat transfer by conduction between any cooling member of an electric and/or an electronic device of the dryer which generates heat and a portion of the pipe 40 which connects the expansion device 22 to the evaporator 23. In particular such an arrangement may be provided for the inverter motor control of the drum-rotating electric motor M1.

[0099] With reference to Figure 11 a third construction variant of the heat pump system 220 for a laundry drying machine is described.

[0100] In the heat pump system 220 shown in Figure 11 part of the cold liquid-vapour mixture coming from the expansion device 22 is diverted to a pipe portion 51 which is thermally coupled to the inverter motor control 25 of the compressor electric motor M2. The pipe portion 51 is then connected to the pipe 30 connecting the evaporator 23 to the compressor 24.

[0101] Preferably the pipe portion 51 is corrugated in a zigzag pattern forming a serpentine type portion. The portion 51 is preferably surrounded by a box-like support member 32, as described above with reference to the first embodiment. The pipe portion 51 is thermally coupled to the inverter motor control 25 so that the heat between the two parts is transferred by heat conduction, as explained above with reference to the first preferred embodiment.

[0102] The pipe portion 51 and the cooling member 57 substantially form an auxiliary exchanger disposed in parallel to the main evaporator 23 of the heat pump system 220.

[0103] According to the invention, the heat generated by the inverter motor control devices 58 is removed by the auxiliary exchanger. This implies a heat exchange between the inverter motor control 25 and the refrigerant of the heat pump system 220.

[0104] Advantageously, dissipation of the heat generated by the inverter motor control 25 does not require any bulky dissipator, such as a finned metal dissipator of the known systems.

[0105] The heat dissipation system of the present invention has therefore a reduced constructional complexity with respect to the systems of known type. Furthermore, the efficient removing of the heat allows the layout optimization of the devices. Therefore, the overall size of the inverter motor control 25 may be reduced with respect to the inverter of the known type.

[0106] It should be noted that the above mentioned advantages may be reached also by providing a heat transfer by conduction between any cooling member of an electric and/or an electronic device of the dryer which generates heat and a portion of a pipe arranged in parallel to the main evaporator 23 of the heat pump system 220. In particular such an arrangement may be provided for the inverter motor control of the drum-rotating electric motor M1.

[0107] With reference to Figure 12 a fourth construction variant of the heat pump system 320 for a laundry drying machine is described.

[0108] In the heat pump system 320 shown in Figure 12 a portion 61 of the pipe 30 connecting the evaporator outlet 23a to the compressor inlet 24a is thermally coupled to the inverter motor control 25 of the compressor electric motor M2. For this purpose the cooling member 57 of the inverter motor control 25 is positioned in contact with such portion 61 of the pipe 30.

[0109] The portion 61 of the pipe 30 is thermally coupled to the inverter motor control 25 so that the heat between the two parts is transferred by heat conduction.

[0110] The pipe portion 61 and the cooling member 57 substantially form an auxiliary exchanger disposed in series to the main evaporator 23 of the heat pump system 320.

[0111] According to the invention, the heat generated by the inverter motor control devices 58 is removed by the auxiliary exchanger. This implies a heat exchange between the inverter motor control 25 and the refrigerant of the heat pump system 320.

[0112] Advantageously, dissipation of the heat generated by the inverter motor control 25 does not require any bulky dissipator, such as a finned metal dissipator of the known systems.

[0113] The heat dissipation system of the present invention has therefore a reduced constructional complexity with respect to the systems of known type. Furthermore, the efficient removing of the heat allows the layout optimization of the devices 58. Therefore, the overall size of the inverter motor control 25 may be reduced with respect to the inverter of the known type.

[0114] Furthermore, the heat removed from the inverter motor control 25 is advantageously transferred to the heat pump system 320 thus increasing its efficiency.

[0115] In fact, the heat removed from the inverter motor control 25 is advantageously transferred to the refrigerant coming from the evaporator 23 and conveyed to the compressor 24.

[0116] More preferably the temperature of the refrigerant at the evaporator outlet 23a may be kept lower than the temperature of the known heat pump systems, which is close to the dew point of the refrigerant, so that the efficiency of the evaporator 23 and of the overall heat pump system 20 is increased.

[0117] In this case, in fact, the evaporator 23 may work more efficiently with the refrigerant inside it which is maintained at least partially liquid. This increases the heat exchange efficiency between the evaporator 23 and the warm moist air stream.

[0118] The complete vaporization of the refrigerant leaving the evaporator 23, which is in fact partially liquid as said above, is then advantageously carried out by the auxiliary exchanger before the refrigerant reaches the compressor 24.

[0119] Still advantageously, then, the heat transferred from the inverter motor control 25 to the refrigerant by the auxiliary exchanger assures the absence of liquid in the refrigerant before it reaches the compressor 24. This ensure the correct functioning of the compressor 24 with a consequent increase of system reliability and lifetime.

[0120] In a further preferred functioning mode of the heat pump system 20, the evaporator 23 may normally work so that at the evaporator outlet 23a the refrigerant is completely vaporized, as in the heat pump systems of the known type. In this case the auxiliary exchanger will further heat the vaporized refrigerant thus assuring the absence of liquid in the refrigerant before it reaches the compressor 24. This guarantees the correct functioning of the compressor 24 with a consequent increase of system reliability and lifetime.

[0121] It should be noted that the above mentioned advantages may be reached also by providing a heat transfer by conduction between any cooling member of an electric and/or an electronic device of the dryer which generates heat and a portion of the pipe 30 which connects the evaporator 23 to the compressor 24. In particular such an arrangement may be provided for the inverter motor control of the drum-rotating electric motor M1.

[0122] With reference to Figures from 13 to 16 a fifth construction variant of the heat pump system 420 for a laundry drying machine is described.

[0123] In the heat pump system 420 according to this embodiment the pipe 150 of the evaporator 23 is thermally coupled to the inverter motor control 25 of the compressor electric motor M2.

[0124] For this purpose a cooling member 77 of the inverter motor control 25 is directly positioned in contact with the pipe 150 of the evaporator 23.

[0125] The pipe 150 of the evaporator 23 is therefore thermally coupled to the inverter motor control 25 so that the heat between the two parts is transferred by heat conduction.

[0126] The inverter motor control 25 preferably comprises a printed board on which the inverter motor control devices 58 are mounted.

