(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 235 942 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.10.2017 Bulletin 2017/43

(51) Int Cl.:
D06F 58/20 *(2006.01)*

(21) Application number: **16166343.0**

(22) Date of filing: **21.04.2016**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **Electrolux Appliances Aktiebolag**
105 45 Stockholm (SE)

(72) Inventor: **DAL MOLIN, Rudy**
33080 Porcia PN (IT)

(74) Representative: **Electrolux Group Patents**
AB Electrolux
Group Patents
105 45 Stockholm (SE)

(54) LAUNDRY DRYER WITH HEAT PUMP

(57) The invention relates to a laundry dryer (1) comprising:

• a cabinet (2) supporting a drying chamber (3) for receiving a load to be dried and having a basement (24), a front wall (20), a rear wall (23), a first and a second side wall (21,22) which define a cabinet inner volume;

• A process air conduit (11) in communication with the drying chamber (3) where an air process stream is apt to flow;

• A heat pump system (30) having a heat pump circuit formed by pipes (31) in which a refrigerant can flow, said heat pump circuit including a first heat exchanger (31) where the refrigerant is cooled off and the process air stream is heated up, and a second heat exchanger (32) where the refrigerant is heated up and the process air is cooled off; said first and/or second heat exchanger being thermally coupled to the process air conduit (11) to perform heat exchange between said refrigerant flowing in said heat pump circuit and said process air stream;

wherein the heat pump system (30) further includes an auxiliary heat exchanger (13) which comprises a skin condenser including a portion (62) of said pipes and a heat radiating wall (18, 18a), the portion (62) of said pipes extending on one side of the heat radiation wall (18, 18a), and said heat radiating wall (18, 18a) being a portion (18a) of said cabinet (2) or being contained within said cabinet inner volume.

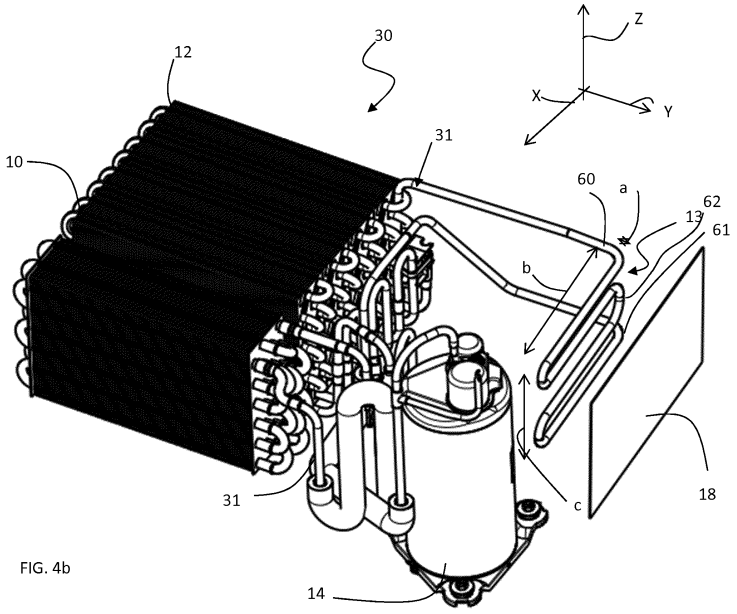


FIG. 4b

EP 3 235 942 A1

Description

Field of the invention

[0001] The invention relates to a laundry treatment apparatus having a heat pump system in which process air for laundry treatment is dehumidified and heated.

Background art

[0002] In driers using a heat pump system for dehumidifying and heating the process air in a closed process air loop, excess energy has to be removed from the heat pump system as soon as the system has achieved a steady state of operation. The so called steady state is an optimum operation state in which the dehumidifying capacity of the evaporator and the heating capacity of the condenser are optimized in view of drying the laundry and energy consumption of the heat pump system. In the steady state the excess energy is the heat loss power introduced to the system by the compressor and which over the time would drive the system to an over-temperature and less-optimum operation, if not removed. From prior art different approaches are known to remove the excess energy when reaching the steady state.

[0003] A dryer having a heat pump system for dehumidifying and heating process air is known from WO 2008/086933. An auxiliary condenser cooled by ambient air is used to remove heat from the refrigerant loop in the heat pump system.

[0004] In the dryer of EP 2 034 084 A1 an auxiliary condenser of the heat pump system is arranged in the bottom section between an ambient air blower and a compressor such that the ambient air cools and removes excessive heat from both, the auxiliary condenser and the compressor.

[0005] In EP 2 573 252, a laundry treatment apparatus having a heat pump includes an auxiliary heat exchanger which is arranged at the external side of the base section.

Summary of the invention

[0006] The present invention is relative to a heat pump laundry dryer for drying clothes and other garments including a heat pump having a plurality of heat exchangers. The laundry dryer of the invention may include either a machine having only drying function or a combined washer dryer, having washing and drying function. Furthermore, it may include either a vented or a condense dryer. The configuration of the heat exchanger(s) in the laundry dryer of the invention is such that an optimal heat transfer capacity is achieved, substantially tailored on the specific geometry of the laundry dryer.

[0007] A heat pump dryer includes a drying chamber, such as a drum, in which the load, e.g., clothes, to be dried (and in some embodiments also to be washed) is placed. The drying chamber is part of a process air circuit; in particular a closed-loop circuit in case of a condensed dryer or an open circuit in case of a vented dryer, which in both cases includes an air duct for channeling a stream of air to dry the load. The process air circuit is connected with its two opposite ends to the drying chamber. Preferably, heated dehumidified air is fed into the drying chamber, flowing over the laundry, and the resulting humid cool air exits the same. The humid air stream rich in water vapor is then fed into an evaporator (or second heat exchanger) of the heat pump, where the moist warm process air is cooled and the humidity present therein condenses. The resulting cool dehumidified air is then either vented outside the dryer in the ambient where the latter is located or it continues in the closed-loop circuit. In this second case, the dehumidified air in the process circuit is then heated up before entering again in the drying chamber by means of a condenser (or first heat exchanger) of the heat pump, and the whole loop is repeated till the end of the drying cycle. Alternatively, ambient air enters into the drum from the ambient via an inlet duct and it is heated up by the condenser of the heat pump before entering the drying chamber.

[0008] The heat pump of the dryer includes a refrigerant circuit in which a refrigerant can flow and which connects via piping the first heat exchanger or condenser, the second heat exchanger or evaporator, a compressor and a pressure-lowering device. The refrigerant is pressurized and circulated through the system by the compressor. On the discharge side of the compressor, the hot and highly pressurized vapor is cooled in the first heat exchanger, the condenser, until it condenses into a high pressure, moderate temperature liquid, heating up the process air before the latter is introduced into the drying chamber. The condensed refrigerant then passes through the pressure-lowering device such as an expansion device, e.g., a choke, a valve or a capillary tube. The low pressure liquid refrigerant then enters the second heat exchanger, the evaporator, in which the fluid absorbs heat and evaporates due to the heat exchange with the warm process air exiting the drying chamber. The refrigerant then returns to the compressor and the cycle is repeated.

[0009] From the above, it is clear that in a working cycle of the heat pump:

1) In the evaporator both latent heat and sensible heat are exchanged with the refrigerant. The latent heat exchange leads to a condensation of the water extracted from the clothes. During this process the refrigerant absorbs heat from the water and evaporates.

2) The cold and dry air exiting from the evaporator is then heated up in the condenser: in this process only sensible heat is exchanged. During this process, the refrigerant is cooled down and condenses.

[0010] In some embodiments, in the first and/or second heat exchangers, the refrigerant may not be subject to a

phase transition. The operation of a dryer having a heat pump is depicted in a schematic manner in fig. 1.