[0127] The printed board and the devices 58 mounted thereon are preferably separated from the evaporator 23 and from the condenser 21. At his end, as schematically and partially illustrated in Figure 14, a separating wall 80 which is preferably part of the basement 14, not illustrated, separates the devices 58 from the evaporator 23, the condenser 21 and therefore from the moist air stream. The devices 58 are advantageously not reached by the moist air which crosses the evaporator 23 and the condenser 21 while only the cooling member 77 may be reached by such moist air.

[0128] Advantageously, dissipation of the heat generated by the inverter motor control 25 does not require any bulky dissipator, such as a finned metal dissipator of the known systems.

[0129] The heat dissipation system of the present invention has therefore a reduced constructional complexity with respect to the systems of known type. Furthermore, the efficient removing of the heat allows the layout optimization of the devices 58. Therefore, the overall size of the inverter motor control 25 may be reduced with respect to the inverter of the known type.

[0130] It should be noted that the above mentioned advantages may be reached also by providing a heat transfer by conduction between any cooling member of an electric and/or an electronic device of the dryer which generates heat and the pipe 150 of the evaporator 23. In particular such an arrangement may be provided for the inverter motor control of the drum-rotating electric motor M1.

[0131] Conclusively it can be stated that a laundry drying machine according to the invention has an efficient arrangement for its components. Thanks to this arrangement, dissipation of the heat generated by any electric and/or electronic device of the machine does not require bulky and expensive heat dissipator. Furthermore, the heat generated by the electric and/or electronic device of the machine may be recovered by the heat pump system thus increasing the system efficiency.

[0132] It has thus been shown that the present invention allows all the set objects to be achieved. In particular, it makes it possible to obtain a laundry drying machine having a reduced constructional complexity and a higher energy efficiency with respect to the systems of known type.

[0133] Clearly, changes may be made to the laundry drying machine as described herein without, however, departing from the scope of the present invention.

[0134] Although illustrative embodiments of the present invention have been described herein with reference to the accompany 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 without departing from the scope or spirit of the invention. 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) comprising a laundry chamber (9) suitable for receiving the laundry to be dried, an air stream circuit (10) for circulating an air stream through said laundry chamber (9) and a heat pump system (20; 120; 220; 320; 420) comprising:

    - a first heat exchanger (21) for heating up said air stream conveyable into said laundry chamber (9);
    - a second heat exchanger (23) for dehumidifying the moist air of said air stream coming from said laundry chamber (9);
    - a compressor (24) comprising an outlet (24b)

connectable to said first heat exchanger (21) and an inlet (24a) connectable to said second heat exchanger (23);
- an expansion device (22) comprising an outlet (22b) connectable to said second heat exchanger (23) and an inlet connectable to said first heat exchanger (21); **characterized in that** it further comprises an auxiliary heat exchanger comprising a portion (31; 41; 51; 61; 150) of said heat pump system (20; 120; 220; 320; 420) arranged between said expansion device outlet (22b) and said compressor inlet (24a) and a cooling member (57; 77) associated to an electric and/or an electronic device (25) of said machine (1).

2. A machine (1) according to claim 1, **characterized in that** said portion (31; 41; 51; 61; 150) of said heat pump system (20; 120; 220; 320; 420) and said cooling member (57; 77) are mutually arranged so that heat transfer between them takes place by conduction.

3. A machine (1) according to claim 1 or 2, **characterized in that** said portion (31; 41; 51; 61; 150) comprises a portion (31; 61) of a pipe (30) arranged between said second heat exchanger (23) and said inlet compressor (24a).

4. A machine (1) according to any preceding claim , **characterized in that** said portion (31; 41; 51; 61; 150) comprises a portion (41) of a pipe (40) arranged between said expansion device outlet (22b) and said second heat exchanger (23).

5. A machine (1) according to any preceding claim , **characterized in that** said portion (31; 41; 51; 61; 150) comprises a portion (31; 41; 61) of a pipe connected in series to said second heat exchanger (23).

6. A machine (1) according to any claims from 1 to 4, **characterized in that** said portion (31; 41; 51; 61; 150) comprises a portion (51) of a pipe arranged in parallel to said second heat exchanger (23).

7. A machine (1) according to any preceding claim, **characterized in that** said second heat exchanger (23) comprises a pipe (150) and said portion (150) comprises a portion of said pipe (150).

8. A machine (1) according to any preceding claim, **characterized in that** said portion (31; 41; 51; 61; 150) comprises a serpentine pipe (31; 41; 51).

9. A machine (1) according to any claims from 3 to 5, **characterized in that** said auxiliary heat exchanger further comprises a support member (32) for said portion (31; 41; 51) of a pipe, said support member (32) being suitable for fixing said portion (31; 41; 51) to said cooling member (57) and suitable for increasing the heat exchanging surface between said portion (31; 41; 51) and said cooling member (57).

10. A machine (1) according to any preceding claim, **characterized in that** said cooling member (57; 77) comprises a thermally conductive material.

11. A machine (1) according to any preceding claim, **characterized in that** said electric and/or electronic device comprises an inverter motor control (25).

12. A machine (1) according to claim 11, **characterized in that** said inverter motor control (25) controls the speed of a motor (M2) of said compressor (24).

13. A machine (1) according to claim 11, **characterized in that** said laundry chamber (9) is a rotatable laundry container (9) and said inverter motor control controls the speed of a motor (M1) suitable for rotating said rotatable laundry container (9).

14. A machine (1) according to any preceding claim , **characterized in that** said heat pump system (20) is received in a basement portion (14) of said machine (1).

15. A machine (1) according to claim 14, **characterized in that** said basement (14) comprises a first area suitable for receiving said first heat exchanger (21) and said second heat exchanger (23) and at least a second area, separated from the first area, suitable for receiving at least said compressor (24) and said expansion device (22).