[0011] In the following, with the terms "downstream" and/or "upstream", a position with reference to the direction of the flow of a fluid inside a conduit is indicated. Additionally, in the present context, the terms "vertical" and "horizontal" are referred to the positions of elements with respect to the dryer in its normal installation or functioning. Indeed, a horizontal plane (X,Y) formed by two horizontal X,Y perpendicular directions is defined, and a vertical direction Z, perpendicular to the horizontal plane, is defined as well in a 3-D space.

[0012] Since the overall system must be in an equilibrium state, the heat pump efficiency is limited by the heat exchange capacity of the air at the condenser side where only sensible heat is exchanged. This means that the evaporator works in a reduced way, having a bigger heat exchange capacity, thus penalizing the performance of the heat pump system, in terms of drying time and energy.

[0013] A solution to this problem of increasing the heat exchange capacity at the condenser side could be to increase the flow rate of the air flowing through the condenser. This increase of flow rate can be achieved for example by the addition of a dedicated fan for the condenser. However, this addition is not possible in all dryers due to space issues within the dryer itself or where an increase in flow rate causes excessive noise.

[0014] A different solution for increasing the heat exchange capacity at the condenser side is to include an auxiliary condenser in the heat pump of the dryer so that the total heat exchange of the condenser is made by the one of the "main" condenser and the one of the auxiliary condenser. This auxiliary condenser is usually cooled down by an auxiliary fan that sucks air from the ambient.

[0015] With an auxiliary condenser, the refrigerant exiting the "main" condenser is additionally cooled (subcooled) by the auxiliary condenser, so the global heat exchange in the condenser is increased, allowing an improvement of the heat exchange in the evaporator as well.

[0016] However, in order to implement such solution, a significant additional space is required inside the dryer, as it is necessary to include, for example within the basement, two further elements: both the auxiliary condenser and the auxiliary fan. Moreover, the heat capacity of the ambient air is poor, which means that a considerable amount of air has to flow through the auxiliary condenser (which implies for example the presence of a "big" fan) or that a substantial air temperature increase has to be achieved. In both cases, an auxiliary heat exchanger having relatively large dimensions is needed, requiring again a large available volume inside the cabinet of the dryer. This large "free" available volume is - as said- not always present in many dryers.

[0017] It is an object of the invention to provide a laundry dryer having a heat pump system in which an auxiliary heat exchanger is integrated in a compact manner and at the same time assuring a non-negligible increase in heat exchange capacity. In particular, the dimensions of the auxiliary heat exchanger are such that the amount of occupied space by it inside the laundry machine is limited.

[0018] Applicants have realized that in order to achieve the above mentioned goal including an auxiliary heat exchanger in the heat pump of the laundry dryer, a special geometry and positioning of the auxiliary heat exchanger has to be selected so as to minimize the volume occupied by it in the cabinet of the dryer, and at the same time ensuring a relatively high heat exchange.

[0019] A further objective of the present invention is to realize a dryer having a heat pump system including an auxiliary heat exchanger the costs of which are relatively low so that the overall costs of the dryer are substantially unmodified by the presence of the auxiliary heat exchanger.

[0020] These goals are at least in part achieved by the present invention by means of a skin condenser as an auxiliary heat exchanger. The skin condenser is a heat exchanger wherein at least one pipe is arranged on one of the two sides of a wall without passing through such wall. The wall acts as heat radiating element. The heat radiating wall can be a part, or the entirety of one or more of the cabinet walls, Alternatively or additionally, the heat radiating wall can be an additional element contained within the inner volume defined by the cabinet walls. Preferably, the skin condenser can be used as a condenser. By using the heat exchange by conduction with a large surface of one (or both) side walls of the cabinet or of an additional element, a higher efficiency of the heat pump is achieved. At the same time, an auxiliary heat exchanger located adjacent to the side wall minimizes the "occupied" free space within the cabinet itself. A cabinet wall is particularly advantageous for arranging the meandering tube of the skin condenser because it generally offers a wide heat radiating medium and a location which does not interfere with other components of the machine.

[0021] According to an aspect, the invention relates to a laundry dryer comprising:

- a cabinet supporting a drying chamber for receiving a load to be dried and having a basement, a front wall, a rear wall, a first and a second side wall, which defines a cabinet inner volume;
- A process air conduit in communication with the drying chamber where an air process stream is apt to flow;
- A heat pump having a heat pump circuit formed by pipes in which a refrigerant can flow, said heat pump circuit including a first heat exchanger where the refrigerant is cooled off and the process air stream is heated up, and a second heat exchanger where the refrigerant is heated up and the process air is cooled off; said first and/or second heat exchanger being thermally coupled to the process air conduit to perform heat exchange between said refrigerant flowing

in said heat pump circuit and said process air stream;

characterized in that said heat pump further includes an auxiliary heat exchanger which comprises a skin condenser including a portion of said pipes and a heat radiating wall, the portion of said pipes extending on one side of the heat radiation wall, and said heat radiating wall being a portion of said cabinet or being contained within said cabinet inner volume.

[0022] According to the mentioned aspect, a laundry dryer having a drying chamber for treating the laundry and a heat pump system for dehumidifying and heating process air vented through the laundry storing chamber is provided. For removing at least a portion of the excessive energy (i.e. excessive heat power or temperature) from the heat pump system, an auxiliary heat exchanger is provided which removes heat from the refrigerant circulated in the refrigerant loop. The auxiliary heat exchanger may function as an auxiliary condenser. Preferably, the heat is transferred from the refrigerant to ambient air which is available in the operating surroundings of the laundry dryer.

[0023] The dryer comprises a cabinet comprising a front wall, a rear wall, side walls (generally in the number of two) and a base section or basement. The front wall may comprise a front top panel to command the functioning of the machine by the user. The cabinet defines the limit between the internal or inner side of the dryer and the external side of the dryer.. In conventional laundry dryers having a heat pump system, like heat pump dryers only or washer-dryer machines, all components of the apparatus - in particular the components of the heat pump system - are arranged in the inner side of the apparatus.

[0024] According to the invention, the auxiliary heat exchanger is arranged at an inner side of one of the walls or basement of the cabinet. Preferably, the auxiliary heat exchanger extends along the inner side of one of the side walls, more preferably starting from a location at or close to the basement of the machine and then preferably extending substantially "only" vertically, with a limited width in the horizontal direction.

[0025] Preferably, the heat pump system except the auxiliary heat exchanger is arranged completely or substantially within the basement of the apparatus. Then, providing an auxiliary heat exchanger located for at least a portion at the basement results in the advantage that the auxiliary heat exchanger is arranged close to the other elements of the heat pump system, so a limited length of additional piping to connect the two is needed. The other components of the heat pump system are a first and second heat exchanger, a compressor, and preferably an expansion device.

[0026] By arranging the auxiliary heat exchanger along a wall of the cabinet at its inner side, a compact overall layout or design of the heat pump system can be provided. In this way, the addition of an extra heat exchanger such as the auxiliary heat exchanger is possible in most of the dryers.

[0027] The auxiliary heat exchanger is preferably connected in the refrigerant circuit in series between the condenser (first heat exchanger) and the expansion device. The auxiliary heat exchanger exchanges heat contained in the refrigerant flowing in the refrigerant circuit of the heat pump system. This refrigerant flows in the auxiliary heat exchanger through a pipe which is a portion of the piping of the overall refrigerant circuit of the heat pump system. Therefore, a portion of the refrigerant circuit piping is forming the piping of the auxiliary heat exchanger.

[0028] The auxiliary heat exchanger according to the invention is a skin condenser, i.e. a heat exchanger which uses a heat radiating wall to dissipate the heat contained in the refrigerant flowing in the pipe portion of the heat exchange piping. This heat radiating wall can be for example a portion of one of the walls of the cabinet or a portion of the basement, more preferably a portion of one of the side walls of the cabinet of the dryer in order to exchange heat. In this way, the need of an auxiliary fan may be cancelled, the heat exchange taking place thanks to the relatively wide surface of the cabinet wall. Alternatively, the heat radiating wall is an additional element to the cabinet, such as an additional plate. This plate can be the only "radiating element" of the auxiliary heat exchanger, that is, the plate is thermically isolated from the cabinet, or it is used to dissipate heat in addition to a portion of the cabinet, such as a portion of the cabinet walls, so that the heat radiating wall of the auxiliary heat exchanger is both an additional element (the plate) and an element of the cabinet (a portion of one of the cabinet's wall or basement). In this latter case, heat exchange takes place between the auxiliary heat exchanger and the cabinet.

[0029] Due to the skin condenser, if heat exchange takes place between the auxiliary heat exchanger and the cabinet, additional heat transfer takes place and heat is transferred to the exterior of the dryer via the relatively wide surface of the walls and basement by conduction. The temperature of the wall might slightly increase without any consequence.

[0030] Additionally, the skin condenser technology allows the realization of an auxiliary condenser at a relatively low price.

[0031] Preferably, the skin condenser is a wire-type heat exchanger or a wire-tube heat exchanger including a pipe or wire.

[0032] Preferably, the auxiliary heat exchanger is a coil heat exchanger, which is formed by one or more wires as tubes.

[0033] Preferably, the auxiliary heat exchanger has a tube for containing and passing the refrigerant, wherein the tube is guided at the inner side of the heat radiating wall in a curved manner or in serpentines or meandering from a lower region vertically upward. The tube or pipe of the auxiliary heat exchanger preferably starts from the lower region to an upper region at the inner side of the side wall. Thus, it consumes only little space. Preferably

the resulting flow path of the refrigerant is from the upper region of the auxiliary heat exchanger to the lower region thereof for higher efficiency in heat exchange. Alternatively the net refrigerant flow may be from left to right or right to left or from below upwards.

[0034] More preferably, said skin condenser includes a single pipe or tube.

[0035] The single pipe or tube is the pipe of the refrigerant circuit. In this way a simple and economical construction is achieved.

[0036] Even more preferably, said pipe or tube includes a plurality of contiguous rectilinear portions connected by bended portions.

[0037] The skin condenser comprises a pipe which is bend and forms a serpentine or a sinusoidal pattern, meandering and forming several curves or bends. It is known that oil droplets - which might form inside the refrigerant circuit - may be trapped and blocked within the refrigerant pipe itself, however the serpentine form minimizes this risk.

[0038] In an advantageous embodiment, said rectilinear portions and bended portions lie substantially on the same skin condenser plane.

[0039] Preferably, the skin condenser is essentially flat and/or planar and/or has restricted extension in the horizontal direction and/or is oriented upright. In this way the space in the basement occupied by the skin condenser is substantially negligible and room is left for the bulky condenser, evaporator and compressor of the heat pump.

[0040] Preferably, said one side of a heat radiating wall is an inner side of the first and/or second side wall.

[0041] Advantageously, the auxiliary heat exchanger uses a portion of the side walls of the cabinet to dissipate heat. A wide surface for heat exchange is thus available due to the cabinet construction.

[0042] Preferably, the heat radiating wall is thermally connected with one or more of the cabinet basement (24), the front wall, the rear wall, the first and the second side wall.

[0043] In case the heat radiating wall is an additional element to the cabinet, the heat exchange capabilities of the cabinet can still be used by the auxiliary heat exchanger putting the heat radiating wall in heat exchange with a portion of the cabinet, such as a portion of one of its walls or of the basement. Even more preferably, said skin condenser plane is substantially parallel to an inner side of said first and/or second side wall.

[0044] As mentioned, the auxiliary heat exchanger may have a 'flat' design. Flat means for example that the skin condenser extends substantially along a plane and its dimensions (e.g. width or length) along one direction are much bigger than its dimension in a direction substantially perpendicular to it. Being flat and parallel to the inner side of the side wall along its bigger dimension allows achieving a very compact configuration.

[0045] Due to the flat design, the auxiliary heat exchanger can be sandwiched between other components or elements of the apparatus.

[0046] According to an embodiment, one of the two horizontal dimensions of the auxiliary heat exchanger is smaller than the vertical dimensions of the auxiliary heat exchanger, preferably much smaller.

[0047] Preferably, said skin condenser is lacking fins.

[0048] The costs of the skin condenser of the invention are extremely reduced.

[0049] Advantageously, said skin condenser is fixed to said first and/or second side wall in such a way that a gap is formed therebetween for air circulation, thereby enhancing cooling of the wall and tubes forming the skin condenser.

[0050] Preferably, the auxiliary heat exchanger is oriented at the inner side of the side wall such that a cooling air flow is induced by natural convection. In particular, the natural convection is a free convection without blower assistance. The gap therefore helps in avoiding the need of the provision of a fan or blower dedicated for the auxiliary condenser itself.

[0051] In a preferred embodiment, said skin condenser includes a plate.

[0052] Preferably, said heat radiating wall is made of metal.

[0053] Preferably the heat exchanging surface(s) of the auxiliary heat exchanger is(are) increased by using one or more thermally conductive elements like: a corrugated metal plate, a heat radiator element, a heat exchanger rip, or combinations thereof. More preferably the plate is used. One or more of these may be provided on or at a surface being in contact with the cooling air (i.e. to the outside of the refrigerant piping).

[0054] One of the dimensions of the heat radiating wall is preferably minimal and this dimension is arranged so that it is parallel to the horizontal direction. The bigger dimension of the heat radiating wall is arranged substantially vertically so that the heat radiating wall, the wall of the cabinet and the skin condenser are one parallel to the other, minimizing their overall dimension along the horizontal plane, where the inner side of the cabinet is already occupied by several components and maximizing the extension along the side wall so as to maximize the heat exchange.

[0055] Preferably, the portion of said pipes extending on one side of a heat radiating wall is glued onto such wall.

[0056] The piping of the skin condenser is to be fastened onto the heat radiating wall. Several possibilities are available, such as screws, rivets, hooks or welding. Gluing is economical and easy to perform during the assembly process.

[0057] In an embodiment, said skin condenser is surrounded by foam.

[0058] The provision of a foam improves the connection of the skin condenser to the laundry dryer, the heat transfer towards the cabinet wall and the protection of the skin condenser

[0059] Preferably, said auxiliary heat exchanger is in series with said first heat exchanger.

[0060] Condenser and skin condenser are in series, so that the refrigerant is further cooled down by the skin condenser.

[0061] Advantageously, said pipe or tube of the auxiliary heat exchanger has an elliptical cross section.

[0062] The provision of an elliptical cross section, in particular if this cross section is vertically oriented, i.e. the major axis of the ellipses is vertically oriented, further reduces the space occupied by the skin condenser in the horizontal direction keeping the heat exchanging surface unchanged compared to a squared or circular cross-section. Preferably the major axis of the ellipse defined by the cross section of the pipe or tube is substantially parallel to the side wall.

[0063] Preferably, an air pumping device is provided to remove heat from the heat radiating wall. Preferably, an airflow provided by the air pumping device is directed towards a compressor of the heat pump system.

[0064] To further enhance heat exchange, a flow of cooling air can be directed towards the heat radiating wall. In order to keep costs low, an already existing component of the dryer can be used to provide for said cooling flow. In heat pump dryer, commonly a cooling fan to cool the compressor of the heat pump system is present, to avoid that the compressor may overheat during functioning. Properly arranging the compressor cooling fan and the auxiliary heat exchanger, a flow of air can be directed from the cooling fan towards the compressor and also towards the heat radiating wall.

Brief description of the drawings

[0065] Reference is made in detail to preferred embodiments of the invention, examples of which are illustrated in the accompanying figures, which show:

Fig. 1 is a schematic view of the principle of functioning of an heat pump;

Fig. 2 is a schematic view of a section of a dryer including an heat pump according to the invention;

Figs. 3a and 3b are two perspective views of a dryer realized according to the invention in a partially disassembled configuration;

Figs. 4a and 4b are two perspective views of a detail of the dryer of figs. 3a and 3b; and

Fig. 5 is a schematic view of a further embodiment of the dryer of figure 3a and 3b.