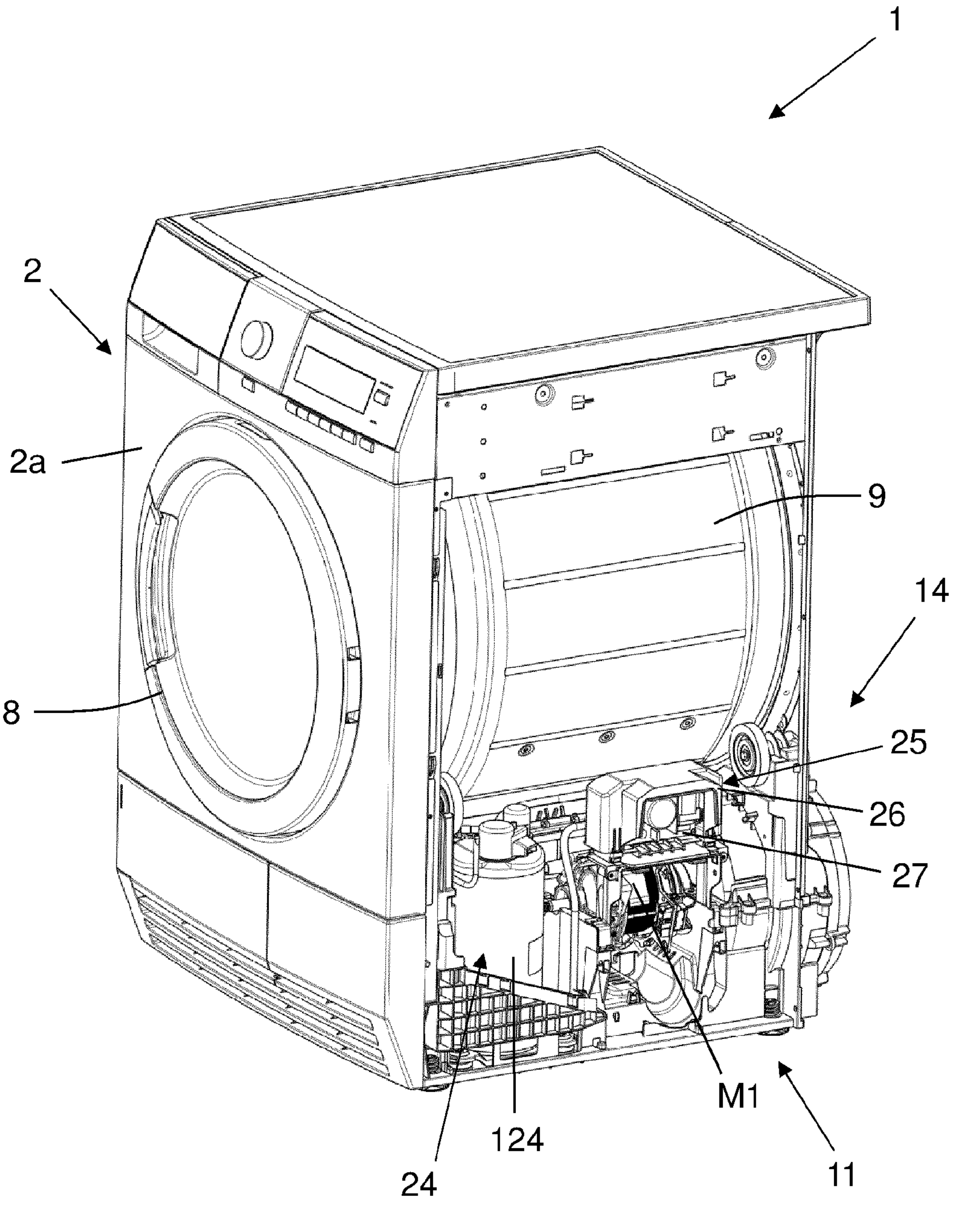

FIG. 1

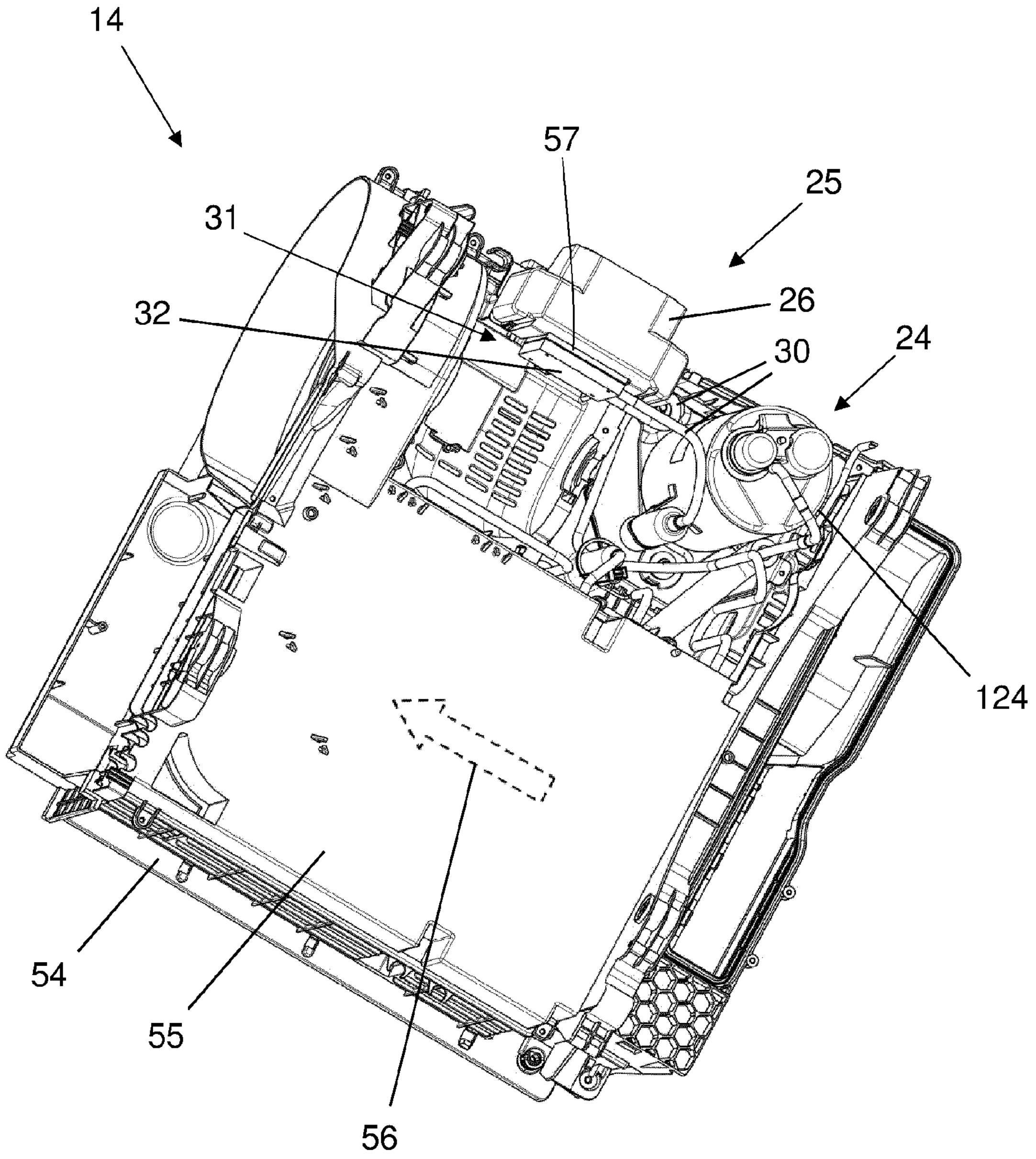

FIG. 2

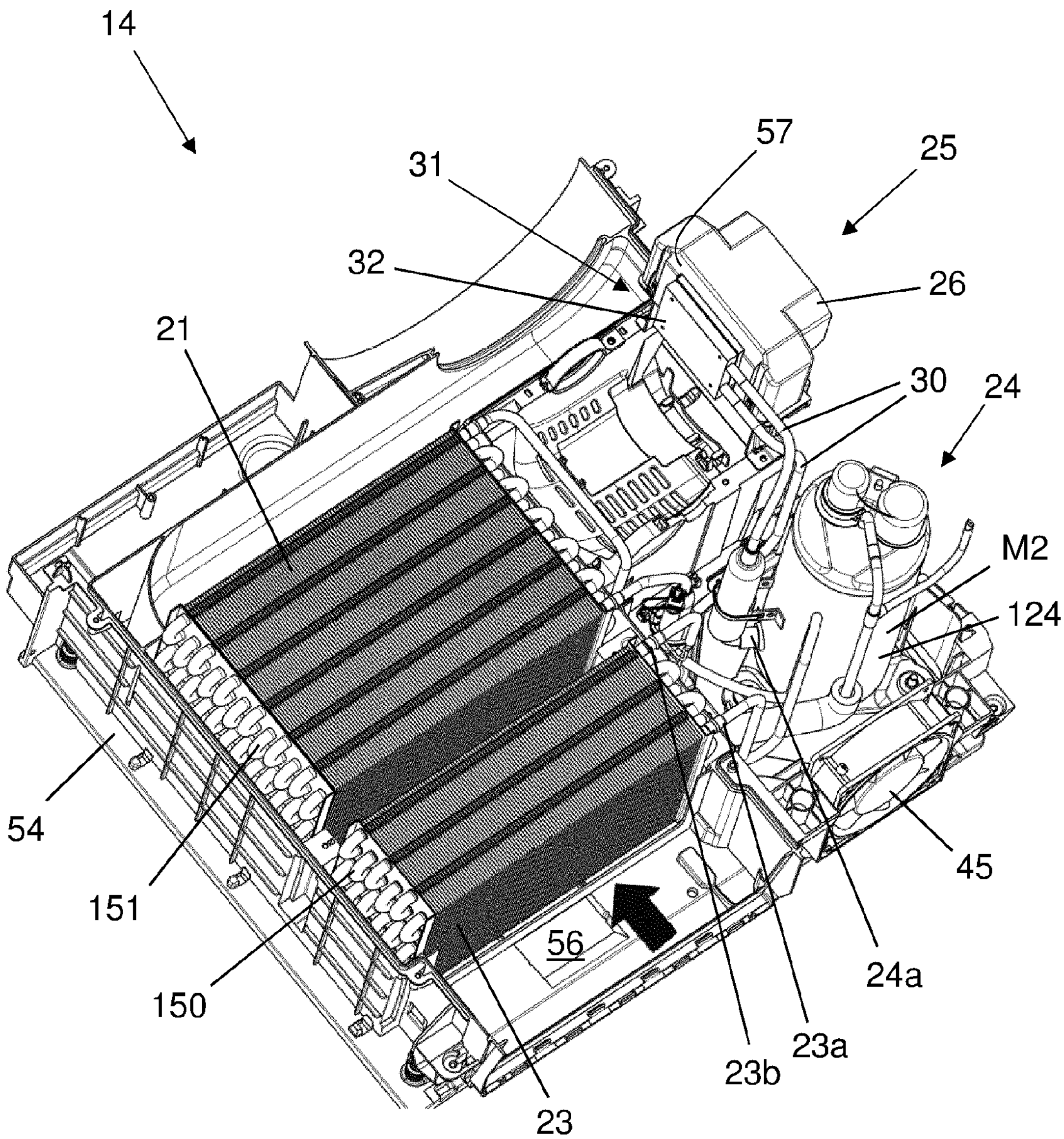

FIG. 3

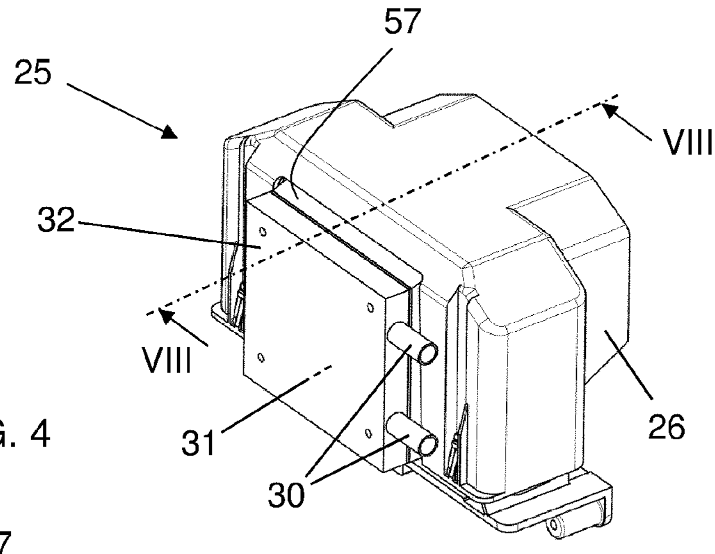

FIG. 4

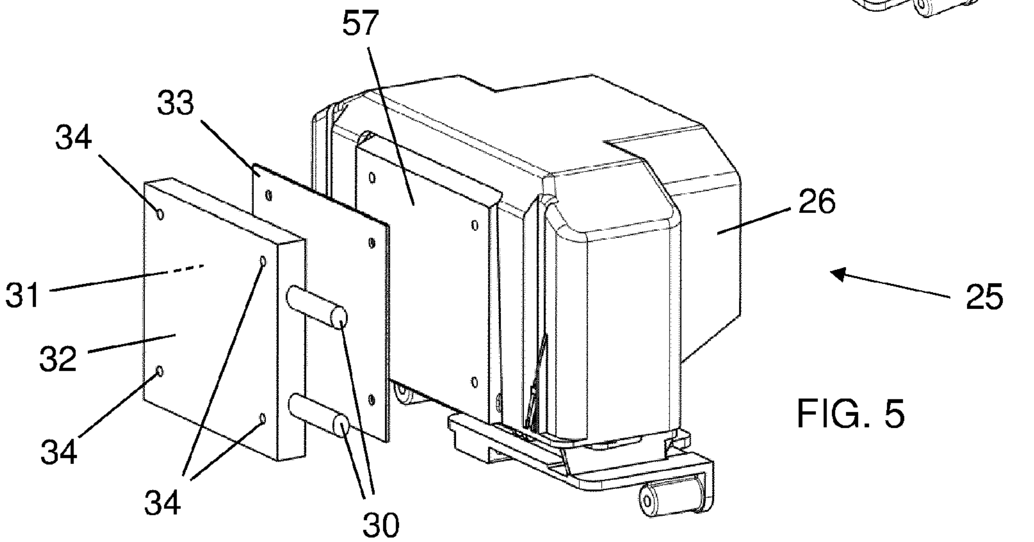

FIG. 5

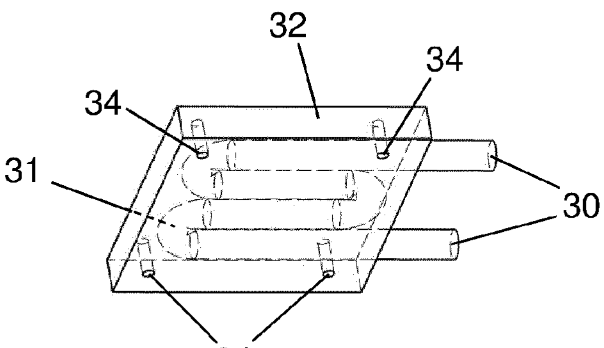

FIG. 6

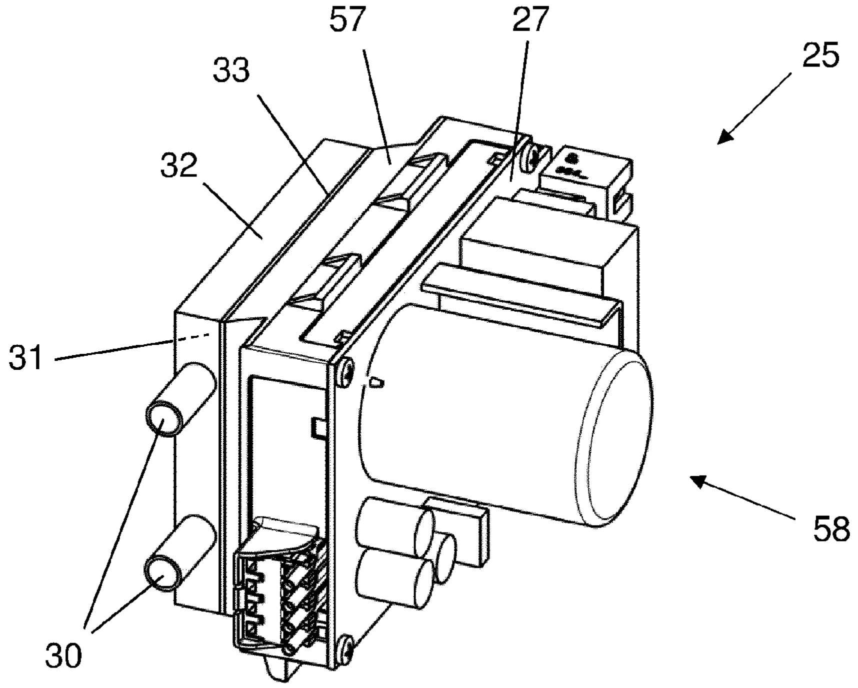

FIG. 7