Best mode to carry out the invention

[0066] With initial reference to figs 3a and 3b, a dryer, which in this embodiment is a heat pump tumble dryer, is globally indicated with 1.

[0067] Laundry dryer 1 comprises an outer box cabinet 2, preferably but not necessarily parallelepiped-shaped, and a drying chamber, such as a drum 3, for example having the shape of a hollow cylinder, for housing the laundry and in general the clothes and garments to be dried. The drum 3 is preferably rotatably fixed to the cabinet 2, so that it can rotates around a preferably horizontal axis (in alternative embodiments, rotation axis may be vertical or tilted). Access to the drum 3 is achieved for example via a door 4, preferably hinged to casing, which can open and close an opening realized on the casing itself.

[0068] More in detail, cabinet 2 generally includes a front wall 20, a rear wall panel 23 and two side wall 21, 22 (in figs. 3a and 3b one of the two side walls is alternatively removed) mounted on a basement 24. Walls 20, 21, 22, 23 and basement 24 can be of any suitable material. Preferably, the basement 24 is realized in plastic material. The cabinet defines an inner space surrounded by walls 20-24 and an outer space external to the cabinet 2. Thus each wall or basement 20-24 automatically defines an inner and an outer side, being the surfaces towards the interior or the exterior, respectively, of the cabinet. In the appended drawings, inner and outer side 22a and 22b of side wall 22 are indicated.

[0069] Preferably, basement 24 includes an upper and a lower shell (the lower shell being visible in figure 4a).

[0070] The dryer 1 (see figures 3a and 3b) defines an horizontal plane (X,Y) which is substantially the plane of the ground on which the dryer is situated, and a vertical direction Z perpendicular to the plane (X,Y).

[0071] Laundry dryer 1 also comprises an electrical motor assembly (not visible in the drawings) for rotating, on command, revolving drum 3 along its axis inside casing. Cabinet 2, revolving drum 3, door and motor are common parts in the technical field and are considered to be known; therefore they will not be described in details.

[0072] Dryer 1 additionally includes a process air circuit 11 which comprises the drum 3. The air process circuit 11 is schematically depicted in fig. 1 as a plurality of arrows. In the basement 24, air process circuit is formed by the connection of the two upper and lower shells. Process air circuit may also include a fan or blower and an electrical heater (both not shown in the figures).

[0073] With now reference to fig. 2, the dryer 1 of the invention additionally comprises a heat pump system 30 including a first heat exchanger called also condenser 12 and a second heat exchanger called also evaporator 10. Heat pump system 30 also includes a refrigerant closed circuit 6 (schematically depicted with lines connecting the first to the second heat exchanger, and vice versa, see in detail fig. 2) in which a refrigerant fluid flows, when the dryer 1 is in operation, cools off and may condense in correspondence of the condenser 12, releasing heat, and warms up, potentially even evaporating, in correspondence of the second heat exchanger (evaporator) 10, absorbing heat. Alternatively, no phase transition takes place in the condenser and/or evaporator, which indicates in this case respectively a gas heater and gas

cooler, the refrigerant cools off or it warms up, respectively, without condensation or evaporation. In the following the heat exchangers are named either condenser and evaporator or first and second heat exchanger, respectively.

[0074] More in detail, the refrigerant circuit 6 includes a piping 31 (see figs. 3a -3b and 4a - 4b for example) which connects the second heat exchanger 10 where the refrigerant warms up and may undergo a phase transition from the liquid to the vapour via a compressor 14 to the condenser 12, in which the refrigerant cools off and may condense again. The cooled or condensed refrigerant arrives via an expansion device 16, such as a choke, a valve or a capillary tube, back at the evaporator 10. The piping 31 advantageously includes a single pipe forming a closed loop.

[0075] Preferably, the dryer 1 further includes a compressor cooling fan (not depicted), located within the inner space defined by the cabinet 2 and adapted to blow air towards the compressor 14. In this way, overheating of the compressor may be avoided, due to a flow of cooling air blown by the compressor fan on the compressor. The activation of the compressor cooling fan may for example depend on a temperature of the refrigerant flowing in piping 31 at a given selected location.

[0076] Preferably, in correspondence of evaporator 10, the dryer 1 of the invention may include a condensed-water canister 40 (shown only in fig. 1) which collects the condensed water produced, when the dryer is in operation, inside evaporator 10 by condensation of the surplus moisture in the process air stream arriving from the drying chamber 3. The canister 40 is located at the bottom of the evaporator 10. Preferably, through a connecting pipe and a pump (not shown in the drawings), the collected demineralized water is sent in a reservoir located in correspondence of the highest portion of the dryer 1 so as to facilitate manual discharge of the water by the user.

[0077] In case of a condense dryer, where the air process circuit is a closed loop circuit, the condenser 12 is located downstream of the evaporator 10. The air exiting the drum 3 enters the conduit and reaches the evaporator 10 which cools down and dehumidifies the process air. The dry cool process air continues to flow through the conduit till it enters the condenser 12, where it is warmed up by the heat pump 30 before re-entering the drum 3.

[0078] It is to be understood that in the dryer 1 of the invention, the electrical heater (not depicted in the drawings) may or may not be present. In an embodiment, the heater can be omitted, being the heat pump system 30 sufficient to heat up the air process stream for the purpose of laundry drying. However, heat pump system 30 and heater can also work together to speed up the heating process (and thus reducing the drying cycle time). In the latter case, preferably condenser 12 of heat pump system 30 is located upstream the heater.

[0079] Furthermore, the heat pump system 30 includes an auxiliary heat exchanger 13 connected in series with the condenser 12. The auxiliary heat exchanger 13 is a skin condenser which is preferably located at the inner side of one of the side walls, either 21 or 22 (in the depicted embodiment at 22). In a different non-depicted embodiment, more than one auxiliary condenser can be included in the heat pump system 30, for example a first auxiliary heat exchanger located at one side wall and a second auxiliary heat exchanger located at the other side wall.

[0080] In the main embodiment shown in the appended drawings, the main components of the heat pump system 30 (except the control electronics which is preferably arranged at a top section of dryer) with the exception of the auxiliary heat exchanger 13 are arranged in the basement 24 which also forms parts of the process air channel.

[0081] Fig. 3a and 3b, and more in detail figs. 4a, 4b and 5, show two embodiments of the auxiliary heat exchanger 13. The auxiliary heat exchanger 13 comprises an inlet tube 60 and an outlet tube 61. The inlet tube 60 and the outlet tube 61 are parts of the refrigerant circuit 6, that is, the inlet and the outlet tubes 60, 61 are two portions of the piping 31. In a preferred embodiment, the inlet tube 60 is connected to an outlet of the second heat exchanger 12 and the outlet tube 61 is connected to an inlet of the expansion device 16. The inlet tube 60 and the outlet tube 61 are connected to one end of a heat exchanging tube or are the end sections of a heat exchanging tube extending in serpentines through the auxiliary heat exchanger 13. The shown heat exchanging tube is formed by elongated extending tubes or rectilinear portions 65 which are connected by curved portions 64 to form together a meandering tube 62 of the auxiliary heat exchanger 13. Meandering tube 62 is also part of piping 31, that is, it is a portion of the refrigerant closed loop of the heat pump system. In the depicted embodiment, the refrigerant first flows through the second heat exchanger 12 and then through the auxiliary heat exchanger 13 and then it flows through the expansion device 16.

[0082] In the depicted preferred embodiment, the meandering tube 62 is the only tube included in the auxiliary heat exchanger 13, which is in other words formed by a portion of the refrigerant piping 31 which meanders in itself forming a plurality of bends.