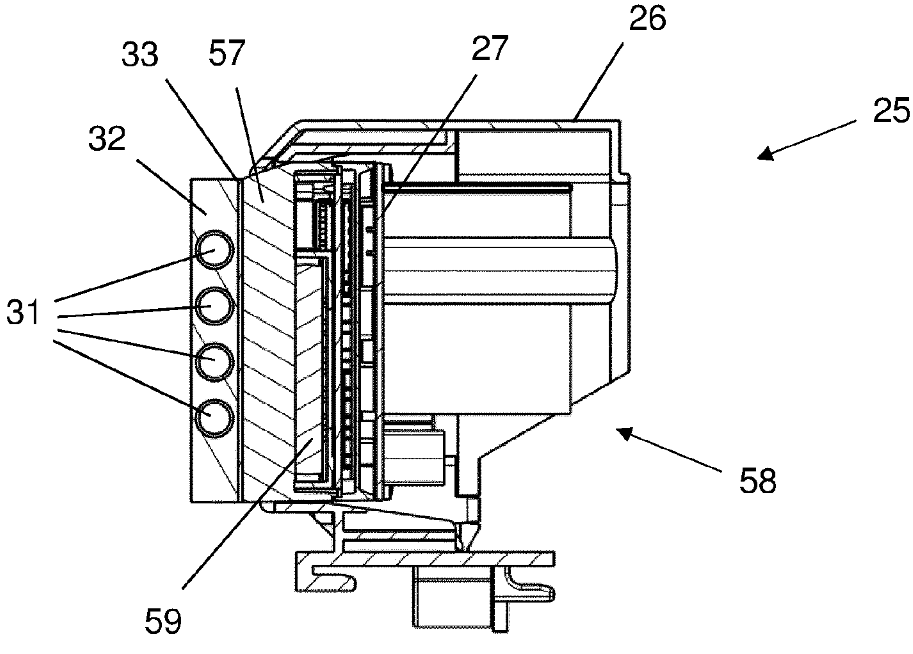

FIG. 8

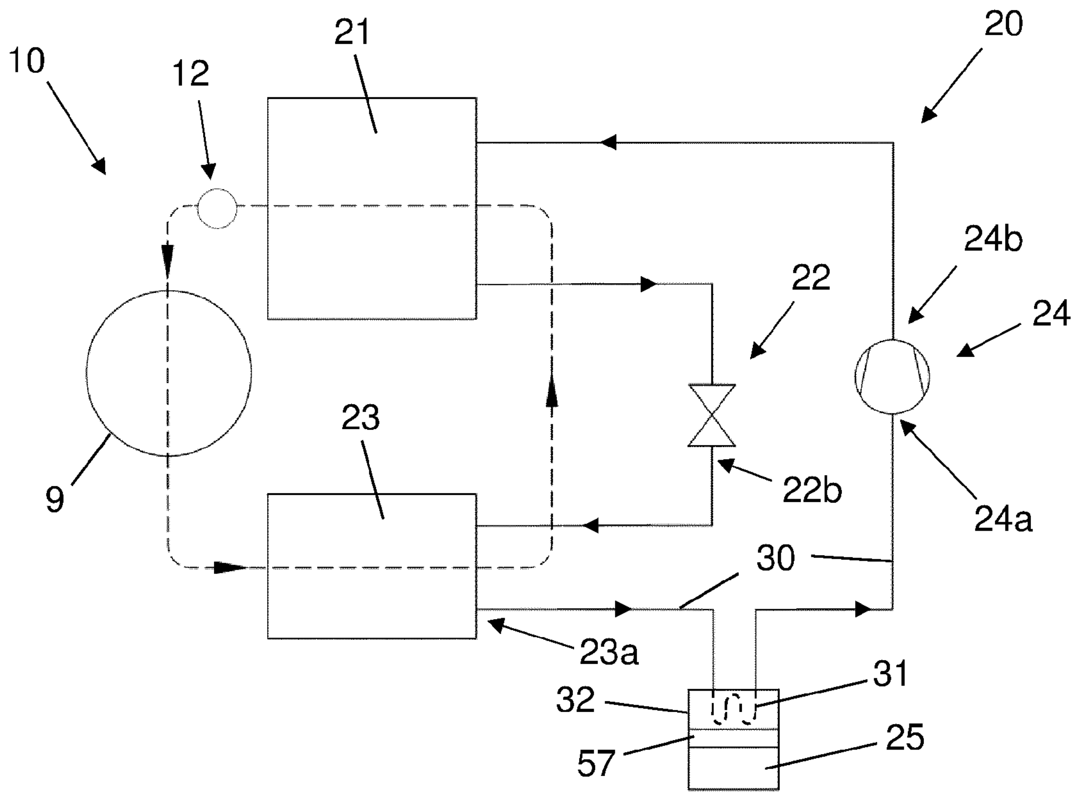
10
12
21
20
24b
22
24
9
23
22b
24a
30
23a
32
31
57
25

FIG. 9

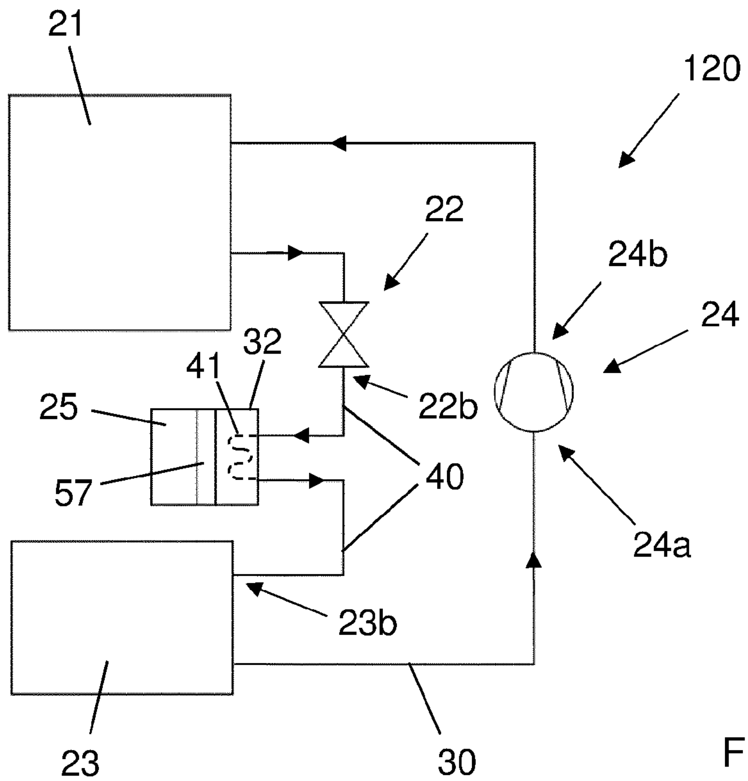
21
120
22
24b
24
32
41
25
22b
57
40
24a
23b
23
30

FIG. 10

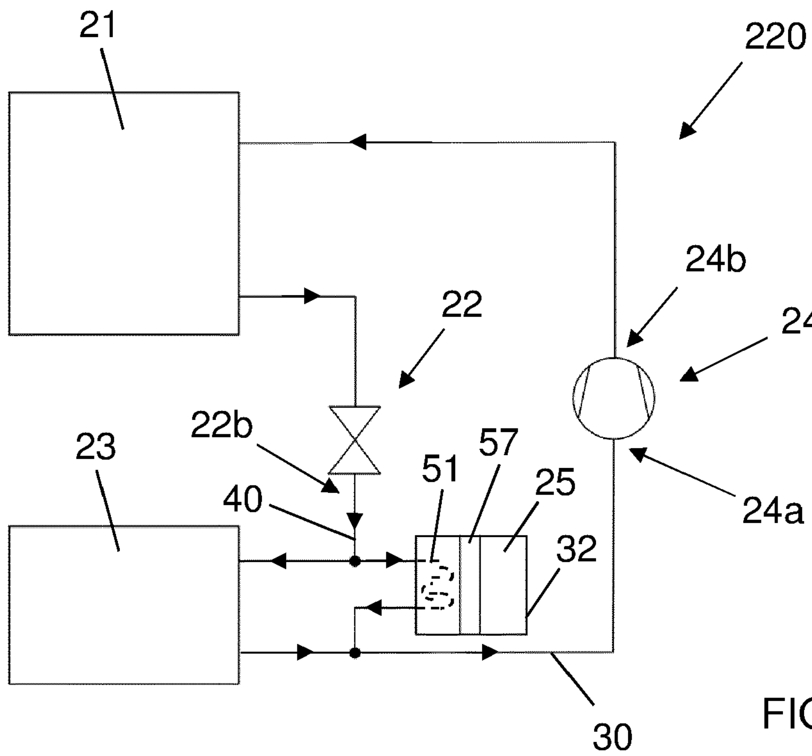
21
220
24b
22
24
22b
23
57
51
25
40
24a
32
30