[0083] Preferably the cross section of the meandering pipe 62 is arbitrary, more preferably elliptical and even more preferably having the major axis substantially oriented parallel to the side wall 22.

[0084] Preferably, the inlet tube 60 is arranged in an higher location than the outlet tube 61.

[0085] In the depicted embodiment, the auxiliary heat exchanger 13 includes no fins.

[0086] As compared to conventional heat exchangers and also as compared to the first and second heat exchangers 10, 12, the auxiliary heat exchanger 13 is substantially "flat". Auxiliary heat exchanger 13 extends with side or horizontal dimension "a" and "b" in the (X,Y) horizontal plane and in a height dimension "c" along the Z

axis, as depicted in fig. 4b. One of the side dimensions, in this case dimension "a", is much smaller than the height dimension "c", and even more preferably is also much smaller than the other of the side dimensions "b". Preferably, as depicted, the meandering tube 62 defines substantially a plane, so that the various rectilinear portions and the bended portions lie on the same plane, e.g. they have the same (X,Y) coordinates. More preferably, this plane is a plane substantially parallel to the vertical axis Z. In this way, one of the side dimensions, which is "a" in the depicted embodiment, is substantially equal to the dimension of the tube 62.

[0087] In this manner, the inlet and outlet tubes 61 and 62 of the auxiliary heat exchanger also lie substantially on the same plane. In the preferred embodiment, the inlet and the outlet tubes 61, 62 are one on top of the other on the vertical axis Z and more preferably the inlet tube is located higher than the outlet tube in the vertical Z direction.

[0088] However in a different embodiment, the inlet tube 61 and outlet tube 62 may be arranged in a horizontal plane, that is, they have substantially the same Z coordinates, or in a plane inclined with respect to the horizontal and/or a vertical plane. Preferably, in any arrangement, the inlet and the outlet tube are parallel to each other.

[0089] As compared to conventional auxiliary heat exchangers, the auxiliary heat exchanger 13 according to the invention occupies a very small area horizontally and provides more freedom of design for integrating it even in narrow spaced dryer inside locations or outside gaps or recesses.

[0090] Preferably, height dimension "c" is parallel to a side wall of the cabinet 2, either 21 or 22. Furthermore, also the larger side dimensions "b" is parallel to the side wall 21 or 22, while the remaining dimension "a" is substantially perpendicular to it, so that the skin condenser protrudes from the side wall horizontally minimally.

[0091] Additionally, the auxiliary heat exchanger 13 includes means suitable to transfer additional heat from the refrigerant flowing in the meandering pipe 62 to cooling air such as ambient air present within the inner space defined by the cabinet 2 or outside the same. For this purpose, the auxiliary heat exchanger 13 includes a heat radiating wall 18 having heat exchanger surfaces for enlarging the heat exchanging surface area. The heat radiating wall 18 can be an additional element in the dryer 1, for example the heat radiating wall can include a plate 18 such as a metal plate, or it can include an element already present in the cabinet, such as a portion of the cabinet itself, e.g. a portion of one of the walls 21, 22, 23 or basement 24 of the cabinet 2.

[0092] The heat radiating wall 18 is adapted to radiate the heat coming from the refrigerant circuit 6, that is, there is a heat exchange between the meandering pipe 62 and the heat radiating wall 18 so that the heat absorbed by the wall 18 can be radiated in the ambient surrounding it. The wall therefore warms up due to the heat transported in the circuit 6 and dissipates this heat at least in part.

[0093] In a first embodiment depicted in figure 5, the heat radiating wall 18 includes a portion of a cabinet wall, for example a portion 18a of the lateral wall 22. However, the portion 18a can be any portion of any of the walls 21-23 or of the basement 24 of the cabinet 2 of the laundry dryer 1. Preferably however it is a portion 18a of a lateral wall 21 or 22. The meandering pipe 62 is located in proximity of the portion 18a so that the heat exchange can take place. Preferably, the meandering pipe 62 is located in front of portion 18a and more preferably parallel to it (that is, the meandering pipe lays on a plane which is parallel to the wall plane containing portion 18a), forming a gap therebetween, for example of constant width. The meandering pipe 62 is located within the inner space defined by the cabinet 2, so that it is not visible from the exterior of the cabinet and cannot come into contact to a user without opening the cabinet.

[0094] Alternatively, as shown in the embodiment of figure 4a and 4b, the heat radiating wall is an additional plate 18, which is preferably interposed between the side wall 22 and the meandering pipe 62. The structure is therefore formed by a side wall 21 or 22, the plate 18 and the meandering pipe 62, preferably located in parallel planes. However instead of the side wall 21 or 22, the structure above described can also be formed with the front or rear wall or the basement. In order to keep the volume occupied by the auxiliary heat exchange 13 relatively small, the plate 18 is located in proximity of any of the walls 21-23 or basement 24..

[0095] Meandering pipe 62 is for example glued on plate 18. Additionally, plate 18 may be in turn glued on the inner side of the side wall 22 (or any other walls 21-23 or basement 24 of the cabinet 2) or it is fixed thereto by any means.

[0096] Preferably a gap is present between the plate 18 and the inner side of the wall 22 so that air circulation is possible.

[0097] In case wall 18 is an additional element and not a portion of one of the cabinet's walls or basement, preferably either heat exchange is possible between plate 18 and the wall or basement 21-24 in proximity to the plate 18, so that also a portion of wall or basement 21-24 with which heat exchange takes place dissipates heat, or the wall or basement 21-24 is thermally insulated from the plate 18, for example using foam or any other insulating material.

[0098] During operation of the dryer 1, the auxiliary heat exchanger 13 acts as a condenser and transfers heat from the process air to ambient air and possibly also to a portion of the cabinet 2 improving the heat exchange of the heat pump system 30.

[0099] In order to further dissipate heat from the heat radiating wall 18 or 18a, air pumping device may be provided in order to blow air towards the heat radiating wall 18, 18a and dissipate air in a quicker and more efficient manner. The air pumping device can be an air pumping device already present in the dryer 1, such as for example

the compressor cooling fan, which may be properly oriented in order to blow cooling air both towards the compressor and the heat radiating wall 18, 18a.

Claims

1. A laundry dryer (1) comprising:

   • a cabinet (2) supporting a drying chamber (3) for receiving a load to be dried and having a basement (24), a front wall (20), a rear wall (23), a first and a second side wall (21,22) which define a cabinet inner volume;
   • A process air conduit (11) in communication with the drying chamber (3) where an air process stream is apt to flow;
   • A heat pump system (30) having a heat pump circuit formed by pipes (31) in which a refrigerant can flow, said heat pump circuit including a first heat exchanger (31) where the refrigerant is cooled off and the process air stream is heated up, and a second heat exchanger (32) where the refrigerant is heated up and the process air is cooled off; said first and/or second heat exchanger being thermally coupled to the process air conduit (11) to perform heat exchange between said refrigerant flowing in said heat pump circuit and said process air stream;

   characterized in that said heat pump system (30) further includes an auxiliary heat exchanger (13) which comprises a skin condenser including a portion (62) of said pipes and a heat radiating wall (18, 18a), the portion (62) of said pipes extending on one side of the heat radiation wall (18, 18a), and said heat radiating wall (18, 18a) being a portion (18a) of said cabinet (2) or being contained within said cabinet inner volume.

2. Dryer (1) according to claim 1, wherein said skin condenser (13) includes a single pipe (62).

3. Dryer (1) according to claim 2, wherein said pipe (62) includes a plurality of contiguous rectilinear portions (65) connected by bended portions (64).

4. Dryer (1) according to claim 3, wherein said rectilinear portions (65) and bended portions (64) lie substantially on the same skin condenser plane.

5. Dryer (1) according to any of the preceding claims, wherein said skin condenser (13) is lacking fins.

6. Dryer (1) according to any preceding claim, wherein said one side of a heat radiating wall (18a) is an inner side (22a) of the first and/or second side wall (22).