FIG. 11

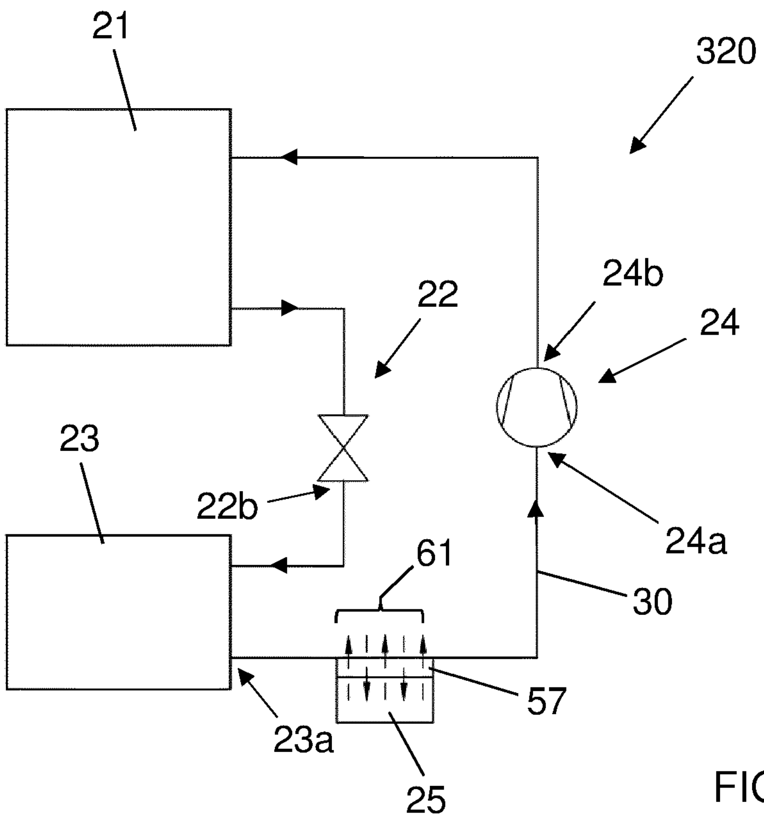
21
320
22
24b
24
23
22b
24a
61
30
57
23a
25

FIG. 12

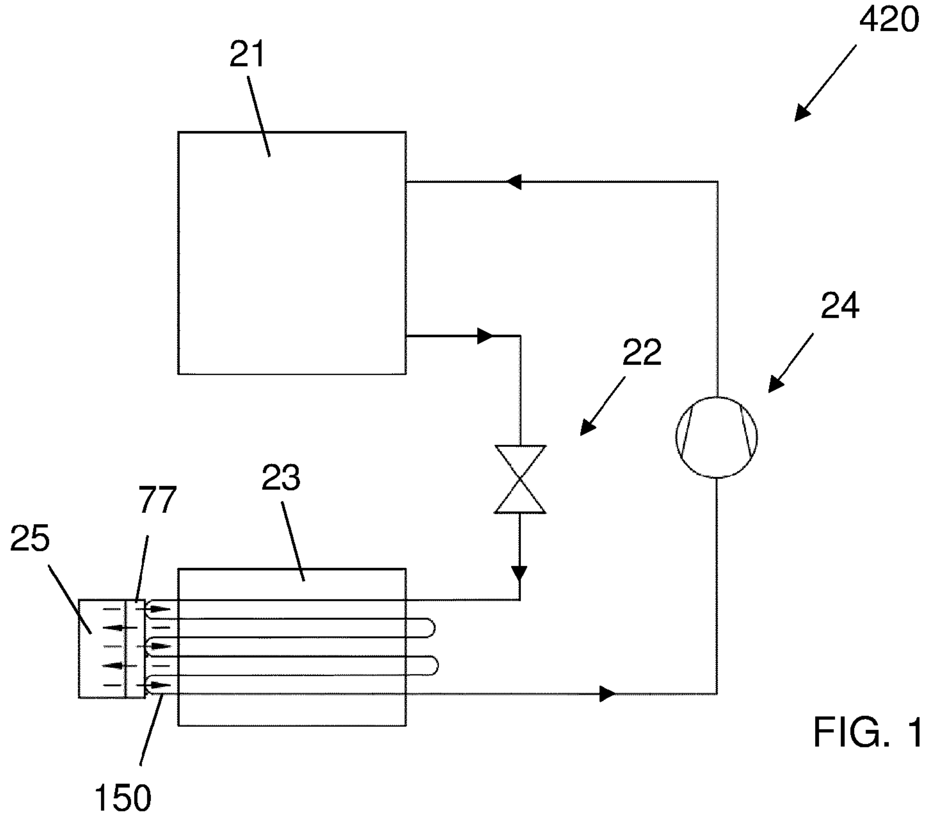

FIG. 13

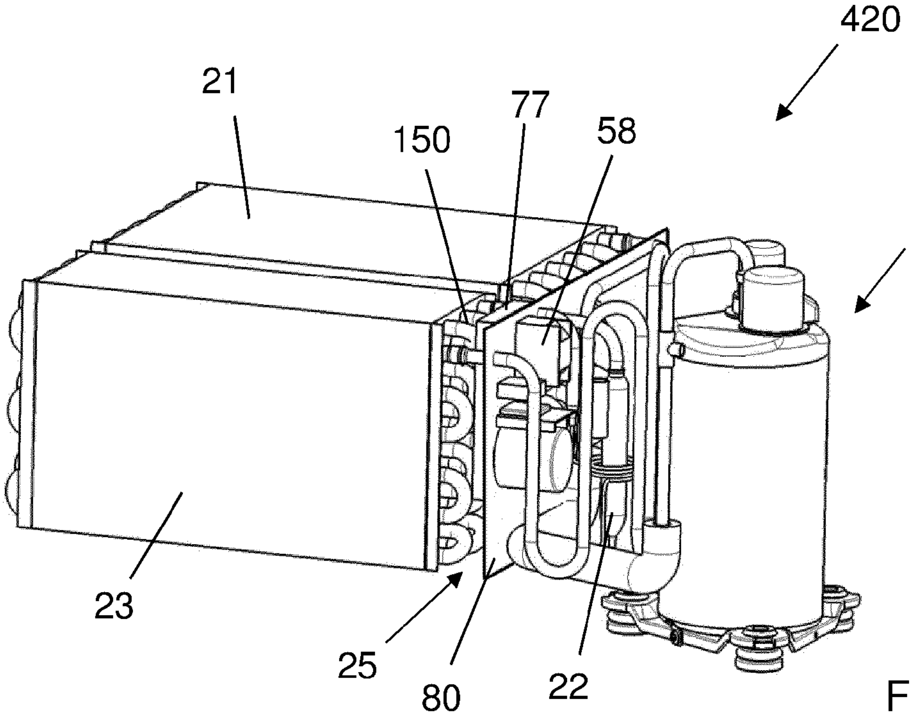

FIG. 14

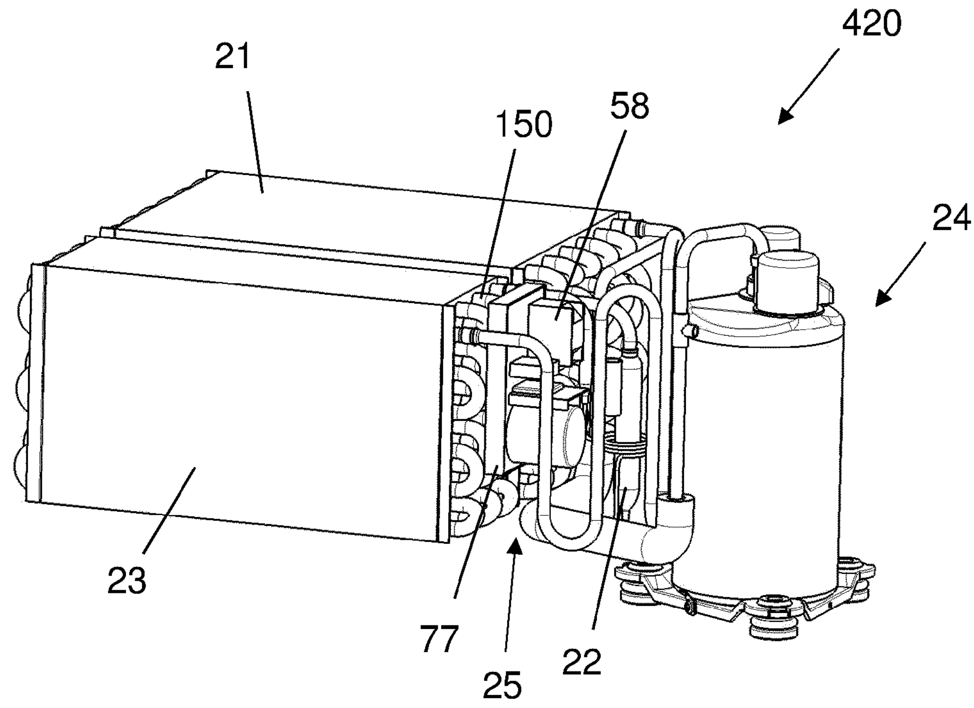

FIG. 15

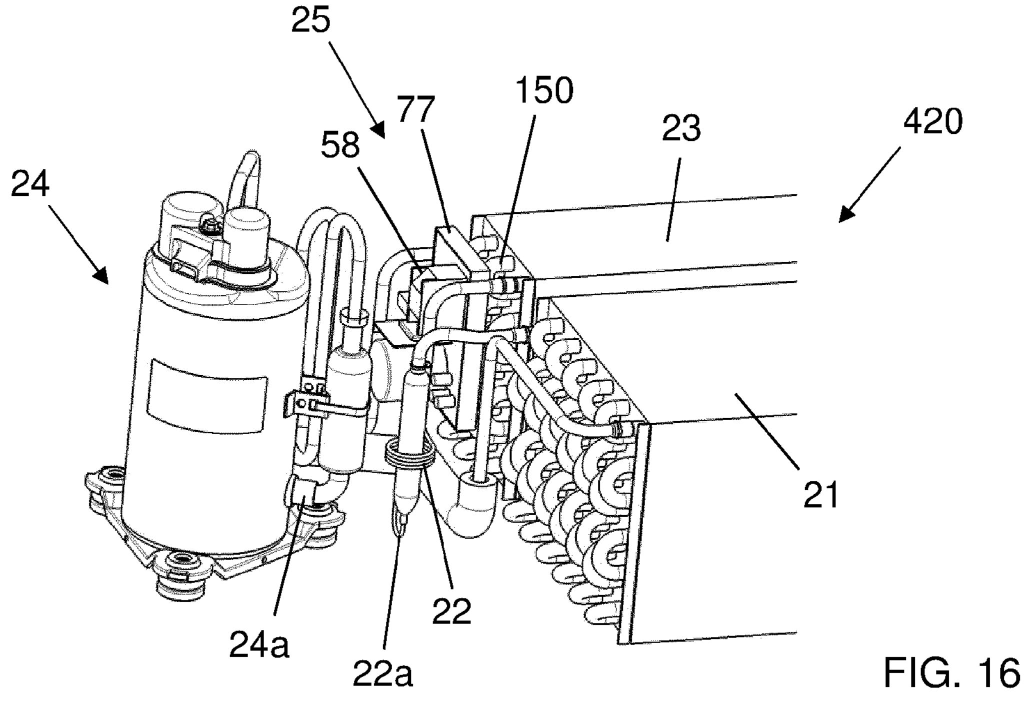

FIG. 16

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EUROPEAN SEARCH REPORT

Application Number
EP 12 16 3954

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D06F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	10 September 2012	Diaz y Diaz-Caneja

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10-09-2012

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