7. Dryer (1) according to any claim 1 to 5, wherein the heat radiating wall (18) is thermally connected with one or more of the cabinet basement (24), the front wall (20), the rear wall (23), the first and the second side wall (21,22).

8. Dryer (1) according to any claim 1 to 5 wherein the heat radiating wall (18) is connected to one or more of the cabinet basement (24), the front wall (20), the rear wall (23), the first and the second side wall (21,22), and it forms a gap therebetween for air circulation.

9. Dryer (1) according to any preceding claim, wherein said heat radiating wall (18, 18a) is made of metal.

10. Dryer (1) according to any of the preceding claims, wherein the portion (62) of said pipes (31) extending on one side of a heat radiating wall (18, 18a) is glued onto such wall.

11. Dryer (1) according to any of the preceding claims, wherein said skin condenser (13) is surrounded by foam.

12. Dryer (1) according to any of the preceding claims, wherein said auxiliary heat exchanger (13) is in series with said first heat exchanger (12).

13. Dryer (1) according to any of the preceding claims, wherein the portion (62) of said pipes pipe (31) extending on one side of the heat radiating wall (18, 18a) has an elliptical cross section.

14. Dryer (1) according to any of the preceding claims, wherein an air pumping device is provided to remove heat from the heat radiating wall (18, 18a).

15. Dryer (1) according to claim 14, wherein an airflow provided by the air pumping device is directed towards a compressor (14) of the heat pump system (30).

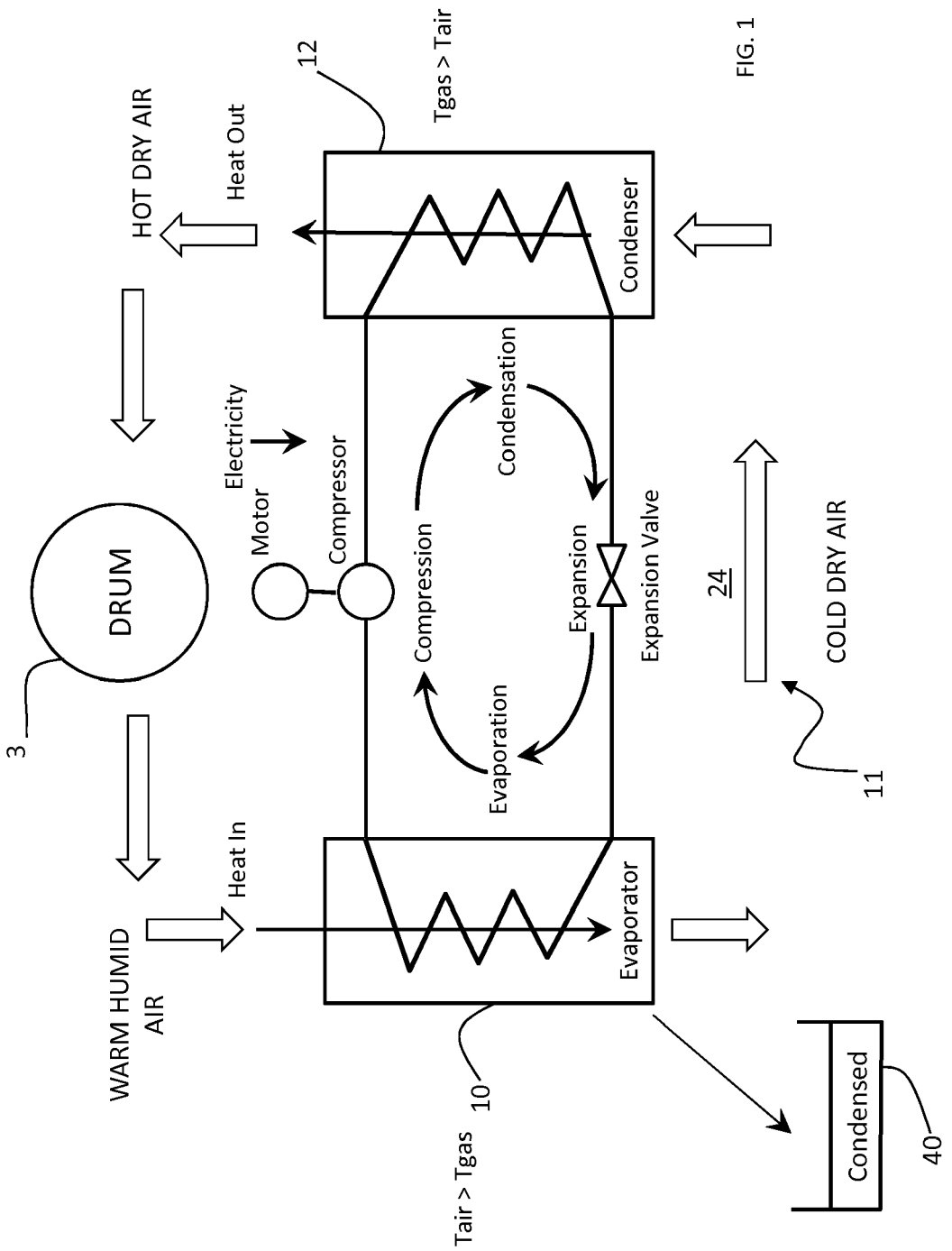

HOT DRY AIR
Heat Out
12
Tgas > Tair
Condenser
Electricity
Motor
Compressor
Condensation
Compression
Expansion
Expansion Valve
DRUM
3
24
COLD DRY AIR
11
Evaporation
Heat In
WARM HUMID AIR
Evaporator
10
Tair > Tgas
Condensed
40

FIG. 1

FIG. 2

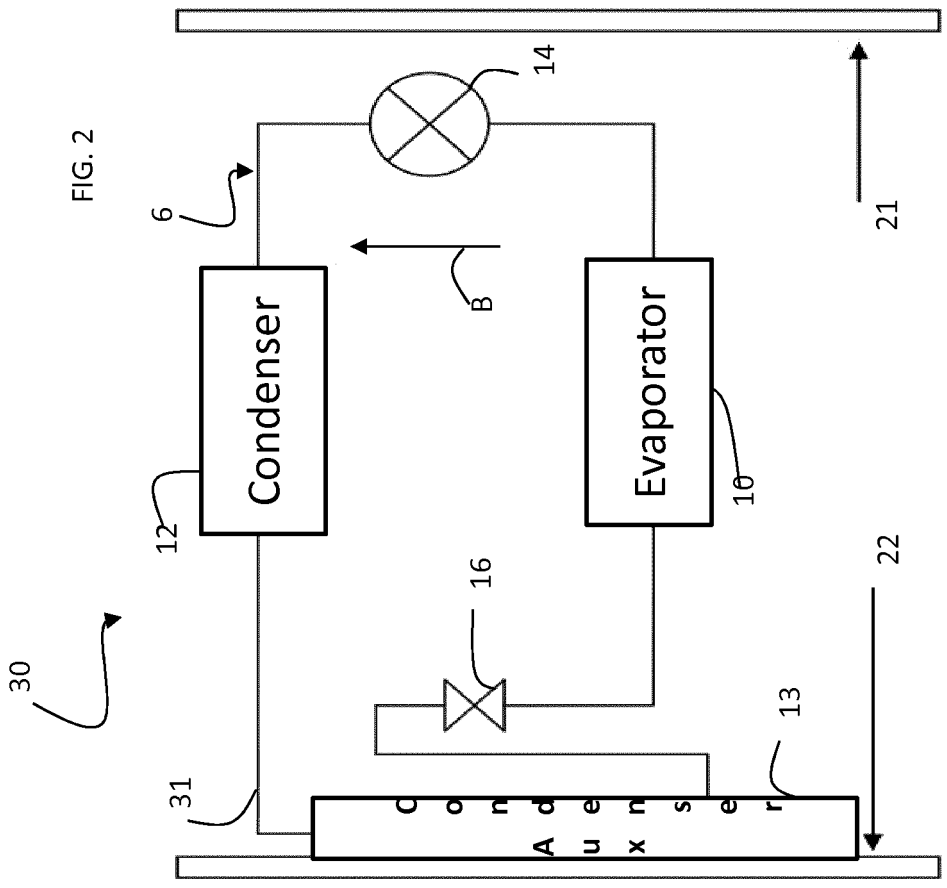
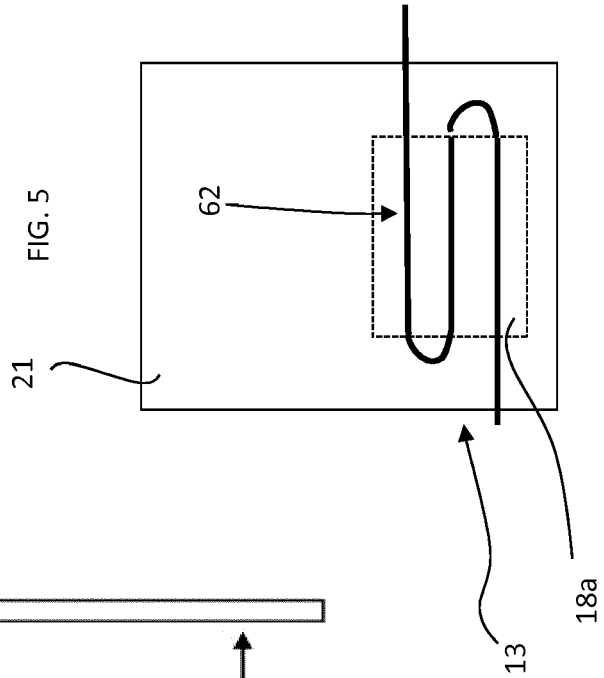

30
31
Condenser
12
6
14
B
Evaporator
16
10
Condenser
13
22
21

FIG. 5


21
62
13
18a

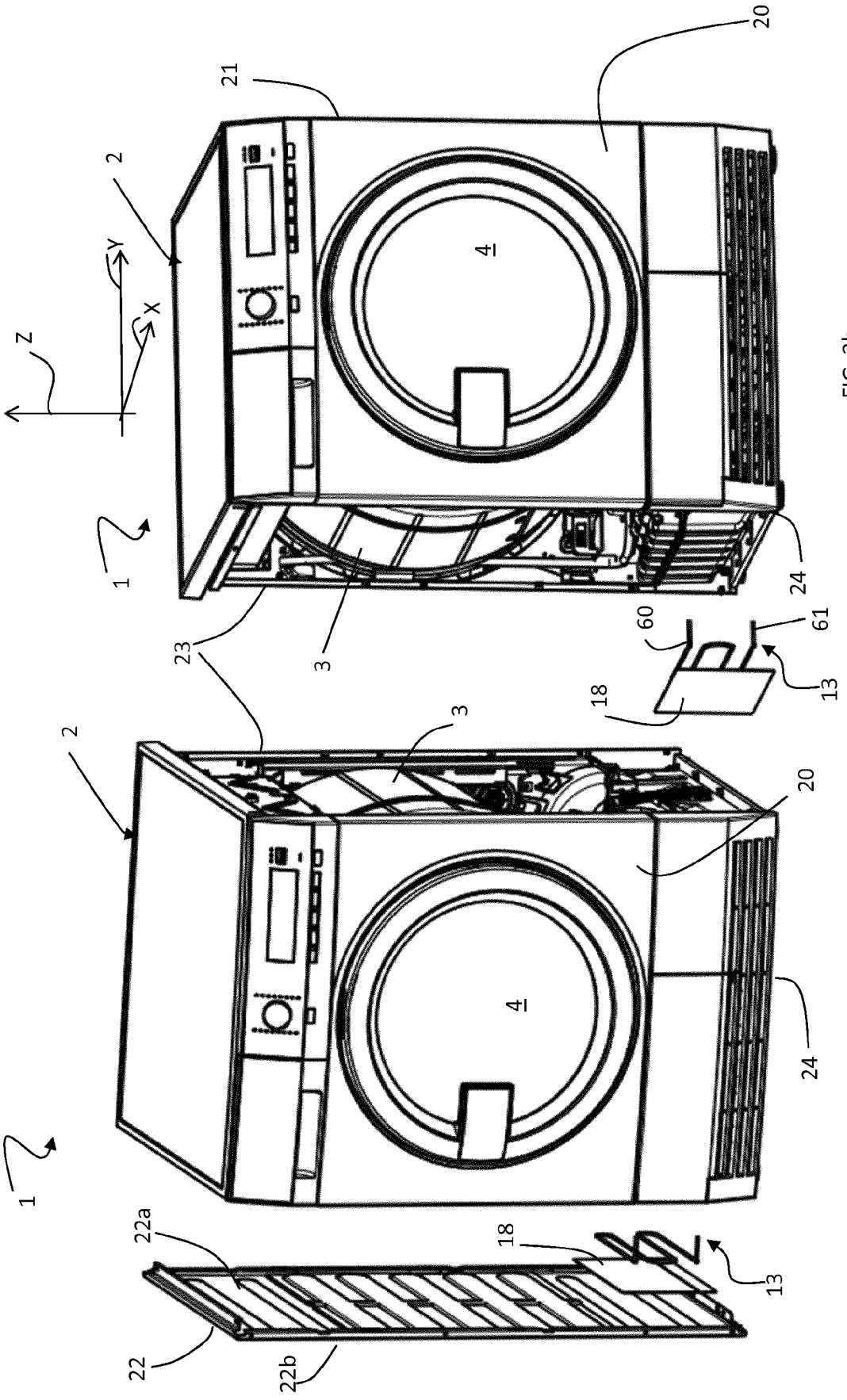


FIG. 3a

FIG. 3b

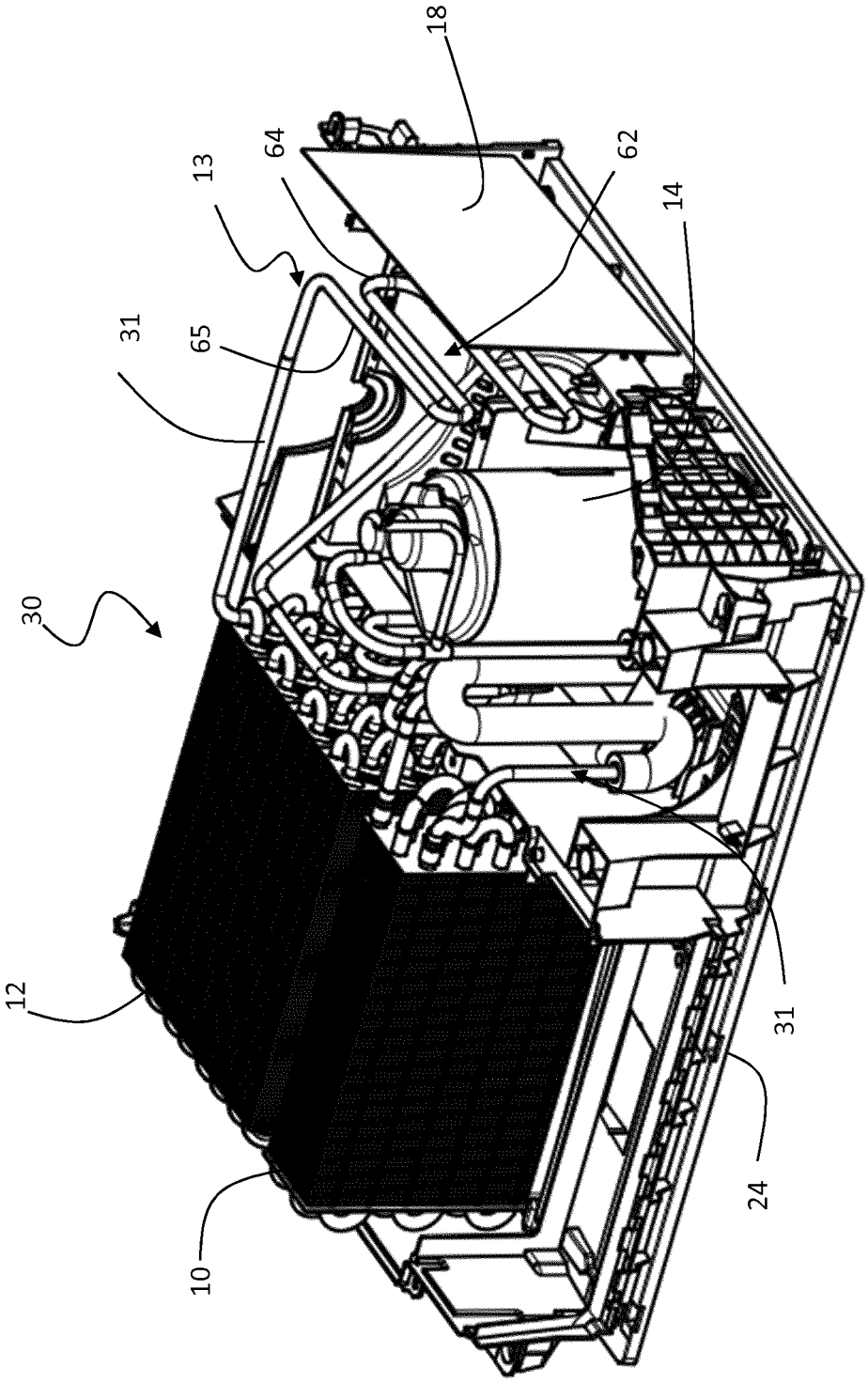


FIG. 4a

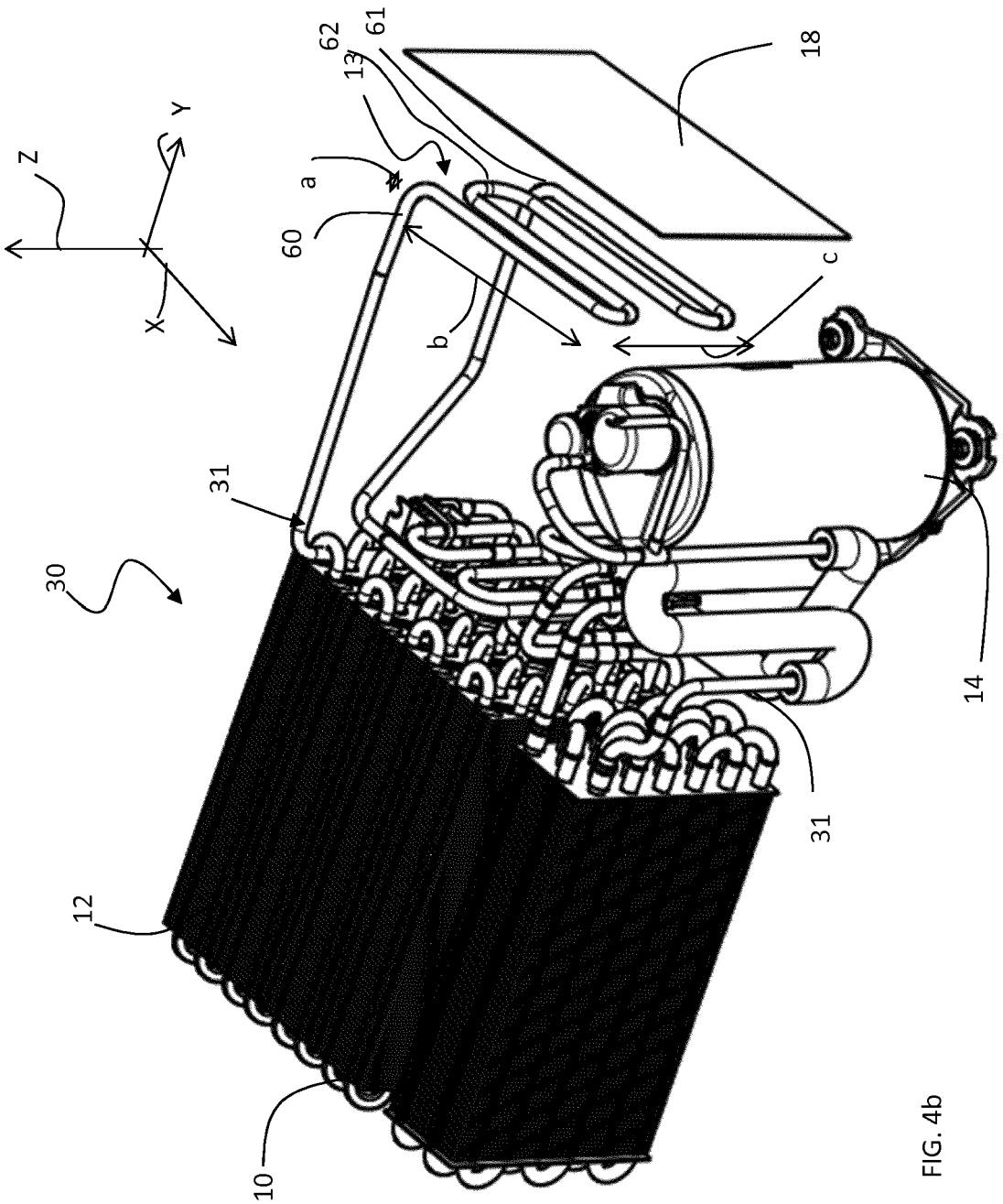


FIG. 4b

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 16 16 6343

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	EP 2 781 644 A1 (ELECTROLUX APPLIANCES AB [SE]) 24 September 2014 (2014-09-24) * paragraph [0006] - paragraph [0009] * * paragraph [0034] * * figures 1-5 *	1-10,12, 15 11,13	INV. D06F58/20
A	EP 2 460 926 A1 (ELECTROLUX HOME PROD CORP [BE]) 6 June 2012 (2012-06-06) * paragraph [0004] - paragraph [0008] * * figure 1 *	1,14	
A,D	EP 2 034 084 A1 (V ZUG AG [CH]) 11 March 2009 (2009-03-11) * figures 1-4 *	1,15	
A	WO 2007/074040 A1 (BSH BOSCH SIEMENS HAUSGERAETE [DE]; NEHRING ULRICH [DE]) 5 July 2007 (2007-07-05) * abstract; figure 1 *	1	
			TECHNICAL FIELDS SEARCHED (IPC) D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 July 2016	Bermejo, Marco

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 16 6343

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

22-07-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2781644 A1	24-09-2014	AU 2014234494 A1	08-10-2015
		EP 2781644 A1	24-09-2014
		WO 2014146953 A1	25-09-2014
EP 2460926 A1	06-06-2012	AU 2011334932 A1	11-04-2013
		CN 103443350 A	11-12-2013
		EP 2460926 A1	06-06-2012
		RU 2013129982 A	10-01-2015
		US 2013340278 A1	26-12-2013
		WO 2012072693 A2	07-06-2012
EP 2034084 A1	11-03-2009	DE 202006018205 U1	15-02-2007
		DE 202007000648 U1	15-03-2007
		DK 2034084 T3	18-03-2013
		EP 2034084 A1	11-03-2009
		SI 2034084 T1	28-06-2013
WO 2007074040 A1	05-07-2007	DE 102005062939 A1	05-07-2007
		WO 2007074040 A1	05-07-2007

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2008086933 A **[0003]**
- EP 2034084 A1 **[0004]**
- EP 2573252 A **[0005]**